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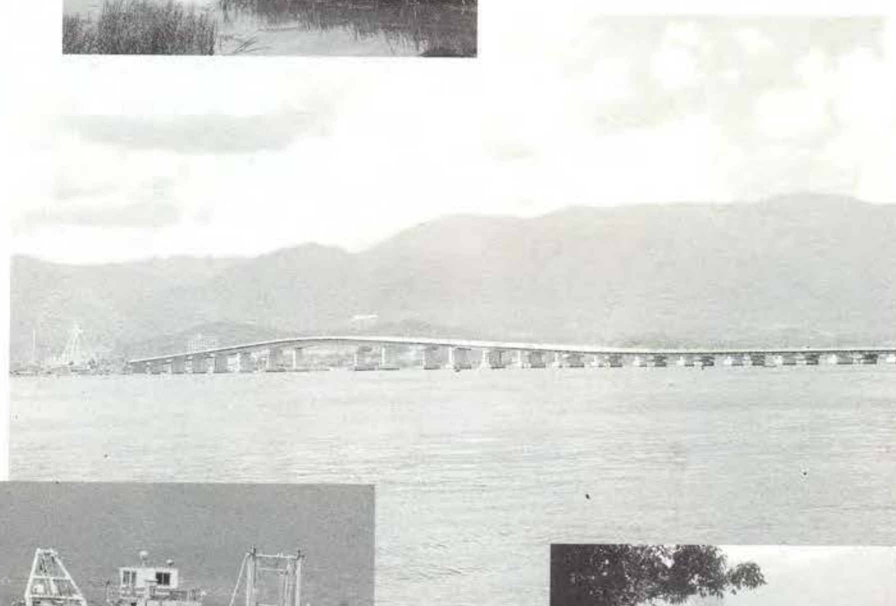

Implemented 25-27 November 1996 in Shiga, Japan
together with the Shiga Prefecture
in collaboration with
The Environment Agency, Government of Japan
The International Lake Environment Committee Foundation

International Shiga Forum on Technology for Water Management in the 21st Century

Shiga, 25-27 November 1996

PROCEEDINGS

implemented by
Shiga Prefecture
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Foreword

Leonardo da Vinci said 'Water is the driver of nature'. It may have seemed to be an overstatement to some people earlier, but as the 21st century dawns, its relevance and importance is becoming apparent to most water professional and decision-makers from all around the world.

As the global population increases, implications for water management are becoming increasingly complex and serious. Increasing population means more and more water is needed for drinking, agricultural production, energy generation, tourism and ecosystems preservation. Simultaneously, the quality of the global water resource is now threatened with continually higher levels of human activities and their attendant impacts in terms of surface and groundwater contamination. Managing our scarce and limited water resources both in terms of quantity and quality, is already a very complex task at present. It can only become even more complex in the future.

Because of these increasing management complexities, and also as water becomes an important hydropolitical issue in terms of development of international rivers, lakes and aquifers, Shiga Prefecture and the UNEP International Environmental Technology Centre decided to convene a major international Forum on water management in the 21st century.

We would like to extend our sincere thanks to the co-organizers of this Forum - The Japanese Environment Agency and the International Lake Environment Committee Foundation, who continuously gave us their generous support.

We expect this publication to make a major contribution in further improving water management processes and technologies in different parts of the world.

Minoru Inaba
Governor
Shiga Prefecture

John Whitelaw
Director
International Environmental Technology Centre
United Nations Environment Programme

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Due to increasing population, changing lifestyles and escalating human activities, the total global demand for water resources as well as food, energy, and industrial goods will continue to increase.

Unless water management processes become increasingly more efficient, the world and especially the developing world is likely to face untold human misery more frequently and more extensively than has been recorded in the past.

The Shiga International Forum on Water managed to bring together scientists from all over the world, people from government and the general public, to explain to us about the global water crisis we are facing now.

The Forum consisted of three sessions, "Water management in Japan", "Water Management in National Contexts" and "International Cooperation". The Forum yielded two major conclusions and three recommendations.

Conclusions:

Global Water Crisis

The world is already facing a serious global water crisis and the problem is likely to become more serious in the future unless we try to take some very important steps including changing mind sets, attitudes, and behavior immediately.

Even though we strongly believe there is a crisis and it is going to get worse in the future, the public at large, decision makers in general and the media still have not accepted the fact that there is a global water crisis or the magnitude of that crisis.

Recommendations:

World Water Forum

All the collaborators of the Forum may consider the possibility of convening a World Water Forum every two or three years. Scientists, government civil servants, international organizations, public decision makers and the media all working together and trying to identify problems and, better still offer some solutions to the world.

Water in the International political Agenda

All the co-sponsors and collaborators of the Forum could put together a small task force that could work in this area and see what might be possible in terms of process to put water on the national and international agenda.

International Collaboration

It was stressed that they need to foster better international collaboration in the field of water and how to work together between the various institutions and countries more effectively.

Opening Statement

presented by Dr. Walter Rast
on behalf of Ms. Elizabeth Dowdeswell
Executive Director, United Nations Environment Programme

Your Excellencies, Distinguished Colleagues, Ladies and Gentlemen:

It is my sincere pleasure to address you today at the opening of this international forum. I also want to extend the greetings of Ms. Elizabeth Dowdeswell, the Executive Director of UNEP. Unfortunately, her previous commitments precluded her being here to address you in person. Nevertheless, freshwater issues have remained among the highest priorities of UNEP under her leadership, as well as being one of her personal environmental concerns. As some of you may know, UNEP has consolidated its freshwater unit and its coastal/oceans programme into a single, integrated Water Branch. I am the former chief of the former Freshwater Unit, and am now the Deputy Director of the combined Water Branch. I have participated in previous fora organized by the Shiga Prefecture and ILEC, and it is my honor to be with you today at the convening of this important international conference.

We are here to discuss water issues. Freshwater has been described by some as a liquid "more precious than gold". As a minimum, we must agree that water is precious, finite and irreplaceable. It is ***precious*** in that we need it both to satisfy our physiological needs as well as its role as a basic commodity for economic development. It is ***finite*** in that we have only so much of it and no more. It is ***irreplaceable*** in that we have no substitutes for it; nor can we manufacture water.

Perhaps the most pristine vision of water is available from space. Observing Earth from above, we see no borders, walls or passport controls--just a magnificent, largely-blue giant globe where all life as we know it exists. From their extraterrestrial perspective, astronauts must doubtless get a feeling of being "a citizen of the world", perhaps realizing more profoundly than most of us that all people are dependent on each other, wherever they live or whatever they do.

Ladies and gentlemen,

It is interesting that, in spite of its obvious importance, in our lives, water is a relatively simple compound, formed by a simple chemical combination of one oxygen atom with two hydrogen atoms. It is present in practically all biosphere layers, being a prerequisite for all life as we know it.

Because of our background, we probably think about water more than most people. In a recent National Geographic article on water, it was suggested that most people seldom think it. Indeed, we expect to see it when we turn on our taps. Most of us can drink or bathe when we wish; we can swim and fish in it when we wish. In fact, humans with adequate water supplies typically ignore it completely. Like our good health, however, when our water supply is affected, suddenly it's all that matters. A person can live for about a month without food--without water, he or she would die within a week. Some life forms can exist even in the absence of oxygen, but not without water.

The statistics also provide an interesting picture. An interesting analogy was provided in the previously-cited National Geographic article, which pointed out that if all the Earth's water could fit in a one-gallon jug (3.85 liters), the available freshwater would equal just over a tablespoon (<0.5 percent) of the total. The total average annual rainfall over land is 110,000 cubic kilometers, of which about 70,000 cubic kilometers is lost through evaporation. Thus, on average, about 40,000 cubic kilometers each year is potential available for human use. Even less, however, is actually available for human use, when we consider such factors as rainfall where there are no people to use it, or excessive downpours resulting in floods that move quickly to the sea, etc. This reduces the readily-available freshwater to about 9,000 cubic kilometers. As total human freshwater consumption is estimated at 4,000 cubic kilometers per year, there still is sufficient freshwater for virtually all human uses on a global scale. Yet, we still suffer the consequences of water shortages because our available water is unevenly distributed around the world, both temporally and spatially.

Historically, the rise and fall of ancient city states, even civilizations, has been a function of the effective management of available water resources. In fact, one of the most basic tasks facing ancient societies was to bring water to cities, to set up and maintain irrigation, and to dispose of sewage. Interestingly, some things haven't changed--these are still some of the most basic tasks facing society today! Clearly, for the majority of people on this planet, the sustainability of their livelihoods is intimately connected to the reliable supply and quality of freshwater resources.

In the human quest for economic development, we spend much of our time gathering, extracting, moving, concentrating and dumping. As a result, we are overwhelming in many cases the ability of nature to breakdown or otherwise neutralize the waste products of our development. With our freshwater resources, we are engaged in a continuing cycle of water use, degradation, discharge, extraction, treatment and reuse, a cycle that is growing increasingly expensive to maintain as we find ever more ways to pollute and otherwise abuse our water resources.

Ladies and gentlemen,

Given the low priority given to water in the political arena on a global scale, it is surprising that the two longest chapters in Agenda 21 deal with rivers and oceans. The freshwater chapter (18) states that freshwater is an essential component of the Earth's hydrosphere and an indispensable part of all terrestrial ecosystems. It further states freshwater is needed in all aspects of life; the general objective is to make certain that adequate freshwater resources of good quality are maintained for the entire population of this planet, while also preserving the hydrological, biological and chemical functions of ecosystems, adapting human activities within the capacity limits of nature and combatting vectors of water-related diseases. Thus, human physiological and economic development needs, as well as the maintenance of our life-supporting ecosystems, are addressed in Chapter 18. This Chapter also makes reference to the improvement of indigenous technologies, as a means of fully utilizing limited water resources and safeguarding these resources against pollution.

As a fundamental aspect of ensuring adequate supplies of good quality water, it is interesting that we rarely value water in economic terms in the same manner as we do other natural resources, such as oil or minerals. Given the increasing competition for this finite, irreplaceable resource, this situation cannot persist, and a change in our perceptions regarding water is inevitable. This change will take the form of a fundamental shift in the way we think about, manage and use water. If we continue to treat water as an abundant, perpetually-renewable and cheap resource, the one thing we can be sure of is serious social, economic and political repercussions over the long term. It is unfortunate that, in spite of the agreements made at UNCED, many Governments have yet to recognize the need to re-design their economic development policies to address the water issue.

So, ladies and gentlemen, we will

discussing lakes here over the next few days. Within the context of what I've already said, how should be view a lake? On the one hand, a lake is simply a hole in the ground filled with water. But, of course, this is a very narrow definition. Obviously, however, a lake is an integral part of a larger hydrologic unit, comprising the surrounding drainage basin, as well as the living and nonliving components contained within it. Many physical, chemical and biological measures exist to allow us to assess the state of the lake water, and the condition of the biological populations living in it. Sometimes, however, it is informative also to remind ourselves of the many uses to which *we* put this resource, including drinking, cleaning, cooking, irrigation, fisheries, aquaculture, industry, commerce, power generation, aesthetics, and even putting out fires!

It is the energy that water acquires as it moves in a drainage basin that allows it to pick up and transport polluting materials to lakes and reservoirs. Therefore, our ability to optimize human uses of lake waters depends on our ability to manage the human activities in the drainage basin that produce the polluting materials that enter a lake in drainage waters. This means we must also address many things other than water, including such diverse issues as economics, law, institutions, demography, education and public awareness, social customs, politics--in short, almost everything but water! Yet, if we address these issues properly, a notion at the core of sustainable development, many water problems also will be solved.

Many of you participating in this meeting are internationally-known experts on various aspects of lakes and reservoirs, and will make definitive presentations on these waterbodies at this forum. At the same time, however, we should not forget the larger environmental picture. One might logically argue that degradation of one waterbody will not necessarily impact another waterbody in a different drainage basin. Nevertheless, the challenges remain the same--namely, the sustainable management and use of the water resource. Within this context, protection of lakes and reservoirs is a global problem. In some cases, the best approach to addressing the problems might be the use of appropriate equipment or technology. To this end, UNEP's International Environment Technology Centre, located in Osaka and Shiga, in collaboration with UNEP's Water Branch, have recently completed a series of regional workshops focusing on techniques, both modern and traditional, for improving the use of, and augmenting water resources, that are practiced all over the world. They include such diverse approaches as optimizing rainwater harvesting, groundwater systems, desalination, reuse of wastewater, and demand and leak reduction. These experiences focus on techniques based on hydro-climatic conditions existing in specific regions. They include discussions of the strengths and weaknesses of alternative approaches, and form the basis for identifying appropriate technologies for given water needs. They will be published within the next few months in the form of a series of guidebooks.

These regional workshops also highlighted that fact that technology, in the form of structures or equipment, is not necessarily the best solution in all cases. It appears that efforts directed to education and public awareness activities that focus on behavioral changes also can be powerful water management tools. Small changes in agricultural practices, for example, can provide significant results, as was also illustrated in a previous study of nonpoint source pollution in the North American Great Lakes Basin during the 1970's. Such changes can even prove economically beneficial to farmers. Surveys also showed that the greater distance a farmer was located from the lakes, the less he or she understood or appreciated their role in causing water pollution. The "soft" approach of greater education and public awareness was the most appropriate approach for this situation, as subsequent experiences showed. The same situation applies to the methodologies and timing for street sweeping or other surface cleaning activities in urban areas.

Ladies and gentlemen,

In closing, I want to encourage a wide-ranging discussion of the issues encompassed in the title of this forum; namely the use of soft options, such as changing management practices, versus hard choices such as alternative technologies. Both are useful in specific settings, and both must be explored within the specific context of lake protection and conservation, as well as the larger context of sustainable management and use of the water resource. In the name of the Executive Director, I wish all of us good luck, and look forward to our discussions and deliberations.

Global Water Crisis
- Differences in regional predicaments -

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ABSTRACT

The paper gives an overview of current differences in terms of water resources predicament between 26 world regions, focusing on three dimensions of water stress (natural, technical and demographic). It discuss the future of global food security in terms of the amounts of water needed and the possibility to mobilize those amounts I different developing regions. The paper closes with some principal comments on key strategies. It stresses the need for a water management that is much better integrated with land use management. It is increasingly imported to link - because of their complementarity - green water use (soil moisture) with blue water use (water in aquifers and rivers), and water quantity with quality. Mechanisms are also need for water sharing both at the local level and the basin level.

INTRODUCTION

The combination of a finite water availability and escalating water needs, waste loads and consumptive use in response to both population growth, growing aspirations in terms of quality of life, and growing food needs greatly increases the complexity of water resources management. The Global Water Partnership is active in trying to go from a rhetoric to a real integrated approach to water resources as called for in Agenda 21. Integration of all water-related activities in a river basin, both those upstream and those downstream, and both water-dependent and water-impacting land uses
will however be difficult without a certain conceptual development. Past conceptual approaches will no longer be effective enough. Even today, water is often seen as a mainly technical issue, and water management an issue of structures, schemes and operational rules. Moreover, there has been an almost pathetic international silence around the specific problems linked to the water scarcity typical for many low-latitude countries in the tropics and subtropics (1) - a silence that lasted until the Dublin Conference in 1992.

Sectoral fragmentation

As the fluidum of life, water is a resource of considerable complexity with many parallel functions (2)

- health function - the realm of sanitary engineers
- habitat function - the realm of limnologists and aquatic ecologist
- socio-economic production function - the realm of civil engineers
- biomass production function - the realm of agro-ecologists and terrestrial ecologists
- carrier function for both solutes and silt - the realm of hydrochemists and geomorphologists.

The water that moves through the river basin, above and below the ground surface has all these different functions in parallel. At the same time natural freshwater functions as the biosphere, carrying pollutants to the ecosystems. All this makes water into a particularly unmanageable resource, especially as political forces are sectoral and water function (**Figure 1**). For example, in response to population growth, political forces drive ambitions to secure water supply and sanitation to the expanding population as a matter of health protection. Similar ambitions drive towards food production and supply and sanitation to the expanding population as a matter of health protection. Similar ambitious drive towards food protection and supply to avid famines, hunger and undernutrition which demands water for irrigation. Again, others try to secure income generating activities such as industrial development which depends on water for water-dependent processes. A task of similar importance, that however of the receives lower priority is to secure downstream usability of the water and the health of aquatic ecosystems, and thereby the sustainability of downstream water supply, irrigation, fishery and ecotourism.

Different types of water scarcity

The escalating food demand involves hung amounts of water to be consumed in biomass production, whether from soil moisture or irrigation. This has contributed in drawing the attention to the basic partitioning of incoming precipitation into two branches: the vertical green water branch containing the water consumed in biomass production and evaporated form land and water systems, and the semi-horizontal blue water branch passing through aquifer and rivers (3). The two branches play complementary roles: the former for rainfed water supply, industry and irrigation.

As demands flow in relation to availability, water scarcity will develop. This makes it necessary to distinguish between different types of water scarcity, in particular between natural and human-induced scarcities:

* natural scarcity for hydroclimate reasons, wherever the climate is arid so that plants easily develop water stress (green water scarcity). This scarcity is typical of regions where precipitation is lower than the evaporative demand of the atmosphere.
* technical scarcity ("use to resource ratio") where a large fraction of the available water has already been mobilized and put into social use.
* demographic water security where the population pressure on the available water is high (per capita availability low). High population pressure can be seen as a proxy for dispute proneness (many people depend on each flow unit of water passing through the landscape), as well as for pollution risk (many people pollute each flow unit of water).

The water scarcity problems of the hunger crescent of Subsaharan Africa have earlier been identified as a combination of the first and the third of these modes (4). The CSD-generated particularly low for Subsaharan Africa as will be seen below.

This paper will put the main focus on the resource perspective, in particular the tendency of regional clustering of problems. It will be shown, that - due to the complementarity of green and blue water and in view of the importance of the global food security issue - the next generation of water management has to be well integrated with land use management.

Socio-economic development and main-induced water scarcity

Five main clusters

Recent a comprehensive overview of water availability and use was presented by Shiklomanov (5), regionalizing the world into 26 different internally rather homogenous regions. **Figure 2** exposes major regional differences in terms of per-capita water with drawls (diagonal lines), demographic water scarcity (population pressure on available water, horizontal axis), and technical scarcity (use-to-resource ratio, vertical axis). By 20% on the latter scale, the costs and efforts mead for water resources management start to be large in the national economy (reservoirs, pipelines, transfers).

The 26 regions tend to concentrate into five clusters with distinct differences in terms of both water abundance/scarcity and per-capita withdrawals, the latter basically reflecting predominance of irrigation. The five clusters can be characterized as follows:

* A: dry climate region with high population pressure and high dispute proneness. Use-to-resource ratio is high in spite of moderate to low per capita withdrawals. Potential in terms of unused water is low (N Africa, W and S Asia);
* B: temperate zone regions with low to moderate population pressure. Use-to-resource ratio is high due to highly wasteful water use. Potential in terms of unused water is low (US, M Asia / Kazachstan, Caucuses);
* C: a climatically mixed regions with low water needs and therefore low use-to resource ratio. High potential in terms of unused water (S America, N Europe, N North America and C Africa);
* D: Water-rich regions with erratic precipitation and moderate population pressures. Use-to-resource ratio remains low due to lack of irrigation. Theoretically a high potential in terms of unused water but the water is difficult to mobilize, see below (dry parts of Subsaharan Africa).

Most limited in terms of degrees of freedom are regions with moderate to high technical scarcity, rapidly growing population pressure, and problems in terms of coping capability due to financing, administrative and manpower difficulties.

Combination of green and blue water scarcity

If we now enter also the natural water scarcity component into the analysis, three of these regions come out as having particularly complex water scarcity situations:

* cluster A, where the socio-economic development, against the bakground of the naturak scarcity, has generated a high level of techniccal scarcity. In fact most of the available water has already been mobilized. This means that future development will depend on ability to change their production and consumption patterns. Where population rapidly grows, food self-reliance will not be possible, but food will have to be imported from better endowed regions;
* cluster C, where socio-economical ambitions in dry climate regions have taken the form of large scale irrigation. The irrigation has however been highly inefficient as reflected in very high per-capita withdrawals of water. This means that the water needed to supply continued population growth in the two Asian regions can gave to be freed by less wasteful irrigation practices. The high

position of USA is largely related to the arid western part if the country. These the general debate demands that aquatic ecosystems be secured by the freeing water through more water-efficient agriculture.

* cluster E which is composed of the semi-arid regions of Sub-saharan Africa. Here the dominance of rainfed agriculture, the poverty and the low coping capability due to lack of professional competence and manpower is reflected in very low per-capita withdrawals. The impression given by the diagram that much water remains to be mobilized is however partly misleading: local water courses are often ephemeral and run dry during a considerable part of the water enters on the periphery (i.e. Botswana) rather than passes through the country such as is the case with the Nile through Sudan and Egypt; and ecological in situations where valuable ecosystems depend on the present river regime (e.g. Okavago delta).

Regional Vulnerability clusters

Table 1 summarizes the three dimensions of water scarcity and coping capability problems in the different clusters. Cluster B, C and D have been divided in a subgroup 1 containing the industrialized regions, and a subgroup 2 with the developing regions and regions the transition. The table suggests an overriding regional structure in the parameter combinations:

-most developing regions, whether in the temperate or tropical/subtropical zone, tend to have problems in all four senses. Some of the regions are however humid (part of S America, C Africa)

- countries in transition generally have all four problems. In the Aral sea region the demographic scarcity is however low

- the industrialized regions tend to have low demographic water stress and low coping capability problems. Some have a certain degree of technical water scarcity (C and S Europe, USA).

Biomass production and natural water scarcity

Many discussion of food security problems tend to have their main focus on sociological, economical, and political issues 86). Little attention is generally paid to the climate; it is taken or granted that climate factors are being incorporated in basic concepts such as agro-ecological zoning. Water is thought of mainly in terms of irrigation, and water scarcity mainly in terms of trough and desertification.

In parts of the world, the growth rate if the world's cereals production has not been quick enough to keep pace with the population growth. The situation is particularly problematic in Subsaharan Africa where the per capita production of food supplies has stayed around 115 kg/p yr through the 1970's and 80's as compared to the 250 kg/p yr needed (7). The author has earlier suggested that this may partly be due to natural scarcity (2). At the same time population continue to growth at high speed.

Food production constraints

Since water is one of the key building stones in plant growth, regional food security will indeed be linked to the overall water availability and the regional constraints that it may introduce as population growth. In dry climate low latitude countries, water scarcity will therefore start to act as a constraint on crop production, which in that climate often needs of the order of 3000 m3 per ton grain produced (4).

At least two fundamental conditions have to be duldilled in order to allow full crop yield (8)(**Figure 3**):

-- nutrient requirements of the crop to be satisfied by the soil water availability in the soil. Deficiencies can be remedied by fertilizer application (green manure, commercial fertilizer, cattle spillings etc.) .

-- Water requirements of the crop to be satisfied by the soil water availability. These requirements depend on evaporative demand (I.E. climate) and length of growing season (crop selection). Soil moisture is limited a) by rainfall deficiencies b) by infiltrability problems. Deficiencies in the latter can be remedied by soil conservation measures. Deficiencies in the former by adding additional water by irrigation.

When rainfall is lower than the water requirements of the plant, the result is poor crop yields. Crop water security is evidently a fundamental precondition for achieving full crop yields, and can be met by two types of water, both recharged from local rainfall (**Figure 4**):

- the soil moisture in the root zone that supports rainfed plant production (green water)
- the water in aquifers and rivers that may provide additional water introduced into the root zone by irrigation (blue water).

Local hydroclimate and hydrography in other words influences that food production potential.

Where is there water enough for semiarid food self-sufficiency?

Food self-sufficiency I dry climate region is closely linked with achieving water security for the plants. Experience shows that a 3-4-fold increase in yields can be attained already by closely linked to success in water control. There are many options for supplying additional water to the soil: besides collation of local runoff also groundwater or water from passing rivers.

An issue of fundamentally global importance is what parts of the world can be self-sufficient in food production, and what regions cannot due to sheer lack of water. The cluster diagram in Figure 2 can be used to get an approximative idea of the overall situation by comparing water availability with water needs based on a simple back-off-the-envelop-calculation.

Water requirements: FAO estimates that for a diet of 2700 cal/p yr (2300 vegetative, 400 animal based) some 1600 m3/p yr of water is needed in the root zone to allow self-sufficient food prodction. In humid climate enough water is provided from green water. In arid climate in contract all the water has to be provided by blue water (irrigation). In semi-arid climate maybe some 50% may be provided from green water, while blue water has to contribute the remaining 50%.

Irrigation has however to compete for blue water from aquifers and rivers with households and industry (at least some 200 m3/p yr if industry is fairly water-efficient, otherwise more). In the semiarid case the per capita need of water is therefore of the order of 100 m3/p yr altogether (1/2.1600+200);

Water availability: **Figure 5** illustrates the overall situation in a principal graph relating the demographic water scarcity (horizontal) to the technical water scarcity (vertical axis) be supplied under the following conditions:

withdrawal level	water availability	population pressure
	at least	lower than
100%	1000 m3/p yr	100 p per million m3/yr
50%	2000	500
20%	5000	200

The 100 m3/p yr line therefore divided the diagram in two regions: to the left of the line food self-sufficiency might be possible in semiarid regions, to the right it is not possible. Semiarid countries on the left side could reduce their water use by increasing their water use efficiency, and thereby manage a larger population. Countries on the right hand side of the lien would need to mobilize more water already to feed their current population on the targeted nutrition level. The problems would escalate when the population growths. Beyond 100 p/flow unit self-sufficiency is impossible since more than 100% of the total water availability would be needed.

Figure 5 also demonstrates the effect of population growth. When the population doubles much more water is needed to secure water fir the different social needs including irrigation. As already indicated, moving up the vertical scale means more reservoirs, canals and pipelines. In dry climates it is difficult to mobilize more than 50% due to evaporation losses from reservoirs. 100% is only possible be large scale waste water reuse, by underground storage, or where a large river passes right through a country (excluding desalination and mining of dossile aquifers).

In going back to Figure 2 conclusions may now be drawn. In all the semiarid regions to the right of the 1000 m3/p yr-line, water scarcity will act as a constraint on crop production, introducing reliance of food import. The diagram suggests that the global bread basket will be humid and subhumid regions in the left bottom corner of figure 2. It also shows - as already indicated - that certain regions use excessive amounts if water, and could free water for other purposes by increasing water use efficiency (USA, Caucuses, M Asia/Kazachstan).

Water constraints will generate large changes in global food trade

In a situation where the population is under rapid growth more water would have to be mobilized just to keep society on the actual per-capita level. In Figure 5 this means moving along the diagonal line corresponding to the respective per capita withdrawal in different regions. In addition, enough water would have to be mobilized to reach the other the mobilization level might be too high to be realistic in view of the evaporation losses from reservoirs needed to make the water available when needed. In another paper the author has shown that water constraints may be severe for a around 55% of the world population by 2025 AD (9).

If dry climate countries cannot be self-sufficient in food production the food has to be imported from elsewhere. The considerable time delays that may be expected in possible adoption of this fundamental dilemma. The considerable gap between the optimists' and the pessimists' conclusions - as analyzed be Mc Calla (10) - regarding future global food export volumes indicates a gap between a doubling of the preset export volume and a quadrupling in only 30 years.

Towards a less risky water resources future

Whenever water scarcity is a key constraint, it is urgent to look at the role of water in socio-economic development as whole. According to a recommendation from United Nations Committee on Natural Resources (11) water resources have to be entered into the socio-economic planning of a country so that the country will early enough detect fundamental constraints to development options. Wherever water is scare, a country should start to analyze its comparative advantages to guide its aspirations and future planning. Many African countries may find out that rather than aspiring at food self-sufficiency and vulnerability to crop failures during droughts or considering to import irrigation water in huge transfer projects (like the massive transfers from the Congo basin or the Zambesi basin sometimes referred to), it may be orderable to import "virtuak water " enclosed in imported food grown in regions better endowed with water than the dry climate tropics and subtropics.

Other major water problems

What we have been discussing up till now is different aspects if the water scarcity problem. The global water crisis however includes also other water problems (12): water supply and sanitation problems, water pollution problems, collapsing urban infrastructure, and water-related land fertility deterioration.

The urban scale and water supply crisis is linked to the fact that urban growth is more or less out of control in many Third World regions. The growth is exacerbated by the rural push, i.e. the poor population strata from marginal areas where it is not considered possible to make a dignified living. Municipal authorities have increasing difficulties to supply the infrastructure needed to provide safe water and sanitation. Many systems carry water only a few days per week. The water supply systems are often in bad shape, highly crashed with large-scale leakage, so that pollutants from equally cracked sewage pipes.

In spite of massive efforts to remedy the public health situation during the International Drinking Water Supply and Sanitation Decade 1981-90), large deficiencies still remain in terms of supply of safe water and sanitation to the Third World population (13). The result is high mortality due to water-related diseases. The huge size of the remaining task (**Figure 6**) makes several regions threatened by continued deficiencies - even in the medium term perspective. Sanitation development has turned out to be even more difficult to achieve. It in fact more or less came to a standstill during the 1990's. The challenge has more dimensions than just technique: public understanding cultural habit, social dimensions etc. If the coverage is to be 100 percent by 2025, there still remain 5.4 billion people to serve.

A whole set of water-related causes are contributing to an ongoing large scale land fertility degradation all over the world. Processes involved includes soil erosion, salinization and water logging from poorly managed irrigation, and acidification (14). According to FAO globally some 20-30 Mha of irrigated lands are severely affected and an additional 60-80 Mha affected to some extend by waterlogging and salinity. This degradation may make current expectations in terms of increase of crop production partly unrealistic. While agroeconomics would like to see the production in Subsaharan Africa grow by 3% per year during the period 1990 - 2010 to meet the food needs, other estimates suggest that a more probable growth rate due to the ongoing land degradation would be 0.5 % per year (7). The gap in-between may contain nothing less than huge starvation episodes.

With increasing amounts of water being withdrawn from rivers and groundwater for supply of domestic and industrial uses, the amounts of polluted return waters have tripped since 1950 (15). Wastewater treatment expands only very slowly. The result is escalating wastewater flows, originating from a whole set of sources: urban wastewater, leaching dry waste deposits and storm waters, industrial wastewaters, and pollution stemming from agricultural practices and from fallout of atmospheric pollutants. Pollutants are of two main types; soft and biodegradable microbiological pollutants, and pollutants from hard chemical containment (toxic, carcinogenic, and genetically damaging). Although factual overview is rather sporadic, it is evident from GEMS studies that surface water pollution is already widespread over the world (16). Moreover, pollutant sources from land use and poorly managed agriculture is causing widespread pollution of subsurface water (i.a. acidification, salinization, nitrate and pesticide pollution).

If some 30 liter per second are needed to dilute the waste per 1000 persons - as sometimes assumed in coarse overviews (15) - wastewater leads evidently cause problems. It is indeed quite normal that water withdrawals plus the dilution flow needed exceed the time stable flow. Judging from the regional overview by Shiklomanov (5), water quality problems might be particularly serious in the N Africa, S Asia, W Asia, M Asia/Kazakstan and Caucuses regions, where already the withdrawals themselves exceeds 30% of the availability.

Especially vulnerable regions in the 30-year perspective are those increasing population, rapid industrialization without treatment facilities, and therefore increasing pollution loads, financing, administrative and manpower problems and vulnerable ecosystems. In this perspective one might expect the quality problems to expand - beyond the regions just mentioned - to incorporate also C Europe, S Europe, S part of Former Soviet Union, and USA.

Aversion of water related threats

The long-term vision that planners and politicians basically aim at is an environmentally sustainable society with the ability to endure and flourish (17). There is no undermining of the natural resource base, i e both land and water productivity are well protected from a long-term degradation, that threatens food production, aquatic ecosystems, human nitration and biodiversity (18). Generally accepted political goals regarding human rights, poverty eradication, and socio-economic development in general have been achieved. Upstream/downstream disputes regarding water sharing and water pollution are skillfully averted. International consensus has been achieved regarding a joint code of conduct based on basic water ethics.

One key issue to be defined in order to reach desired future is how the water resources available to a country or region can contribute in generating income for the inhabitants, in other words for eradication of poverty and for securing a reasonable quality of life and economic development within the resource constraints given. Another is how food security can be achieved for that region by combining local rural production, peri-urban production based on renovated urban waste water, and import of food from better endowed regions.

Socio-economic development involves at least two water related components, both water-dependent and to be carried out in a non-undermining manner, i e by avoiding any major impacts in terms of water quality degradation: 1) industrial production; 2) cash crop production. Poverty eradication involves at least three components that are directly or indirectly water-related:

* morbidity reduction through health-protecting activities (safe water supply and sanitation)
* security in a access to food either through self-sufficient crop production, or through purchasing of food which depends on access to a secured family income
* family income which depends on employment opportunities in sustainable industrial or cash crop production, both water-dependent.

Emerging management directions

Aversion of the different water-related threats hindering poverty eradication and income generation will demand a number of challenging management efforts:

* conflict aversion: water sharing strategies and regulations, based on a universally accepted water ethics
* pollution aversion: proper management of waste (liquid and solid) and of water soluble agricultural chemicals
* aversion of land fertility degradation: integrated soil/water/nutrient management
* aversion of urban water supply collapses: development and maintenance of the urban water/sanitation infrastructure
* aversion of crop failure: either simple drought proofing technology based on rainwater harvesting or local runoff collection, or conventional but water-efficient irrigation.

It is getting more and more essential that policy makers are able to see differences between two main categories of environmental problems: on the one hand, scarcity-related resource problems which complicate development, and on the other man-driven side effect problems such as pollution, desiccation, rising or decreasing water table etc. The latter get superimposed on the former and thereby contribute in escalating the scarcity dilemma. Most of the attention of the Rio Conference was concentrated on the latter category (climate change, desertification, biodiversity degradation). This unbalance in terms of international attention towards man-made environmental problems rather than problematic environmental preconditions for human livelihoods is disturbing. It is difficult to get rid of a suspicion that advise from Northern environmental experts in Rio may have suffered from a good deal of temperate imperialism. Indeed, some of us have heard Latin American colleagues grumble about "the new Spaniards."

As shown in this paper, the amounts of water needed for food self-reliance in many dry climate regions with rapid population growth suggests that the problems involved are far from negligible. On the contrary some 55% of the world population by 2025 will be living in countries which will have great problems or not even be able to depend on their own for supply sources. There is also the additional problem that agriculture's traditional primacy in allocation is being increasingly questioned. There is therefore the possibility that agriculture will many places have to give up more and more water for higher value uses. The effects of such a shift in water allocation priority have however never been fully assessed (3).

What policies should make possible

Mismanagement of water and water-related land use will be manifested in a whole array of societal problems: health problems, food supply problems, contamination and water useability problems, economic development problems, disputes and conflicts whenever the availability is limited, and ecosystem disturbance problems. The lesson to be learnt is that water has to be addressed by a comprehensive and holistic approach, carefully avoiding the tunnel vision traps of yesterday.

What the world is still waiting for is a convention of code of conduct that addresses the scarce resource itself, in particular how to equitably share the finite and limited freshwater resource on which we all depend - more and more people every single day. since the water passing though a river basin has to be successfully used for all the different functions, water sharing has yet to be performed both locally between all the different sectors of users, and regionally in a river basin body. The local sharing has in other words to fit into the regional framework, securing a fair upstream/downstream sharing, and providing the basic conditions for what can be locally shared between competing user groups down the river. Attention has to be paid to consumptive as opposed to polluting water use. The latter uses can be part of a sequential reuse down the river valley, provided that pollution does not make downstream use impossible, whereas the former are losses as seen from the perspective of downstream users. It makes the downstreamers the prisoners of the upstreamers, who influence both downstream opportunities and problems. When the upstreamers pollute the water, it is the lifeline of the downstreamers that they pollute.

What policies need to make possible can be structured according to the four main functions discussed earlier in this chapter.

1) due regard to be taken to alternative ways to achieve food security by finding the right combination between nationally produced food and filling of deficiency gap through trade

2) rules to be developed for sharing a limited water resource and stimulating its most worthwhile use

3) policies to be developed to improve human health by introducing barriers to water-related decease vectors

4) policies to be developed to protect valued aquatic ecosystems.

The fact that water issues tend to cut deeply into world socio-economic, food security related and ecological processes makes the policy shifts and their global consequences an issue of clear relevance for the United Nations to address.

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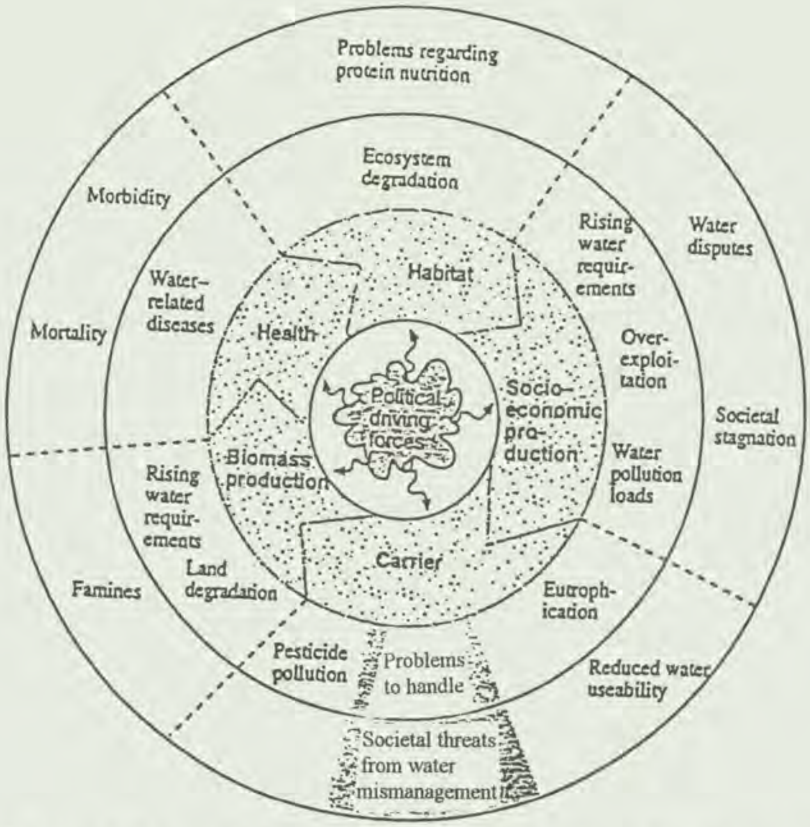

Figure 1. Problems to handle and societal threats related to water mismanagement when political driving forces act on single water functions.

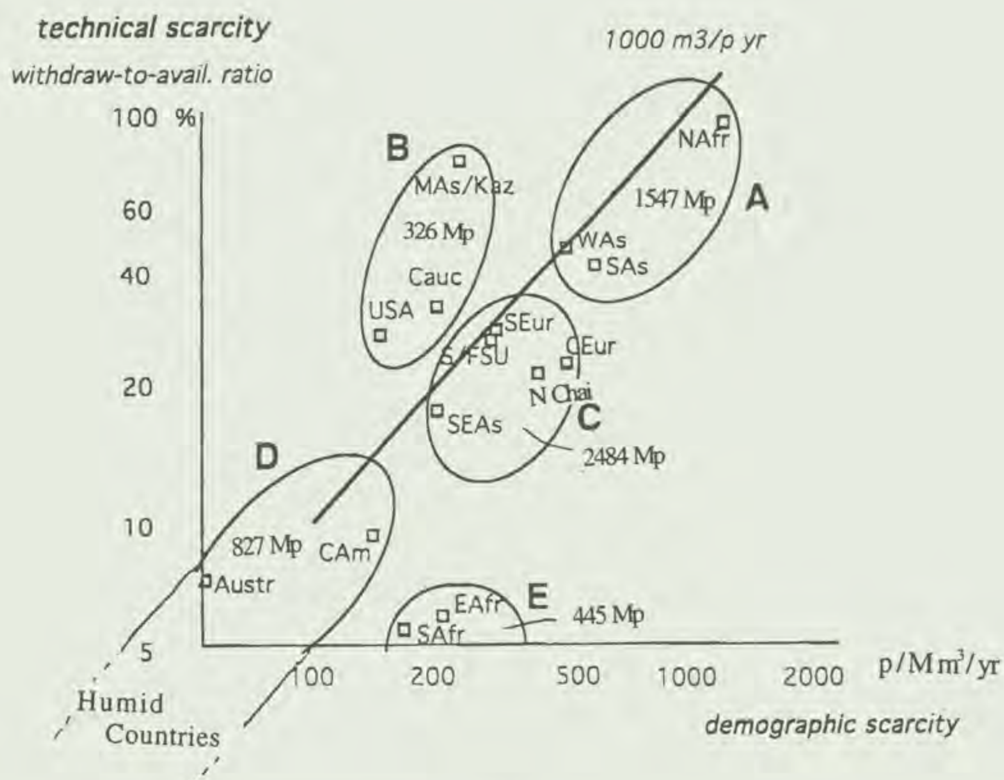

Figure 2. Global differences between regions with different characteristics in terms of demographic and technical water stress. Five different clusters are shown including the total 1994 population in each.

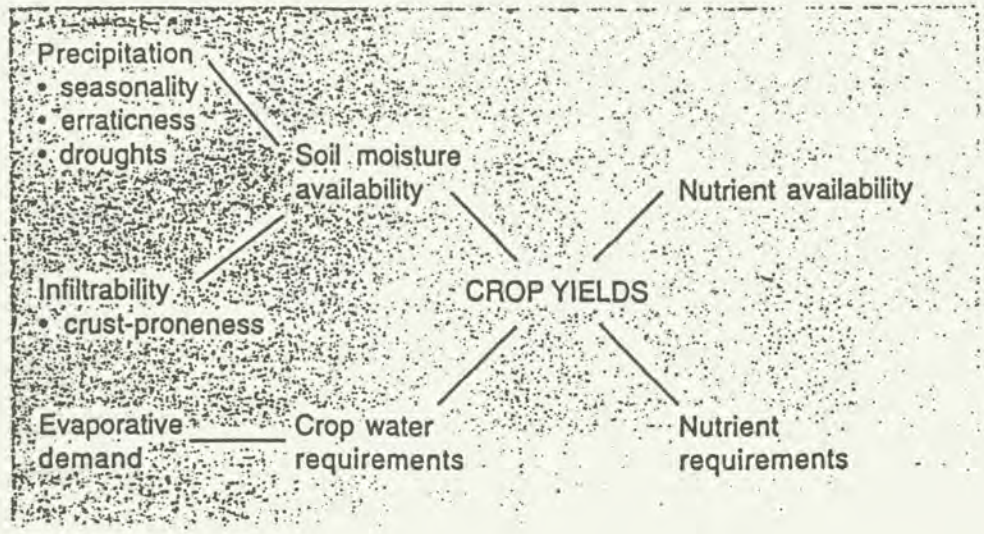

Figure 3. Two fundamental conditions have to be fulfilled to allow full crop yields.

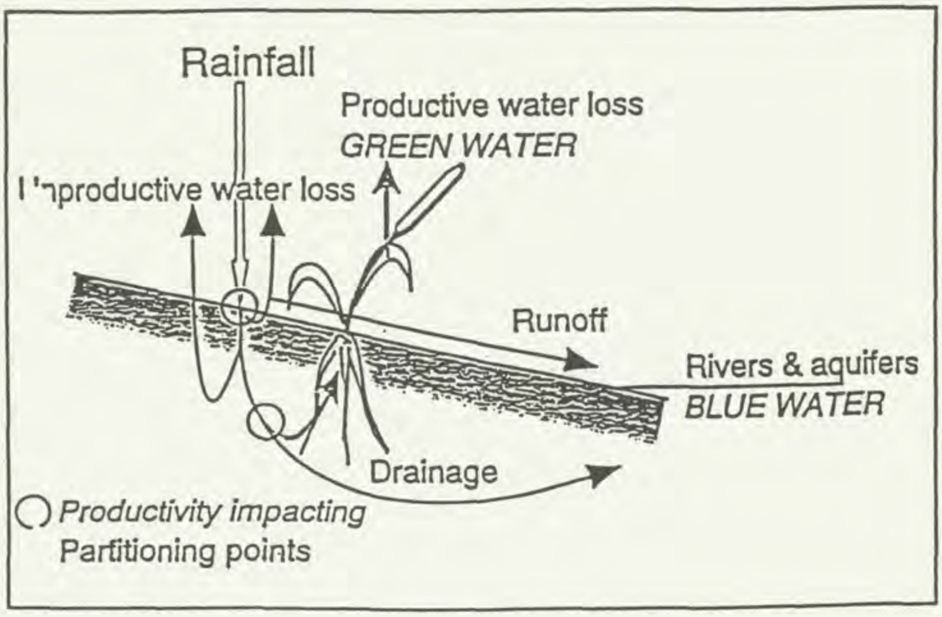

Figure 4. The partitioning of incoming precipitation at the ground surface between soil water recharge and recharge of aquifers and rivers.

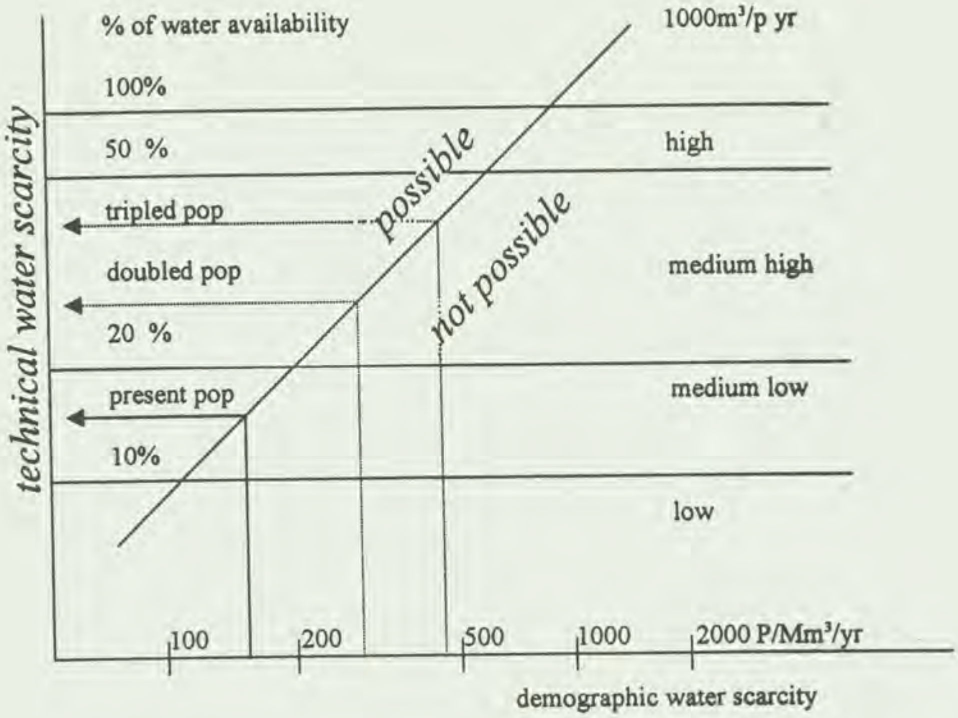

Figure 5. *Possibility of food self-reliance. Diagram shows the resulting water demand (as percent of total water availablity, vertical axis) when 1000 m3/p yr (diagonal line) is needed to support a certain population (horizontal axis, showing people per one million cubic meter of annually recharged freshwater). The dotted lines show how demand rapidly increases when population doubles and treples.*

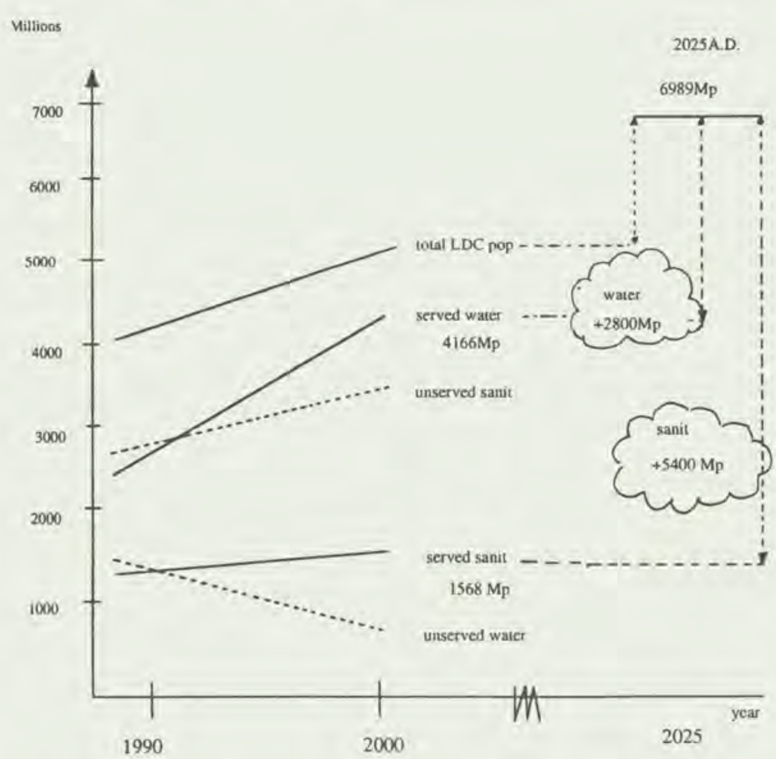

Figure 6. *Development of water supply and sanitation 1990 - 2000 and the challenges remaining up til 2025, assuming that every person should by that time be secured safe water and safe sanitation. Data from ECOSOC 1995.*

__Table 1. Main water management problems in the different clusters__

region	natural scarc	technical scarcity	demogr scarcity	coping capab problems
A	+	+	+	+
B1	-	+	-	-
B2	+	+	+	+
C1	(+)	+	-	-
C2	+	+	-	+
D1	(+)	-	-	-
D2	(+)	-	-	+
E	+	-	-	+

Legend: parenthesis indicates part of the region only

Water in the International Agenda

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Introduction

The Shiga International Forum on Water is happening at an important crossroad in human history. In a scant three years, we will be entering not only a new century but also a new millennium, which can bring mankind new opportunities, unprecedented prosperity, and vastly improved quality of life to all people from all over the world, from the North to the South, and from the East to the West. It can also bring the continuation or even acceleration of human misery. Currently some one billion people can barely obtain the equivalent of $100 per capita annually for food, shelter and clothing. Around 14% of the global population live in extreme hunger, and some 11,000 children die every day due to malnutrition and luck of clean water. The next century and the next millennium has the potential to change all these ills, provided a concerted and enlightened approach is made by the world's leaders, but it equally has the potential to increase the litany of miseries. What the future will foretell no one can forecast reliably. However, what can be forecast with total confidence is that unless and until a determined attempt is made to identify the problems, and realistic, cost-effective, and feasible solutions are put forward and implemented, progress will continue to be somehow limited. At best incremental, politically correct rhetoric may receive considerable applause at the global meetings and conference, but they are unlikely to make much dent in solving the world's problems. Jumping on the latest fashionable bandwagon is no solution: in fact it can often aggravate the problem.

The Shiga Forum, which is being held at the twilight of the present millennium, does have the potential to change the direction of the future developments in the area of water. By bringing together the leading water experts of the world, and senior representatives from the major bilateral and multilateral aid agencies, this Forum has the potential to change the nature, direction and speed of the future water developments, nationally, regionally and globally.

Water crisis

For a variety of reasons, water has not been considered to be a critical resource on a global basis. During the decades of the 70's and 80's, issues like food, energy, environment and debts of the developing countries were considered to be the most critical, and thus warranted global political attention. Water was not considered to be the most critical, and thus warranted global political attention.

Water was not considered to be a critical issue. Even during the 70's, when the drought Africa created a major human catastrophe, the global reaction was that it was primarily a problem of desertification and not of water. This thinking has continued in the 90's: the world now has a convention on desertification, but a similar global convention on water, which affects more people, is nowhere in sight.

It is our contention and firm belief that even though the world has been preoccupied with the various crises during the past 25 years, ranging from climate change to the disposal of hazardous wastes, from biodiversity to the destruction of the ozone layer, another major crisis was in the making, that on water, which has managed to miss the global attention. And yet globally, water has had more impacts on human lives and welfare during the past two decades than all of the high profile items on the international political agenda. It is now an established fact that millions of people are dying each year primarily in the developing world, due to droughts, floods and lack of clean water.

Reliable data on actual number of deaths from water-related causes are not known, because they occur almost exclusively in the developing world, and primarily among the poor. However it is now commonly accepted that such deaths now total in several millions annually. In spite of this continued problem water is basically missing from the international political agenda, and yet issues like climate change, which has not killed a single person so far, and is unlikely to do so for the next two decades, is considered to be a very high priority issue. Such anomalies are not neither easy to understand nor can be justified morally.

Water missing in the international agenda

The omission if water from the international agenda is a very important but a sad fact and one that the water profession needs to consider very carefully. While a few have glossed over this sad situation like a proverbial ostrich with its head buried in the sand, our profession can no longer ignore this condition, especially when water still accounts for millions of deaths throughout the world each year. Some, like the current "spin doctors" of the American political scene, have tried to give a good gloss to this sad state of events, but this does not make it any more acceptable or palatable.
One can legitimately ask why issues like climate change which has not killed a single person thus far anywhere in the world and is not likely to do so in the near future, has received and continues to receive extensive political and media attention. And yet, even though it can be clearly documented that millions of people are dying each year from drinking unclean water and/or drought and flood related problems, water and or drought and flood related problems, water has a very low place in the international agenda. Equally why does such glaring disparity exist, since such low priority to water is morally indefensible. The reason for this are many, and probably we can better understand this situation by objectively analysing why water was not considered to be a major issue for discussion at Rio.

Failure of the Dublin Conference

First, The International Conference on Water and the Environment (ICWE), which was convened in Dublin in January 1992 by the United Nations system, was expected to formulate sustainable water policies and action programmes for UNCED. Its timing, only four months before the Rio meeting, was ill conceived. Even if the Dublin Conference had come out with some substantive ideas and programmes, which it did not, and had also considered critical issues like how much would such programmes cost, where would the funds come from and who would implement the programmes, which again it did not, there simply was not enough time to incorporate these ideas properly and effectively into the Rio programme. Thus, not surprisingly, some 500 participants from around 60 countries unanimously expressed their disappointment during the Third Stockholm Water symposium because of the "failure of the UN System both to succinctly address the critical situation of the global water problems at the Dublin Conference, and to put water firmly in the Rio agenda"

Second, in spite of the suggestions of certain governments, especially Sweden, during the Preparatory Committee meetings for UNCED, and advice of some individuals knowledgeable on the rules and the regulations of convening UN World Conferences, the Dublin Conference was organised as a meeting of experts and not as an inter-governmental meeting. The distinction between a meeting of experts and an inter-governmental meeting is a very important one, especially in terms of the UN World Conferences, since such Conferences can only consider recommendations from inter-governmental meetings. The pattern and precedent for this was firmly established by the earlier UN World Conferences of the 1970's and 1980's. Thus, not surprisingly, certain countries strongly objected at Rio to any reference to the Dublin Conference. Accordingly, the world Dublin does not even appear anywhere in Agenda 21, including the chapter that deals with water. Nor even the so-called Dublin principles were mentioned. Even the meagre results of the Dublin Conference had no perceptible impact on the water chapter of the Agenda 21. In retrospect, in all probability, water chapter of Agenda 21 would have been similar, even if the Dublin Conference had not been convened.

Absence of water experts

Another reason as to why was not higher up in the Rio agenda was the general absence of water experts during the preparatory meetings of UNCED. These meetings were attended primarily by the bureaucrats from the environment and the foreign ministries of the countries concerned. The Western governments generally supplemented their teams with subject-matter specialists as and when they were necessary. This was generally the case in the areas where they were primarily interested, which were climate change, biodiversity and deforestation. Seldom did the Western governments strengthen their teams with water experts, since water has not been an important issue to them economically and/or socio-politically in recent times.

If the Western governments were not so interested in water, why did not the governments of developing countries make a serious attempt to put water higher up the Rio agenda? This is a valid and important question, since water is a critical issue for nearly all the developing countries, which are located in the tropics and the sub-tropics, in contrast to the industrialized countries which are invariably in temperate climates.

There are many reasons for the non-action by the developing countries to give water a higher profile at Rio. As a general rule, the Environment Ministries of the Third World jealously guarded their positions during the preparatory process of Rio vis-a-vis their other ministries. Water Ministries were generally ignored, and were seldom consulted in determining what should or could be the priority issues. To the extent they were consulted, it was to solicit their technical views on specific nitty gritty issues. Higher order issues remained unaddressed.

It would also be fair to say that the Water Ministries of developing countries were generally unaware of the importance and significance of the Rio Conference until it happened. Most thought it would be just another UN Conference, which very few, if any, would remember after 2-6 months. By the time they realized that Rio was going to be an unique event, which would have a major impact on the global development as well as on availability of investment funds for water for many years to come, it was simply too late!

A very major event like the UNCED has an unique momentum and dynamics of its own: it is very difficult to make significant changes when it is about to take place or taking place. One can safely say that many very senior water officials realized the importance of the Rio and the Agenda 21, and also how they were going to affect their ministries and work programmes, only after UNCED was over. By this time of course, it was simply too late to make any changes; they had already missed the main boat!

It was not thus by any plan or design that water did not have a higher priority at Rio. The UN system had banked on the Dublin Conference to make the difference. The failure of the Dublin Conference, the absence of any fall back strategy in the event of a failure, and the very poor timing of ICWE which left only4 months between the two events in Dublin and Rio, were all important contributory reasons which did not strengthen the cause of water at Rio.

In addition, the benign neglect of the water issues by the West, and the non-realisation of the importance of the UNCED by the water ministries of the South, ensured that water remained a minor item in the international political agenda. It was an issue that could perhaps be discussed under the item "Any other business" of a normal agenda!

Clearly we have now missed the boat. At present we do not see any other boat on the horizon which could take us where we want to go. If water should be a priority item in the international agenda (Biswas, 1993), we have to build our own boat! The issue no longer is whether we should build our own boat, since no sane person is likely to question this necessity, but rather the process by which this boat should be built to ensure it take us where we want to go. We simply cannot afford another failure. History will not forgive us if we fail again.

However, before what could be the process is discussed, it would be desirable to outline the differing North-South perspectives on water, the importance of which many people have failed to appreciate.

North-South perspectives on water

From the perspective of the South, throughout history, water has always been considered to be a mandatory requirement for development , certainly at a much higher level of awareness than in the North. At present no responsible government in the South is likely to consider its development policy or strategy to be complete unless it specifically considers the water sector, in terms of its use and availability for domestic and industrial production, hydropower generation, and environmental requirements. A similar level of interest generally does not exist in the North, where water is mostly taken for granted, expect during periods of prolonged droughts of floods. These differing levels of interest can be highlighted by the following important but fundamental differences between the developing countries so far as water is concerned.

· nearly all nations in the South have a Ministry of Water Resources of Ministry of Irrigation, whereas the vast majority of countries in the North do not have such a full fledged ministry;

· nearly all developing countries have a national plan for water or are in the process of preparing one, whereas a national master plan for any country in the North is an exception rather than the rule;

· water quality and not quantity is the predominant water issue of the North, whereas in the South water quality continues to be the major concern;

· a major critical issues of the South is how to provide enough clean water to its rapidly burgeoning megacities during the coming decades. Water riots have already been observed in a few megacities of the developing world. Such riots could occur with increasing frequency in the future, unless water supply for the population, both rich and poor, can be assured. Water availability for megacities of the North is unlikely to be a serious problem in the future;

· a prolonged drought can markedly reduce the productivities of individual developing countries, can significantly contribute to the reduction of per capita food availability, and often is a direct cause of famine. Such droughts could cause numerous deaths of humans and livestock, and contribute to untold suffering. Implementation of national development plans fall behind expectations. In contrast, the economies of developed countries are more resilient, famine has been basically unknown during recent decades, and people in any affected region for the most part promptly forget the occurrence of the drought as soon as it is over. While prolonged drought is a matter of life and death in most countries of the South, it is a mere "temporary inconvenience" to the countries of the North.

The difference between the perspectives of the North and South on the adequate availability of water can be graphically illustrated by the recent well publicized report Our Common Future by the Brundtland Commission. The report which has now been severely criticized by the water professionals for its "water blindness" is remarkable for its total omission of water issues: these did not merit even a cursory treatment (Biswas, 1992a).

Concluding remarks

Water has always been considered to be a vital ingredient for sustainable development of the South in the past, and all the current trends indicate that it will continue to remain a critical resource for the foreseeable future. With the steadily increasing population, and more and more people reaching higher standards of living, water demands in these regions will increase significantly in the coming decades. Due to economic, environmental and political reasons, it is highly unlikely that the present approach of continually expanding supply to meet increasingly higher water requirements would continue to be a realistic solution. Various approaches to demand management need to be seriously considered in the near future, but it should be realised that it would not be an easy process to implement certain policies, like water pricing, due to existing socio-political and institutional constraints.

It should be realised that the interests of developed and developing countries are different at present, at least in terms of priority that should be accorded to water in the international political agenda. For developing countries, water is a critical issue, but for developed countries, it is not so important. The Dublin Conference on Water and the Environment failed to put water higher up the political agenda at the UN Conference on Environment and Development at Rio de Janeiro in 1992, where water attracted very little attention. Considering millions of people are dying in the developing world every year due to lack of clean water, and flood-and-drought related causes, it is essential that both the developing world and the water profession make a concerted attempt to put water higher up in the international political agenda.

The water management profession is now facing a problem, the magnitude and complexity of which no earlier generation has had to face. In the run-up to the 21st century, our profession really has two choices: to carry on as before with a "business as usual" attitude that tries to solve future complex problems on the basis of experiences from simpler problems of the past, or continue in earnest an accelerated forward looking effort to identify the real problems of the future and face the challenges squarely by implementing workable solutions within the short time frame available to us. We really have very little time to change our mind set and make this tremendously difficult transition possible. We no longer have any soft options left: only hard choices.

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100 Years of River Modernization in Japan
Quantitative Water Management in Japan

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It was in 1896 that Japan, which embarked on a journey toward the establishment of a modern state with the Meiji Restoration in 1868, started river management projects, especially flood control projects, on a full scale. Building of water supply systems and sewage systems was started early in the 20th century and their full-scale construction started nationwide in 1950 and 1960, respectively. With the advancement in civil engineering technology, flood control projects were successfully carried out, and water resource development was actively pursued after 1960. It goes without saying that there have been great progress and prevalence in each field. This paper introduces the phenomena unique to Japan which have resulted from the rapid modernization and economic growth unparalleled in the history of the world, for the benefit of other countries, especially those developing countries which have great potential for further economic development.

Mega Flood Control Projects Started Based on the Former River Act

In 1889 the Constitution of Imperial Japan was put into effect, which means Japan was finally being modernized in terms of institutions. The Tokaido line started operation between Shimbashi and Kobe in July, 1889 as a sign of steady advance in the use of railways. The former river act was officially announced on April 8, 1896. Reparations from the Ching dynasty in China after Japan's victory in the Sino-Japanese War of 1894-1895 strengthened the financial base of Japan, and an increase in river improvement budget was expected. On the other hand, a series of great floods experienced all over Japan in early 1880s through 1890s raised public outcry for flood control measures, and triggered heated discussions on flood fighting. The heightened public awareness prompted the government to promulgate the River Act referred to above as it started drastic flood control projects. Flood protection works were gradually started at the initiative of the Home Ministry for key rivers based on the River Act. As river-related acts, the Sabo Act and the Forest Conservation Act were officially announced in 1897. These two acts plus the River Act are generally known as three acts concerning anti-erosion and anti-flood measures.

In 1896, the Yodo River and the Chikugo River were placed under the direct control of the Home Ministry, followed by the Tone River, the Sho River and the Kuzuryu River in 1900, the Onga River in 1906, the Shinano River, the Yoshino River and the Takahashi River in 1907; and the Watarase River in 1910. In order to enlarge cross-section of these rivers once and for all, large-scale flood control works were conducted, including widening of river width, building of high continuous embankments, and excavation of river beds. These works were all completed in the 1910s through early

1920s. Such mega flood control projects were implemented based on a policy of quickly concentrating great floods into river channels and push damaging flood water out onto the sea as soon as possible. This explains why continuous high embankments were built. In the preceding days, river embankments had not been so high or rivers had had no embankments at all in some areas in Japan.

These flood control projects were a bold, unrivaled scheme never tried in Asia's Monsoon areas which are characterized by extraordinary heavy rain and floods. Peoples in the monsoon areas had historically stuck to residential patterns and farming methods based on the assumption of floods and overflows without the slightest idea of concentrating flood water into river channels. In southeast Asian nations in particular, wet and dry seasons take turns regularly in such a visible manner that peoples could easily adopted their lifestyle in accordance with regular floods and overflows. Piloti style houses, and floating rice which extends its stem with the rising water level, found in agricultural areas in these countries are typical examples of their adaptation. In our country also, people effectively adapted themselves to the nature to control floods in alluvial low land frequently hit by floods, in many cases building refuge houses, and growing such agricultural products in low land along the river as have high resistance against floods.

With the promulgation of the River Act, however, the Meiji Government implemented flood control strategies of concentrating even great floods into river channels for one key river after another with firm determination. At the close of Tone River improvement work in 1930, Hidekichi Sanada, Director of the Tokyo Civil Engineering Office of the Home Ministry, emotionally described as shown below on the monument erected at Sekiyado which was located at the point where the Edo River separates from the Tone River. He could hardly hide his joy of having completed the big project of the century.

It is more than 50 years since the first trial of mattress works in 1875 until completion of river improvement in 1930. We believe this river improvement works, one of the most difficult tasks ever attempted, was the largest flood control project in the Meiji, Taisho and Showa eras under the reign of three emperors, in terms of scale and the volume of work involved. It bears comparison with any projects. Most parts of the Kanto Plain will be free from floods for a long time to come, and people will be relieved of worry about disasters and industries will further develop.

The flood control projects including the Watarase River, a branch, during the thirty-year period between 1900 and 1930 ranks among the largest in Japan's civil engineering projects since the Meiji era. What is more important is, however, that such a big flood control project as executed on the Tone River was implemented for all the key rivers in Japan during the same timeframe.

The effects of these mega projects were remarkable. Frequency of inundations in alluvial low land where inundations due to floods had occurred often on a wide area lowered dramatically, security level increased for these areas, rice production increased under stable conditions, and cities became safer. These improvements provided invisible support for Japan's development in the first half of the 20th century. Thus the large investment made in flood control since the middle of the Meiji era seems to have produced adequate results.

Difficulties in the Great Flood Disaster Period after the World War II

Only five years after the completion of the Tone River large flood control project described above, a big flood hit Japan unexpectedly. On September 26, 1935, a typhoon and a front caused the flood level to rise in Kurihashi and Sahara one meter above the highest level experienced up to that time which was recorded in the 1910 flood. In Sahara, the flood water was only 40 cm below the point of breaking the embankment. In the wake of this flood, the Tone River flood control plan was forced to be modified substantially into an River Enhancement Plan which included a floodway to Tokyo Bay. Then one flood struck after another in 1938 and in 1941. In retrospect, the series of big floods was only a prelude to Kathleen Typhoon which caused a big flood resulting in the breaking of the Kurihashi embankment.

The World War II and the confusion following the defeat in the war not only prevented the implementation of the Tone River Enhancement Plan from being continued but also made continuation of maintenance works impossible. Unfortunately, while flood control measures remained unimplemented for every river in Japan as well as for the Tone River, a series of big typhoons and late-rainy season heavy rains hit the nation left in ruins in the wake of the defeat in the war, from late 1940s to late 1950s. Serious flood disasters occurred almost every year during this period, claiming more than 1,000 lives per year. At that time Japan was known for her severe flood damages. Control of flood disasters was said to be the key to Japan's post-war reconstruction.

The 15 years between 1945, the year the war ended, when Typhoon Makurazaki seriously damaged the western part of Japan in September, and 1959 when the Typhoon Ise Bay struck in September was the worst period in the history of flood disasters in Japan as shown in Figure 1. The reasons for such disasters are, as described above, a series of unprecedentedly large-scale typhoons and late-rainy-season torrential rains, and stagnating flood control projects during and after the war. But changes in runoff mechanism in key river basins and channels are considered responsible as well. Table 2 shows the large flood discharge and design flood discharge in major floods in the Tone River for the past 100 years. It reveals how peak flow increased after every great flood and how flood control plans expanded in steps accordingly. Such increases in the size of floods and the scope of plans are not limited to the Tone River. On almost all the key rivers the trends are somewhat similar to that for the Tone River. Each river experienced the highest flood flow in great floods in or after 1945. (Refer to Table 3)

The changes in runoff mechanism at the time of flood were brought about by drastic changes in land use caused by active development of river basins, and by flood control projects focused on the building of continuous high embankments. It is true that heavy rainfall in the river basin was successfully concentrated into channels in an urgent manner for pouring into the sea, but the same amount of heavy rain in the river basin as in the past caused larger flood flow midstream and downstream.

Technical activities taken toward rivers are essentially not easy as rivers are a part of the nature. Technical activities by human beings toward rivers and river basins, which are regarded as an organism, are different from constructing individual structures or facilities. Even if immediate objectives are met, side effects which cannot be fully expected occur inevitably. For example, the Okozu Diversion Channel which was constructed in the 1910s through mid-1920s to divert the flood flow from the Shinano River eradicated great floods which had often hit the Niigata Plains, greatly contributing to rice production and better life for the people in this area. On the other hand, the diversion work was a remote cause of the erosion of the Niigata beach, which made it necessary to invest a large amount of money in coastal conservation. This, however, leads nobody to believe that the construction of the Okozu Diversion Channel was a failure.

During the post-war 15-year period of successive great floods, new flood control plans were drawn up for each of the ten big rivers, which included the building of multi-purpose dams as a new addition to the existing river improvement measures. One of the purposes was flood control. Following the passage in the Diet of the bills for Promotion of Electric Power Development and for the establishment of the Electric Power Development Company, construction of dams exclusively for hydroelectric power development was pursued as a national policy. Hydroelectric power development was positioned as the key to Japan's industrial recovery as the rapidly developing dam technology at the time and abundant water resources available in Japan attracted much attention. Being in the limelight as one of the initial stars in hydroelectric power development was the Sakuma Dam which was completed on the Tenryu River in 1956. The large dam, the first in Japan to be as high as 150 m, was an epoch-making structure at that point in time, having a hydroelectric power plant generating 350,000 kW. In addition, use of large civil engineering machinery which was imported from the United States and made great contributions to the building of the dam triggered drastic changes in subsequent large-scale civil engineering projects in Japan, which then provided for rapid preparation of social infrastructures as a basis for the high economic growth from mid-1950s through mid-1960s. Electric power generation dams and multi-purpose dams were built smoothly, supported by advancements in dam-related design and theories as well as in construction techniques. The types also ranged widely from gravity dams to arch dams and to rockfill dams. The age of high economic growth was at the same time the age of dam construction boom.

NEW EXPERIENCE IN THE AGE OF HIGH ECONOMIC GROWTH

The high economic growth age after riding out difficulties in the age of successive great floods brought other challenges to rivers, namely water shortage and new types of flood disasters in urban areas. The high economic growth which amazed the world was realized through rapid changes in industrial structures, movement of capable workers from rural areas to big cities, development and business application of new technologies in various fields, efficient development of waterfront industrial areas, etc. These changes naturally accompanied sudden increases in demand for water, which was symbolized in the water shortage in Tokyo during the summer of 1964. Big cities and industrial districts with swelling population had an urgent need to secure water resources. The Water Resources Development Promotion Act and the Water Resources Development Public Corporation Act were put into effect in 1961 to meet the need of the times. Specific water resource development projects, generally taking a large amount of time, were not implemented in time for making up for Tokyo's water shortage in 1964. Progress in water resource development since mid-1960s, however, has helped to avoid nationwide water shortage as witnessed in the high economic growth age although water was sometimes in short supply in such places as Fukuoka in Kyushu and Takamatsu in Shikoku Island.

During the half-century period since the end of World War II, some 1,500 multi-purpose and power generation dams were built for flood control, water resource development and water power development. They have almost solved the problem of water shortage. That is, river development centered on dams was the key to water resource development. In recent years, however, additional difficult problems are involved in dam construction owing to availability of few locations suited for construction, increases in construction costs resulting from increased compensation and environmental protection expenses, and obligation to maintain harmony with the environment.

Future measures related to water resources still include water resource development through dam construction for some time to come, but they should be flexible and respond to characteristics of each area in diverse ways such as creation of the society oriented toward recycling through use of sewage water, shared water use including review of water rights, utilization of rainfall, desalination of sea water on remote islands. Thus Japan's quantitative water management is entering a new phase.

During the period of high economic growth, building of infrastructures lagged behind the concentration of people into cities, resulting in a lot of urban problems. New types of flood disasters unique to cities as well as water shortages are typical examples. Urbanization completely changes hydrologic cycle in the area. Use of farm land for housing, pavement and building of sewage systems result in less rainfall filtration, and surface runoff of heavy rains rushes to sewerage, and rivers in cities can no longer accommodate water, causing easy breakup of embankments. The first example of such flood disaster unique to cities was submersion of newly-developed housing areas in Tokyo's uptown at the time of the Typhoon Kano River in 1958. Every subsequent downpour in uptown Tokyo brought about inundation in wider areas as if it were following the wave of housing development. New types of flood in cities first witnessed in Tokyo's uptown prevailed to one city after another nationwide where population was rapidly growing. In short, energetic urbanization as a driving force for high economic growth lead to drastic changes in land use in river basins and in hydrologic cycle, and to frequent flooding in cities.

The cause-and-effect relation between urbanization and urban flood disasters is similar to that between development of key river basins and subsequent floods through changes in hydrological cycle since the 1880s although to a different extent. Changes in water cycle similar to those which had took place on major rivers including the Tone River for decades occurred again during the high economic growth period in river basins of smaller rivers for a period of some ten years. Development of river basins and promotion of flood control projects remarkably changed water cycle and water flow under normal conditions particularly in Japanese rivers to varying degrees and for different lengths of time. Urbanization is a global phenomenon in the post-World War II period. In the Asian monsoon area where Japan is located, paddy fields capable of storing water are changed into housing sites, further increasing flood flow in rivers running through cities.

River basin development and energetic flood control projects, backbones of rapid modernization since the Meiji era, and drastic urbanization in the post-World War II days greatly changed hydrological regime, serving as a key factor in frequent floods.

In view of the fact that urban floods are caused by sudden changes in land use in river basins, traditional river improvement measures are obviously insufficient. The River Council presented "Comprehensive Flood Control Measures" in 1977. They were referred to as "comprehensive" because they were aimed not only at flood control of channels but at controlling heavy rains in the entire basins. Specifically, as much as surface runoff is kept in river basins by temporarily storing heavy rains in, or making them infiltrate into parks, school grounds, or sports fields, in order to reduce water rushing to sewerage or channels. The comprehensive flood control, though oriented toward city rivers only, was the first step in changes in Construction Ministry's flood control policies. Basically, flood control concept should be comprehensive regardless of times and places. Floods cannot be controlled only by means of artificially fixed channels. In the fields of learning and administration, specialization has increased efficiency, making it possible to come close to the highest level. However, in river administration as part of national land administration which, by nature, should cover all the related aspects, administrative actions for flood control for entire river basins are demanded in response to rapid changes in national land use resulting from extraordinarily hectic urbanization. Suggestions for comprehensive flood control measures may be regarded by some as first aid. But they reflected the right path flood control measures should take.

Promotion of measures against huge flood exceeding design discharge in 1987 was another advancement in flood control. Under Japan's flood control policies, probable flood levels have been specified according to the importance of the river, and design flood discharge for particularly important rivers is set at 200-year probable flood level. Today the flood safety target is considerably high as compared with the highest probable flood level of 100 years set in the past. It also means, however, that administrative authorities cannot assume responsibility for floods exceeding that level. Since immediately following the nationwide flood damage caused by Baiu-front in 1972, an increasing number of victims have been filing suit against river administrators. In such flood-disaster-related lawsuits, whether the flood water exceeds the design flood discharge or not servers as a key deciding factor.

The River Council presented measures for controlling such a huge flood in the submitted report in an attempt to take some actions even against such damage for which no specific actions had been taken. This is because it is such flood as exceeding design flood that causes grave flood damage. It is assumed that the Council made the recommendation based on the recognition of the need to take actions even against such damage. One of the specific measures is what we call "super-embankments" which have been being built on many rivers. With this type of banks, levee crown is widened and the width of embankments made several times as large as for regular embankments once and for all. "Super-embankments" not only increase safety from flood but also help to proceed with urban renewal on the widened levee crown along city rivers like the Sumida River in Tokyo. Even where the river does not run through the central part of the city, diverse development projects are going on centering around "super-embankments", which suggests river projects should basically be implemented from a comprehensive viewpoint. Historic projects such as building of Shingen embankments by Takeda Shingen on the Kamanashi River and of Taiko embankments by Toyotomi Hideyoshi on the Yodo River in the 16th century are highly appreciated as they were of comprehensive nature. Under the democratic system where no dictatorial policies are permitted, administrative actions for rivers through integration of administrative policies are strongly demanded.

TOWARD RIVER IMPROVEMENT IN THE 21ST CENTURY FOCUSED ON RIVER ENVIRONMENT

Since late 1980s, partly through reconsideration of general loss of interest in rivers, there has been growing interest in river environments and renewed recognition of rivers as something which should make people comfortable. Loss of importance of navigation resulting from wide use of railway systems since the Meiji era, and elimination of fears about rivers realized through promotion of flood control measures caused people to pay less attention to and lose interest in rivers. Rapid development of road transportation in the post-war period, deterioration of river water quality and building of high embankments towering straight also helped to cause people to lose interest in rivers.

Along the Sumida River like other riversides, high embankments were constructed to fend off flood tide the size of that caused by the Typhoon Ise Bay , which prevented the river surface from being viewed by the people taking a walk along the river. The structures invited unfavorable general response. Today, however, "super-embankments" have been completed for some 20% of the river length and terrace revetments built, making riverside walking possible. The new tall buildings on the bank stand facing the river. River control projects not only aimed for coping with floods and droughts but emphasizing usual relation between the river and the public have been gradually making progress since the 1980s. Water quality in the Sumida River and many other urban rivers has improved over the high economic growth days. People are thus rediscovering interest in rivers.

Since late 1970s much attention has been paid to the aesthetic aspect of the river, and riversides, embankments and revetments have been prepared so that people can have an easy access to them. The trend has gradually prevailed to rivers all over the country in the 1980s. What is really important to the relation between man and the river is, however, conservation of the river in such a way as the river can perform its natural functions as part of the nature, not giving it a face-lift on revetments, etc. This, in turn, depends on the preservation of an ecosystem on the river. In the vanguard in such a move is the ecological revetment completed through stone masonry on the Ichinosaka River in the city of Yamaguchi in 1972, where mugworts and willows were planted in the flood channel, and fireflies returned (the bank protection works is also known as the fireflies revetment works). This case was followed by various cases of works nationwide which took ecosystem into consideration .

In 1991 the Construction Ministry decided to start the creation of naturally diversity river improvement works all over the country, which pay due attention to favorable condition for the growth of living creatures, and provide for the conservation and creation of beautiful natural views. Then in 1995 the River Council submitted a report on "How the future river environments should be like", presenting three basic items for conservation and creation of river environments, namely, 1) securing diverse natural habitats, 2) securing healthy hydrological cycle, and 3) reconstructing river-community relations. The Council made a report again in 1996 on the basic direction of river-related policies toward 21st century's society, in which the Council in the 100th year since the promulgation of the former River Act looked back on the 100 years of modern flood control measures, listed current challenges in river development, and reflected on rivers in the society in the 21st century. The four basic items included in the report are 1) emphasis on the viewpoint from the river basin, 2) emphasis on ties with the community, 3) focus on diverse aspects of the river not only at the time of flood or drought but all year round, and 4) grasping of diverse needs of residents, publicizing and provision of information, and sharing of well-structured information systems.

TOWARD THE NEW ERA BASED ON THE REFLECTION ON THE PAST 100 YEARS

The 100-year path of river modernization since the introduction of the former River Act has been extremely hectic with lots of twists and turns like the history of our country filled with changes. Big flood control projects bravely implemented to conquer devastating great floods reached a certain stage in the 1920s, a little over 30 years after the start, producing remarkable results. Natural response to such flood projects, however, seem to have begun in mid-1930s. A series of great floods that hit Japanese rivers during the post-war period of some 15 years in addition to the ruins left in the wake of World War II prevented Japan from reconstructing herself.

It became urgently necessary to develop water resources to meet increasing demand for water resulting from urbanization as well as to promote disaster restoration and flood control projects. The new types of urban floods and water shortages experienced in the high economic growth days were finally being conquered through countermeasures around the 1970s, when a new wave of anti-dam-construction movements and flood-related lawsuit hit the country. Consequently, river projects were faced with new challenges such as how to proceed with dialogs with residents and, as a prerequisite, how to provide relevant information.

Worsening pollution nationwide developed into more extensive environmental problems. Public works which includes river improvement projects now has more complicated and more serious impacts on the environment with an increase in its scale, which together with diversification of people's values causes river projects to be faced with difficult problems which have never been experienced before. As for river control projects such as flood control and water resources development, plans should be established based on a new philosophy rather than considering how to select what planning methods or construction methods. River administrative authorities made several attempts since the comprehensive flood control measures in 1977. Rapid social changes and globalization of environmental problems are forcing the authorities to take another turn. The optimum river environment suggested by the River Council in 1995 and the direction toward the 21st century in river-related policies presented in 1996 are regarded as the latest policies. River development projects which used to focus on flood control or specialize in flood control and water resource development now needs to have closer ties with the community, while seeking the optimum environment.

Not only 100 years of river modernization but also successive difficulties experienced during the half-century period following the end of World War II are closely related with rapid growth of Japan during the same period, a rare event in the history of the world. The author hopes the history of water in Japan will be of some help to developing countries proceeding with their modernization, particularly to those in the Asian monsoon area, in their water management. The systems and techniques implemented for rivers during the 100-year period certainly yielded lots of results, but it may also be true that they lead the Japanese to lose their subtle way of looking at the nature. The Japanese used to be good at dealing with rivers as illustrated in the scenery created by river works up to late 1860s. Pictures of riversides drawn by painters and descriptions of rivers and watercourse made by foreigners during their travel in the 19th century also attest to that. We should remember our traditional view of the nature and resume our relation with rivers and water.

Table 1 Major Events in 100 Years of River Modernization

1896	Former River Act promulgated. Modern flood control started on the Yodo River and the Chikugo River.
1900	Modern flood control started on the Tone River and other rivers.
1910	Great flood disasters on the Tone River and other rivers. First-phase flood control plans.
1930	Improvements completed for the Tone River and the Yodo River.
1931	The Shinano River/Okozu Diversion Channel completed.
1934	The Typhoon Muroto (great flood disasters in Kansai and Shikoku areas).
1935	Great water disaster on the Tone River.
1938	Baiu front-caused heavy rains (great water disasters in Rokko and Kobe areas).
1940	River water management projects started.
1945	The Typhoon Makurazaki (great flood disasters in western part of Japan). World War II ended.
1947	Kathleen Typhoon (great floods on the Tone River and the Kitakami River).
1949	River improvements plans for 10 major rivers drawn up by the Flood Control Investigation Council.
1950	Jane Typhoon (storm surge in Osaka Bay).
1951	Comprehensive river development projects started.
1952	Two acts concerning hydroelectric power development promulgated.
1953	Baiu-front-caused heavy rains (great flood disasters in the North-Kyusu area and the Kii peninsula.
1954	The Typhoon Toya-maru (An Aomori-Hakodate ferryboat sank. Wind and flood damage in Hokkaido).
1958	The Typhoon Kano River (great flood disasters on the Izu peninsula, and in Tokyo and Yokohama).
1959	The Typhoon Ise Bay (nationwide great flood disasters including the Ise Bay area)
1960	Emergency measures act for flood control and debris control in the mountain area put into effect.
1961	Two acts concerning water resources put into effect. The Typhoon Second Muroto.
1964	New river law promulgated. Water shortage in Tokyo.
1972	Baiu-front-caused heavy rains devastated the whole country. Water disaster-related suits started increasing.
1974	Embankments of the Tama River broken.
1975	Embankments of the Ishikari River broken.
1976	Typhoon No. 17. Embankments of the Nagara River broken.
1977	Implementation of comprehensive flood control measures started.
1987	Development into measures against huge flood exceeding design discharge.
1991	Naturally diversity river works started.
1995	Emphasis shifted toward river environments.
1996	Basic direction of river-related policies toward the 21st century presented.

Table 2 Changes in Large Flood Discharge and Design Flood Discharge in the Tone River (Yatta-jima)

Large flood discharge	Year flood occurred	Design flood discharge	Year design discharge established
3750	1896	3750	1900
7000	1910	5570	1910
10000	1935	10000	1939
17000	1947	17000	1949
		22000	1980

Table 3 Largest Flood Discharge Experienced and Design Flood Discharge at the Time

	Measured at	Largest flood discharge experienced	Experienced on	Design flood discharge at the time	Year design discharge established
Ishikari River	Grand Ishikari Bridge	12,060	Aug. 6, 1981	9300	1965
Kitakami River	Kozenji	7,900	Sept. 16, 1947	5600	1941
Tone River	Yattajima	17,000	Sept. 16, 1947	10000	1939
Kano River	Ohito	4,069	Sept. 26, 1958	1700	1953
Nagara River	Chusetsu	6,713	Aug. 13, 1960	4500	1949
Yodo River	Hirakata	7,800	Sept. 25, 1953	6950	1937
Gono River	Ozekiyama	6,740	Jul. 12, 1972	5800	1966
Chikugo River	Senoshita	10,700	Aug. 13, 1960	5500 (7000)	1949

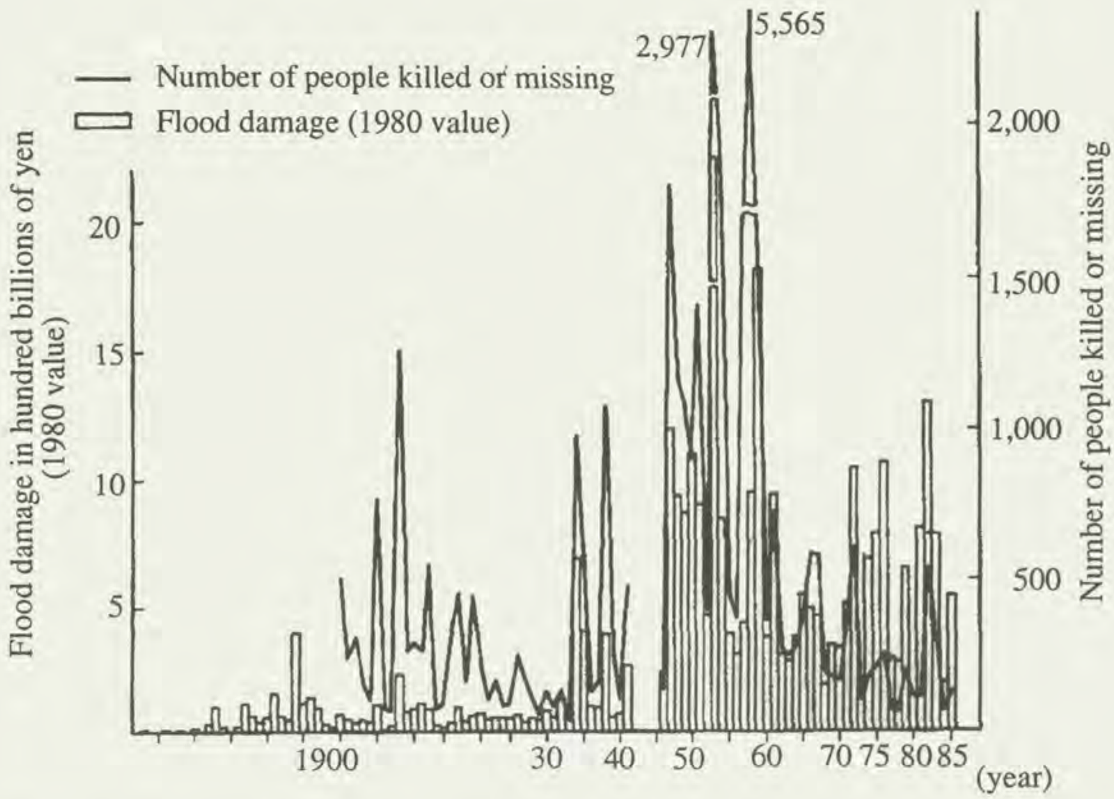

Figure 1 Changes in flood damage (1980 value) and the number of people killed or missing since the Meiji era (from 1985 edition of the "Flood Statistics"

Water Quality Management In Japan

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KEY WORDS
Metabolism of water, Crisis of modern water and wastewater works,
Multi-component water supply system, Water pollution and shortage.

In this modern society, great amounts of food, water and fuel flow into human dwelling from other environment and waste as discarded to the outer environment again. Among those metabolic substances for cries water is used in the largest amount. The modern period makes easy use of many metabolic substances with the help of fossil fuels with large scale system being supported by rapid bulk transportation systems.

The modern period based upon the bulk transportation and large scale simple production way is about to be ended by environmental restrictions. Water and sewage works are typical urban metabolic system with simple but large scale structure. The consumption of water by human beings who occupy 25% of the total mass of animals inevitably put large impact on natural water environment. Shortage of water and heavy pollution have occurred all over urban areas. In addition to this, micro pollution by various synthetic organic chemicals can have fatal consequences for safe drinking water supply being maintained by the simple monomeric modern water works system. All water systems are in crisis.

In the coming post modern society new water metabolic system to support various water demands with appropriate quality and quantity by an optimal use of water resource and technology under severe restriction of energy consumption and environmental protection are required. Design and construction of urban water metabolic system which is based upon an essential use of potential quality should be performed by appropriate use of water collection and discharge area on a basin with cascaded use of water and the least amount of reuse (recycling) of once used water.

To extend the useful life of modern water and wastewater systems, advanced water and wastewater treatment have been introduced into the conventional bulk transportation system. This inevitably, has increase energy consumption and cost but not fully eliminate the risk caused by recent deterioration of water quality, especially that caused by synthetic organic chemicals.

To escape from the above mentioned difficulties and to match the new environmental conditions, multi-quality water supply and discharge system with appropriate water quality and restricted volume for each use are needs in the post modern aquatic metabolic system. For this kind of aquatic metabolic system, a so called dual water supply system which introduces low quality recycling supply to meet nonpotable water demand, has been proposed. Many Japanese metropolitan areas recycled treated sewage for flesh toilet is used. The ratio of recycled water use to the clean water is at most only about 1/5. Hence, the problem of balancing the demand for water quality and quantity to maintain the urban metabolism with aquatic environment is not solved essentially.

The author has proposed a separate heigh quality drinking water supply which can supply about 20-30% of whole urban demand from clean water resource (Tambo 1983). The remaining 70-80% us nonpotable demand and possible to supply from downstream river sources and shortages. Conventional water supply may be used for nonpotable purpose when its quality is in doubt. The unpolluted upstream basin should be used for new portable supply with limited volume and ample activity to conserve the collecting area. Midstream and downstream basin water treated by the conventional water purification system should be used for nonpotable use through conventional water works. The area of the collecting basin will be doubled by shifting the nonpotable water supply intake downstream. In the severe drought periods, treated sewage, the quality of which is improved by an appropriate advanced treatment train, could be introduced into the nonpotable water supply system. By using this dual supply system both the water shortage and risk for pollution will be avoided. However, this system requires very large investment for the expensive new high quality supply net work to assure satisfactory drinking water. Many criticize this approach as being very difficult and too expensive because new pipe line must be laid in heavily populated urban areas. However, this proposal to separate colleting basins based upon quality of resource and demands severe as a basic prototype concept. Quality management and basin zoning is one set of issues.

To overcome The difficulties of cost ineffectiveness, the author has proposed another multicomponent water metabolic system for urban area with the least energy consumption and cost to construct and maintain the system (Tambo 1988, 1990). The author proposes The use of downstream water body and ground water start both for transportation and improvement of quality. The author also proposed step wise dual system construction by introducing nanofiltration membrane system at the end part of distribution mains to take out about 10% of water for potable high grade use (Tambo 1995). The supply lines of the upgrade water will be combined with the progress of membrane treatment introduction and finally would be a separate high quality potable water supply lines. The conventional supply lines will work as ordinary lines to supply various demands other than drinking.

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History of Lake Biwa & Yodo River's Water Issues and the New Trend

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ABSTRACT

Lake Biwa has been the source of abundant water for the downstream of the Yodo River, and it has also played the role of a control reservoir during floods and prevented many potential disasters. The development of the cities of Kyoto, and Osaka etc as centers of civilisation have undoubtedly been aided by the presence of the lake.

However, this development of the catchment area did not come about by the meer existence of the natural functions of Lake Biwa, but was also the result of positive outcomes from, struggles between residents of the region. The water control system of Lake Biwa and the Yodo River was a direct result of resolving these issues.

In the Edo period there was confrontation between residents near Lake Biwa and those downstream near the Yodo River about flooding resulting from the dredging of the Seta River. The residents near Lake Biwa made every effort to get the permission of the Shogunate to implement this measure. Water use issues continued in the Meiji period and afterwards. Phase I of the River Water Control Project was implemented to resolve flood control and irrigation issues before and after World War II, lowering the water level of Lake Biwa. However the residents around Lake Biwa were unsatisfied with compensation for damage caused by lower water levels. During the postwar high economic growth period, water demand from Lake Biwa increased enormously to record levels with the residents around the lake being strongly opposed to the situation. The Lake Biwa Comprehensive Development Project was implemented in 1972 having resolved these problems.

The history of struggle and resolution between demands for flood control, and water usage needs of Lake Biwa and the Yodo River will reach a turning point when the Lake Biwa Comprehensive Development Project is completed in March, 1997. Under the project extensive water control measures have been taken to improve safety with regard to flood control and water usage in both Lake Biwa and the Yodo River, bringing about order to Lake Biwa's water control system. An abnormally dry season in 1994, and heavy flooding in 1995 were handled with ease as a result of the progress made by the Lake Biwa Comprehensive Development Project and regulation of the associated Seta River Weir.

Nevertheless, flow capacity during the flood season downstream from Lake Biwa in the Seta and Uji rivers is still insufficient and construction of reservoirs to improve this situation has yet to be completed.

Moreover, there are still many environmental problems that must be resolved quickly. These problems include musty water and the blooms of blue green algae in Lake Biwa and the various reservoirs, and the decrease in the natural shoreline. The most important themes regarding water environment policy for Lake Biwa and the Yodo River are to ensure good water quality to preserve the rich ecological system and to provide suitable areas on the shoreline for leisure purposes.

In conclusion, I would like to emphasize that administration related to water policy must reflect new viewpoints being more cooperative in nature in order to resolve many problems such as water quantity and the deteriorating water environment. We are

trying to increase sewerage facilities, the purification of river water and promote an agricultural effluent policy in the Lake Biwa catchment in our future water quality conservation plans. The necessity of an integrated approach including cooperation between and beyond different instituteinal organizations will be increasingly important in the future.

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The Emerging Lake Biwa Issues:

From Water Resources Development to Restoration of Ecological Environment

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1. LAKE BIWA IN BRIEF

Lake Biwa is one of the great lakes in the world not because of its size($675km^2$ in surface area and 27.5 billion m^3 in volume), but because of its importance as one of the oldest lakes in the world having many indigenous species of flora and fauna, as a great water resource providing water to some 14 million people around and downstream including Kyoto, Osaka and Kobe areas, and as a managed natural system supporting extensive human activities for 1.2 million population living in its watershed extending only 6 times its surface area. Historically the lake has provided for good fishery and for productive paddy agriculture upland despite occasional flooding.

The people in this region, or the current Shiga Prefecture, whose jurisdictional boundary closely coincides with that of the watershed, have thus fostered for centuries strong attachment to the lake. With future water shortage predicted in the late 1960's at a time when Japan was undergoing rapid economic growth, a large scale water resource development for downstream megalopolises called the Lake Biwa Comprehensive Development Project was initiated in 1972. The 25 year project involving water resource, flood control and regional infrastructure development is to be finally completed in early 1997, allowing the maximum discharge of additional $40m^3/sec$ to downstream region at times of droughts. The discharge may cause lake level to drop at a maximum of 1.5m below the normal level.

In the meantime, extensive land-based activities have evolved over decades involving urbanization, industrialization, large-scale land improvement and irrigation in the watershed. Such changes have resulted in altered watershed system, necessitating not only point-source pollution control like sewerage and industrial wastewater management, but also non-point source run-off control including that for paddy irrigation return flows. Perhaps for these and other reasons, the lake ecosystem exhibits signs of eroding integrity which in turn has roused growing concern for the Shiga and downstream residents.

2. WATER RESOURCE DEVELOPMENT

Among the distinct phases of Lake Biwa management, the earliest and the longest of the phases was that of management of flooding and droughts. The paddy farmers in the catchment basin had periodically suffered from these natural disasters before the construction of a weir at the only outlet river, Seta River, in 1905, which has since moderated the magnitude of their impacts. This phase was followed several decades later by that of management of water resources. The Lake Biwa water, serving the downstream needs by way of the Yodo River water course, had long been more than adequate. But when Japan began to exhibit phenomenal economic growth in the 1960's and the downstream thirst was difficult to quench with the flow of the Yodo River at the time, the water of Lake Biwa immediately became a hot subject of debate. Shouldn't we exploit further the resource value of the Lake Biwa water in view of the projected shortage of water for industrial and municipal uses? After lengthy political jockeying among the parties concerned, the Shiga and the downstream local and prefectural governments, with the help of the central government agreed to engage in a large-scale water resource development project called the Lake Biwa Comprehensive Development Project in 1972.

The basic idea of the Project was to allow the discharge of 40 m^3 of additional water at times of droughts. The corresponding drawdown of water level was set at 1.5m below normal. The Project is comprised of water resource development projects, flood control and related water management projects, and the compensatory public works projects for development of the catchment land. It was originally a ten-yea project. Upon failure to complete the component project by 1982, it was extended for another 10 years, and then for additional 5 years to become a 25 year national project. The Project whose total budget eventually turned out to be 1.8 trillion yen (or 18 billion dollars) is to be finally completed in March 1997.

The outcome of this development project is rather obvious. Upon completion of all of the component projects, the lake water will be released to meet the downstream need as appropriate, and the improvement of the in-flowing river system and the coastal fringe will help alleviate flooding damage better. In addition, Shiga Prefecture is much better off in terms of the economic development achieved through the course of LBCDP and of the future potential, with extensive infrastructure development undertaken thanks to the financial arrangement made through the Project.

3. SIGN OF DETERIORATING WATER QUALITY

In the meantime, the first grave sign of lake water quality deterioration came, all of a sudden, in the form of large scale red tide along the eastern coastline of the Northern Basin of Lake Biwa in early 1977. The sighting of this phytoplankton, *Uroglena Americana*, was quite a shock to the Shiga resident as the Northern Basin had been, up till then, believed to be nearly pristine. The red tide has since been sighted almost every year.

Total Phosphorus Concentration (TP)

Prompted by the red-tide incident, the Shiga Prefecture enacted an ordinance to ban the use and sale of phosphorus containing synthetic detergents, known as the Eutrophication Control Ordinance of 1980. Though, the control of land-based sources of pollution had been progressing to some extent by then, it was only after this particular time period that the prefecture began to succeed in mobilizing resources for undertaking extensive control measures for water quality management.

It is to be noted, however, the process leading to the enactment of the ordinance may be regarded as unique as the enactment of the ordinance itself. For many of the long-term Shiga residents, Lake Biwa has, throughout history, been the spiritual and cultural asset, and it was more the citizens of Shiga Prefecture who were so alarmed by this red-tide incident and organized themselves to initiate, despite pressure from the detergent industry, the so called "the use-soap movement" to save the lake from its supposedly doomed destiny.

A wide array of control measures has been introduced over decades for improving the Lake Biwa water quality, and some of them are noted for their significant contribution in improving water quality. The control of industrial wastewater probably was among the first to take effect in significantly reducing pollution loads flowing into Lake Biwa. Already by the mid 1970's, it was becoming difficult for large-scale industries to get away discharging polluting wastewater into water courses leading to the lake, due in part to the Water Pollution Control Law of 1970 taking effect with stringent punitive provisions. The wastewater from smaller-scale industries have been progressively brought under control, though still a large number of marginal-scale industries is yet to be regulated fully.

4. MANAGEMENT OF LAND-BASED SOURCES OF POLLUTION

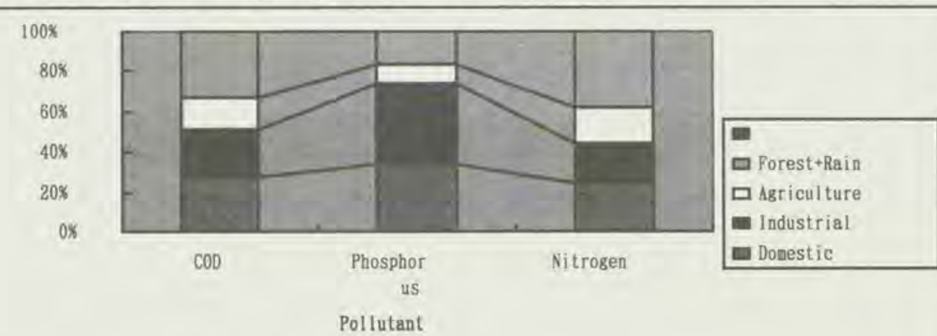
The household wastewater has been and still is a major polluter, the treatment of which require various forms of sewerage systems. As of 1995, the regionalized system of sewerage(public sewerage) is to cover more or less the entire flat-land part of the watershed and it is currently serving some 30% of the entire population(which corresponds to about 40% of planned service population). The four regional treatment plants are equipped with advanced treatment capability to remove nutrients.

There are also small scale sewerage systems for agricultural communities and a variety of on-site sewerage systems collectively called "the Joka-so system". Some are equipped with advanced treatment capability. They serve some 27% of the population(agricultural community treatment system 4.1% and the on-site system with excreta and gray water treatment 9.2%, and the rest being the on-site system with excreta treatment only 13.7%). And there are some 43% of population still not served by conventional flash toilet system with appropriate sewerage extended to them. The excreta collected from these households are transported to one of the 12 night-soil treatment systems all equipped with advanced treatment capability not only of organic content but also of nutrients. The public sewerage is to be expanded to take up a few percentage of population a year, thus expected to lead to some 70% of population to be served by it by around 2010.

Table 1. Sewerage Service for Household Wastewater

Types of Sewerage	Public Sewerage	Community Sew.	Nightsoil System
Population Served	380,000	342,000	487,000
Service %	30	27	43

The management of point sources of waste load is pretty much it, except perhaps for dairy wastes which are also stringently being regulated with requirements for on-site treatment. Thus regulation of industries and provision of sewerage to households and commercial establishments are two prime point-source management strategies. How about non-point sources of pollution? The four major sources of non-point pollution are (1)rainwater, (2)forest and filed runoffs, (3)paddy runoff, and (4)urban runoff, and some rough estimates of the magnitude of individual contribution are shown in Figure



Contribution of Pollution Load

3, though the non-point portion is more likely to increase than decrease as more survey data are collected.

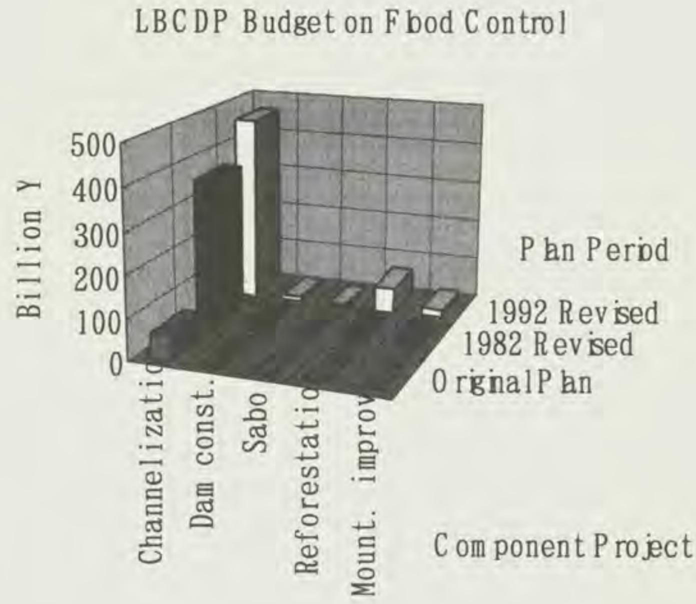
Is there a good prospect for reducing their inputs into the lake? Perhaps not, as of now. The development of a comprehensive non-point source control system introduction will not only be expensive but it will require legal and institutional measures yet to be elaborated. The financial resources required to construct and manage such facilities will be enormous, while they will still be tied up for point source control for some time.

This is particularly so with wet weather non-point sources of pollution, or storm-water runoff into the lake. Elaboration on the control programs for non-point pollution from both urban and agricultural sources has just began. The paddy filed runoff under dry weather flow may be managed much more effectively, by a combination of structural and non-structural means of control. The current thinking is to regard individual paddy fields as point sources under dry weather condition. Proper management of irrigation water and reduction of wasteful use of fertilizers and pesticides are the keys to successful control of dry weather runoffs. Promotion of agricultural best management practice and technology development for more efficient resource use will also help.

5. ENVIRONMENTAL COMPONENT PROJECTS IN LBCDP

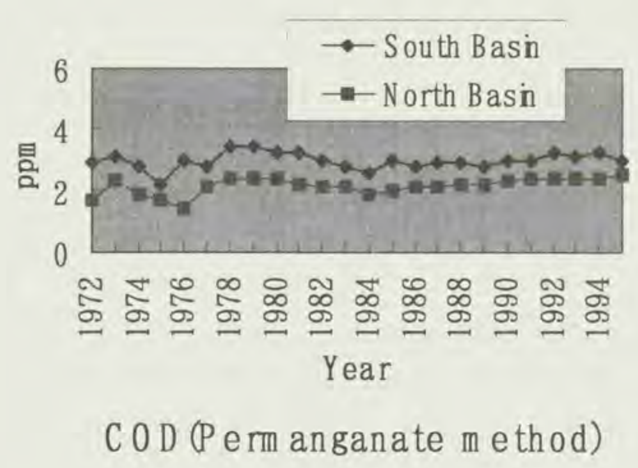
Though LBCDP at the outset did not imply lake water quality as being a primary ingredient of the plan in the original plan, it turned out to be closely associated with water quality issues both with respect to the eventual inclusion in the plan of component projects for upgrading water quality (particularly in the 1982 revision of the Plan) and with respect to the negative impacts on lake water quality of the development projects and activities directly or indirectly related to LBCDP (Figure 4).

As for the former, a significant amount of investment was budgeted to undertake environmental component projects in LBCDP when it was renewed for a 10 year extension in 1982. The investment for sewerage and night-soil treatment system was increased by 26 billion yen for the 1982-91 period. In addition, new component projects such as dairy waste management, agricultural community sewerage, refuse disposal, and surveillance and monitoring system, were also added. The budgetary provisions for these environmental component projects included in LBCDP greatly helped the prefecture. That is, the budget provision for environmental component projects included in LBCDP was in addition to the existing budged of the relevant projects to be carried out by the prefecture.



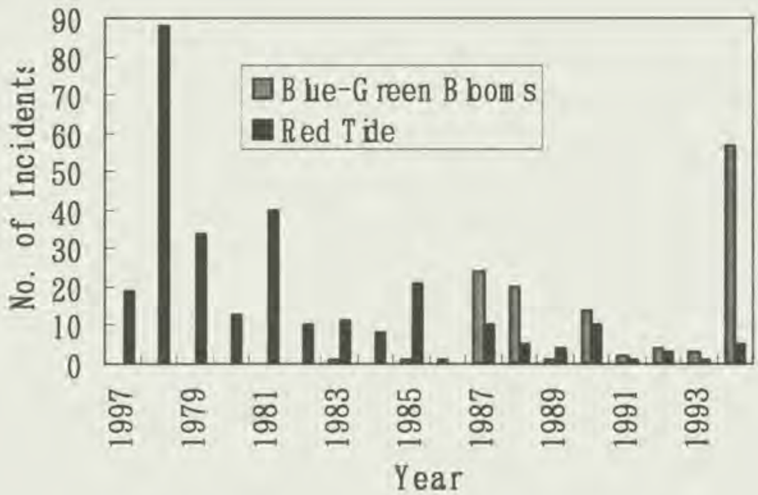
The negative impacts of LBCDP became a major issue in the 13 year litigation brought against the governments by a group of concerned citizens claiming for the their rights to preserve the lake environment without being subjected to extensive alteration as specified in the plan. Though the litigation ended in 1989 with the plaintiffs losing the case, it drew a great deal of attention as many of the concerns expressed on ecosystem integrity in the allegation turned out not only to be justifiable, but also correctly implied the direction of the environmental policy of the post-project era. For example, the prefecture ordinance enacted in 1992 to protect the coastal reed-bed, much of which had been destroyed for constructing the levy cum round-the-lake tourist motorway, was the reflection of regret for having lost the valuable natural habitat.

6. THE CURRENT STATE OF THE LAKE



COD (Permanganate method)

The evolving process of development and conservation taking place over the past few decades around Lake Biwa has culminated to show the changing trends in the quality of lake water and of lake ecosystem. The typical water quality indices, like COD, TP and TN, exhibit that, despite all the environmental programs implemented, the improvement in lake water quality has not been so impressive. There is even some worsening trend in COD in recent years as shown in Figure 5.



No. of Algal Bloom Incidents

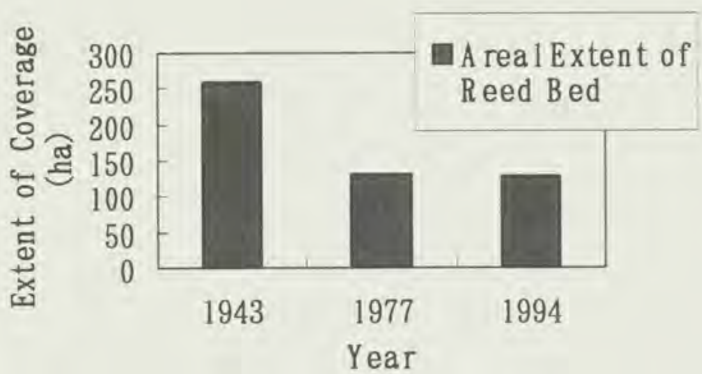
What about the trends of water quality in much longer-term? The water transparency at specified sites and the bottom DO in the Northern Lake are the two indicators of longer term trend which happened to be available and serve to help interpret the lake water quality trend over the past several decades. They show that Lake Biwa water quality had slowly been deteriorating even before the red tide incident of 1977. In addition, there are other more subtle indicators to infer what is taking place for the lake ecosystem. For example, Figure 6 shows that there is perhaps some change in dominant species of nuisance causing phytoplankton in the lake .

To put them all together, it is appropriate to judge that the deteriorating trend has been accelerated since then up till mid 1980's, and, though the rate of deterioration have been slowed down afterwards, the trend itself has not been quite reversed yet.

7. THE IMPENDING ISSUES

The management of Lake Biwa water quality is about to enter a new phase, a phase which will involve, in addition to acceleration in point and non-point source control measures aiming to further reduce entering waste-loads, introduction of control measures for achieving a greater degree of lake ecosystem integrity to be accompanied by improved lake water quality in terms of quality parameters other than COD, TP and TN. The emerging features of control measures characterizing the new phase include (1) realignment of protected watersheds and land-uses, (2) development of ecotone areas including restoration of the once reclaimed attached lakes and (3)the integrated management of priority watersheds.

Realignment of the protected watershed and rezoning will probably involve extensive political process. The major issue will be devising of proper economic incentives such as compensatory payments for the existing land owners, as almost every piece of watershed land is owned and engaged in some sort of productive activity. As for ecotone development, there will have to be close collaboration between agricultural and urban sectors with respect to infrastructure development or redevelopment involving coastal regions of the lake and numerous water courses. As for the integrated management of priority watershed, the key is to redesign the water courses hitherto independently developed by different sectors of the government.



Reduction in Reed Bed

While nobody disputes today of the need to make appropriate transition from the era of water resource development with the necessary environmental considerations to the new era in which achievement of ecosystem integrity is singled out as the objective of first and foremost importance, this transition demands some fundamental changes in the thinking as well as in the approach for the long range government planning. What the so-called the post-LBCDP is facing today is exactly this.

In the days of planning for development of infrastructures, be they for water resource development or for improvement of basic public needs like sewerage, the approach was to set specific quantitative targets, most likely based on some sort of political decision, and then mobilize the necessary resources to realize those targets. The target would be not only clear but also quantitative. The issue was, for retrospective assessment of achievement of the targets, how far behind has the implementation been for reasons of lack of resource mobilization or of capability to implement them.

In the days of planning for the objective to achieve ecosystem integrity, the approach will have to be entirely different. Not only would the targets be unclear and difficult to describe quantitatively, the process leading to achievement of the goal would be an evolving one. In other words, the determination of how sound is sound enough for the ecosystem under consideration must reflect the sense of value of the public involved, and this sense of value will have to be continually refreshed with new findings about their own existence in the ecosystem which is to be conserved or restored.

It is within this context, that the current process of elaboration on planning for the era of post-LBCDP will be retrospectively reviewed and evaluated by our descendants in future.

ACKNOWLEDGMENT

The data included in the above tables and figures came from the Shiga Prefectural Government.

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Promotion of Regional Water Quality Improvement Programmes at Lake Biwa and Yodo River

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Abstract

The prefectures of Shiga, Kyoto, Mie, Nara, Osaka and Hyogo share the basins of Lake Biwa and the Yodo River. The population in the basin is approximately 12 million and about 16 million make use of their waters. This water is circulatory and is used three times in the upper-stream, mid-stream and downstream and such use is a significant cause to the pollution of the waters of Lake Biwa and the Yodo River.

The Lake Biwa Comprehensive Development Project is a pioneering project for preservation, flood control and irrigation of Lake Biwa and has been implemented in cooperation with the national government, Water Resourse Development Public Corporation, Shiga prefectural government, municipalities around Lake Biwa and downstream prefectural governments, obtaining excellent results.

In the measures for preserving the water quality of Lake Biwa and Yodo River, various policies have been implemented. These policies include the measuring and observing of water quality, regulation and equipment of many kinds of waste water treatment facilities including sewage treatment facilities. However water quality has not shown a visible improvement yet, because in Lake Biwa various bad phenomena including musty water, appearance of freshwater red tide and breeding of microcystis have occurred. Musty water and pollution by micro noxious matter are also issues in the Yodo River. To tackle this issues six prefectural governments and three designated cities established the Preservation for Water Quality Foundation of Lake Biwa and Yodo River in cooperation with the national government and some related organizations in September, 1993. The Foundation tries to preserve the water quality of Lake Biwa and Yodo River with integrated and cooperative activities of basin residents.

The water quality of Lake Biwa and Yodo River has remained the same or even deteriorated slightly, and new measures for improvement of water environment are required because it is clear that the measures that have been implemented so far have a limited effect. As result, the Water Environment Council, consisting of 16 private knowledgeable people,

was set up with the Preservation for Water Quality Foundation of Lake Biwa and Yodo River acting as the secretariat. The Water Environment Council made a comprehensive set of suggestions entitled "Change Lake Biwa and Yodo River into a Beautiful Environment".

These suggestions consist of three doctrines, five goals and seven measures. The three doctrines are healthy water circulation, partnership and creation of a new water environment. The five goals aim to create lakes and rivers to be able to supply natural and safe drinking water, a safe place for swimming, a healthy environment for fish and to reflect and support historical culture. The seven measures are based on revolutionary social measures and improvement of water environment.

We hope the implementation of the suggestion made by the Water Environment Council will truly turn Lake Biwa and the Yodo River into a beautiful environment. On the basis of the suggestions, we will create a new water culture and begin to act as one entity for the whole region.

(In order to get detail paper please contact Mr.Hitoshi Otsuki, Lake Biwa - Yodo River Water Quality Preservation Organization, 1-1-30 Kitahama, Chuoh-ku, Osaka 541-0041 Japan, original in Japanese)

Water Quality Status of Lake Taihu

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Abstract:

The paper has discussed water quality state of Lake Taihu, and found that water organic pollution is serious in some water body and nutrient level of the lake is in eutrophic state. The paper also put forward some important proposal to control the development of eutrophication of Lake Taihu.

Key words: Eutrophication, water pollution

Lake Taihu is one of the five biggest fresh water lakes in China, situated in the area with a high speed of economy development in Jiangshu province, Zhejiang province and Shanghai Municipality. It takes very important effect on the increasing of local economy, sustainable development of society and climate regulation in regional environment.

1. Importance

Lake Taihu has the multiple function of water storing and regulation, irrigation, water supplying, aqua culture, shipping, climate regulation and tourism.

2. Main Environmental Problems

According to the data of the latest 15 years from 1981 to 1995, the main environmental problems of Lake Taihu are eutrophication in whole lake and organic pollution in part water body.

2.1 Eutrophication

The result of investigation has shown the that average concentrations of TN and TP of Lake Taihu far exceed the standard for eutrophication. Lake Taihu is from meso-trophic to eutrophic level as whole, partial water body is in the eutrophic level. According to the data in 1995, the greater part of water body of Lake Taihu reached eutrophic state.

2.2 Organic pollution

The organic pollution in partial water body along the bank, especial near cities and towns, is very serious. The development of organic pollution of the whole lake is fast.

The standard of water quality used in this paper is the Document **GB3838-88** set by the Chinese State Environment Protection Bureau.

The water quality of Lake Taihu, which average of COD_{Mn} has reached 4.48mg/L, is of Grade III of the state standard. The water quality of Lake Meiliang and Wuli, which are small bays near Wuxi city near Lake Taihu with the highest speed of pollution development, is of Grade IV and Grade V of the state standard.

3. Trends of Eutrophication and Organic Pollution of Lake Taihu

3.1 Trend of Eutrophication

The trophic state development of Lake Taihu can be divided into three periods: at the beginning of 1980's, most of the lake was from meso-trophic to meso-eutrophic level; at the late of 1980's, most of the lake was from meso-eutrophic to eutrophic level; at the middle of 1990's, most of the lake was in eutrophic status.

(1) 1980-1981, about 83.3% of water body of Lake Taihu was of meso-trophic and meso-eutrophic level

(2) 1987-1988, in trophic types of Lake Taihu, meso-throphic state disappeared, about 60% of water body was of meso-eutrophic state, the area of eutrophication of the lake reached 40%.

(3) 1990-1991, about 75% of the whole water area of Lake Taihu were of meso-eutrophic level, about 20% was of meso-trophic level, and about 5% was eutrophic level.The causes of trophic level fall down probably was the flood in 1991 summer.

(4) 1995, Majority of the water body of Lake Taihu reached the level of eutrophication, lake Wuli and Meiliang reached hyper-eutrophication.

3.2 Trend of water pollution

The water quality development of Lake Taihu also can be divided into three periods: at the beginning of 1980's, most of the lake was of Grade II of the state standard; late of 1980's was the period of transition of water quality from Grade II to Greed III; at the middle of 1990's, majority of the lake was of Grade III.

(1) 1980-1981, water quality of Lake Taihu was mainly of Grade II.

(2) 1987-1988, comparing with the beginning of 1980's area of water body belonging to Grade
III had a increase about 6.6%, Grade IV had Increase about 2.2%, and hyper polluted water has appeared.

(3) 1993-1994, water quality of about 70% of Lake Taihu was of Grade III, the proportion of water body belonging to Grade V was becoming greater.

(4) 1995, according to the monitoring data, majority of water body of Lake Taihu was of Grade III.

4. Present State of Water Pollution of Lake Taihu

4.1 Present State of Eutrophication

(1) Trophic status of Lake Taihu

(2)Level of nutrients of Lake Taihu
The averages of TN, TP of whole lake have reached 17.5 and 6.6 times of eutrophication standard.

4.2 Present state of Orgasmic Pollution of Lake Taihu

1994-1995 ,6 major parameters of water quality of the lake were very high, TP and Volatile phenol were exceeded the standard level.

Water area of Grade V takes up 1% of the total, Grade IV takes up 10%, Grade III takes up 70%, Grade II takes up about 15%. The average water quality of Lake Taihu in 1995 was of Grade III.

5. Conclusion and Proposal

1 Most part of Lake Taihu water body has reached eutrophic level, water quality is of Grade III.

2 Development of water pollution of Lake

Taihu is very fast.

3 We appeal various effective measures are taken immediately, so as to control the development of eutrophication of Lake Taihu.

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Table 1 Trend of Trophic level of Lake Taihu

Trophic level	80-81	87-88	90-91
Oligo- eutrophic			0.35%
meso- eutrophic	4.3%		20%
meso- eutrophic	41.5%	59.5%	>4.65%
eutrophic	16.8%	40%	5%
hyper- eutrophic	0.40%	0.50%	

Table 2 Trend of water pollution of Lake Taihu

Grade	80-81	87-88	93-94
I	69%	59.4.%	15%
II	30%	33.6%	70%
III	1%	3.2%	14%
IV		0.8%	1%

Table 3 Eutrophic level of Lake Taihu

L. Wuli	hypereutropic
L. Meiliang	eutrophic- hypereutrophic
Zone of Main Water Body	from mesoeutrophic- eutrophic to eutrophic
Lake shore zone	eutrophic
Average	eutrophic

Table 4 Present State of Water Quality (94-95)

L. Wuli	IV-V
L. Mailing	IV
Major Lake	II-III
Lake shore zone	III-IV
Average of whole Lake	III

Southeastern Anatolia Integrated Development Project (GAP) of Turkey: An Overview of Issues of Sustainability

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ABSTRACT

The Republic of Turkey has initiated a comprehensive socioeconomic development project in its less developed southeast region. The Southeastern Anatolia Project, or GAP with its Turkish acronym, aims at improving the living standards of some 6 million residents of this 75,000 km^2 region by mobilizing the natural resources of this area for an integrated development on a regional scale.

GAP is planned, designed, coordinated and implemented in an integrated manner taking into account interactions among different sectors and as well as activities within individual sectors.

The Southeastern Anatolia Project, in its historical context, was formulated as a package of water and land resources development projects in 1970's, which was later transformed, in early 1980's, to a multi-sectoral, socioeconomic regional development program. A Regional Administration (GAP-RDA) was established in 1989 for the management of the program. Sectors covered in the development program include irrigation, hydropower, agriculture, urban infrastructure, rural development, forestry, healthcare and education among others. The water resources program of the $32 billion project includes 22 dams, 19 hydropower plants and irrigation of 1.7 million hectares of land.

The holistic approach adapted by GAP-RDA is based upon an expanded principle of sustainability. A definition of sustainability has been established for GAP which covers, as its main components

* economic viability,
* sustainability of agricultural system,
* sustainability of irrigation,
* environmental sustainability,
* spatial sustainability (i.e. land use and transportation), and
* social participation, equity and human resources development.

This paper describes, in brief, the size, main features, financial aspects and the status of the integrated socioeconomic project in its general context thus forming the basis for operational as well as specific issues.

It then attempts to provide an overall discussion of the sustainability framework for development in its different but highly interrelated facets.

The paper, having established the macro, dual basis where, on one hand, dams are a part of integrated water and land resources development which is a means for socioeconomic regional development and

environment, on the other hand, is an integral part of the framework which provides the philosophical ground with operational implications.

Any development effort, regardless of size or nature, is an intervention into the established systems in physical, social and economic terms. As with any intervention, it is bound to have impacts, direct and indirect, beyond the planned and/or desired consequences. A project as big and comprehensive as GAP is no exception of this. The studies, activities, measures and modifications that came as a result of the cognizance of this fact form the remainder of the paper where impact of dams, within the more relevant component of irrigation and hydropower development as well as with their direct relation to environment is elaborated.

After establishing the main, global benefits such as flood control, enhanced living quality, improved infrastructure, economy, nutrition and welfare, the paper comments on the adverse, undesired impacts along with the measures adapted to mitigate them. Within this context, issues related to the proper use of technology, management, training at different levels, integration of water and land as well as the institutional aspects and participation of the public/stakeholders/NGO's are mentioned.

The paper later describes, in more detail, environmental impact studies, their main findings and proposals in regard to watersheds, irrigation development with an emphasis on management, environmental health matters along with the measures taken.

Some of the other headings covered in the paper are:

* Land use planning from macro (1/25,000) scale to zoning (1/5,000) to implementation (1/1,000) scales and the land use authority held,
* Agricultural land consolidation to improve water and land utilization efficiency,
* Site selection criteria for major projects, industrial zones and mass housing programs,
* Turkish Environmental Law and related regulatory frame,
* Re-use of irrigation return water,
* Re-cycling of urban wastewater,
* Erosion control and watershed rehabilitation,
* Participatory resettlement and sustainable redevelopment as a result of dam reservoirs,
* Eco-city and eco-village planning and development on pilot areas,
* Land use, transportation and navigation planning for Atatürk Reservoir and surroundings,
* Action plan for sewerage and wastewater treatment,
* Promotion of multiculture, and
* Protection of biodiversity among others.

The paper concludes emphasizing the commitment to sustainable development, to planning ahead rather than damage reduction and the effort to integrate relevant and sometimes conflicting aspects rather than compromise.

A. DESCRIPTION OF PROJECT AREA

A.1. History of Region

There is evidence of human settlement in southeastern Anatolia since the Neolithic Age (7000-5000 BC) however settlement began in earnest during the Old Bronze Age (2500-1900 BC) with the proto-Hittites. Since then numerous peoples have lived in the area including the Assyrians, Cimmerians, Persians, Seleucids, Romans, Arabs, Seljuk Turks and Ottomans. There are consequently a large number of different types of archaeological remains in the region. The GAP Tourism Study in 1991 identified 1063 sites of historical, cultural, natural and archaeological interest.

A.2. Geography, Geology, Climate and Soils

Southeastern Anatolia lies eastward of the Mediterranean north of the border with Syria and Iraq. The region consists of the nine provinces covering a total area of approximately 75,000 km^2 or 9.5% of the total area of Turkey.

The GAP Region is encircled to the west, north and east by the southern ranges of the Southeastern Toros Mountains, which rise to over 2500m within the GAP Region and are most extensive to the east.

The topography of the GAP Region can be subdivided into two main units, the uplands and the plains. The uplands extend southwards from the Southeastern Toros Mountains. They consist of high, deeply incised mountains around the perimeter of the GAP Region; mountain blocks within the region; dissected plains, hill country and lava uplands; and small areas of plains. The latter include areas with relatively low slopes. The plains occur to the south of the region and extend through Syria and Iraq to the Arabian Gulf along the valleys of the Euphrates and Tigris rivers. These mainly lie between 550m and 400m above sea level with a rolling topography. Separating the plains are areas of hill country.

The present-day geology reflects events which have occurred since the Upper Cretaceous period which resulted in the deposition of alternating marine deposits, such as limestone and marls, and non-marine deposits. Renewed uplift in the Miocene resulted in the creation of several structural features. The seas finally retreated giving way to continental clastic deposits. During the Pliocene intermittent basalt lava flows occurred covering large areas. Recent deposits include alluvium and floodplain deposits, slope wash and talcs. These mainly consist of unconsolidated clays, silts, sand and gravel.

The two main soil types are the calcareous brown soils and basaltic soils. In the low lying areas the soils generally belong to the brown soil group. Soils in the Lower Euphrates basin are mainly clay loams, fine silty clays, and clays.

The climate of the region is characterised by dry, hot summers and mild to cold, wet winters. Mean annual rainfall decreases from over 1200 mm in the north to 311 mm in the south just by the Syrian border. Mean monthly rainfall is very low between June and September and reaches a maximum in December and January with a high degree of inter-annual and intra-annual variability.

Monthly temperatures are lowest in January and peak in July. Data show a strong difference between north and south; frosts occur from the end of November to February or March.

Mean annual potential evapotranspiration rates are 1164 mm in north GAP and 1257 mm in south GAP with the highest mean monthly rates in July of 211 mm in north GAP, and 224 mm in south GAP.

The majority of the GAP Region lies in the Euphrates-Tigris basin. The Euphrates River lies in the western part of the GAP region. The total catchment area of the Euphrates in Turkey, i.e. upstream of the Syrian border, is 103 thousand km^2 of which 22% lies within the GAP region. The upper Euphrates basin is separated from the GAP region by the Southeastern Toros mountains. The mean annual runoff near the Syrian border is estimated to be 31 billion m^3. Two serious droughts have occurred during the record period in 1958-62 and 1970-75 when annual discharge fell to 49% and 62% of the annual mean. In the wettest year, 1969, the annual runoff was 186% of the mean.

The Tigris River lies in the east of the GAP region. It drains a catchment of 38 thousand km^2 upstream of the Syrian border, of which 30,000 km^2 lies within the GAP region. Mean annual discharge in Turkey is estimated to be around 17 billion m^3. This system also had low flows during 1958-62 and 1970-75 with the mean annual discharge reduced to 47% and 58% of the mean. In the wettest year, also 1969, the annual runoff was 204% of the mean annual runoff. The seasonal variation in monthly discharge is similar to the Euphrates River: the peak mean monthly flow in April and the lowest in September.

There are few natural lakes in the GAP Region. Estimates of open water areas in the region total about 200 ha. When GAP dams are built, the area of open water created by reservoirs will exceed 2,500 km^2. Atatürk reservoir would have the largest surface area (817 km^2), followed by Keban (675 km^2), Karakaya (298 km^2), Ilisu (295 km^2) and Silvan (181 km^2) reservoirs.

The water quality of the rivers is good and suitable for irrigation with electrical conductivity values of below 0.6 mmhos/cm and SAR of below 0.4

The potential groundwater resources are found in the plains in the south of the region. Groundwater has been abstracted from the Suruç plains since 1960 and the aquifer is estimated to be fully utilised. Groundwater from the Urfa-Harran and Mardin-Ceylanpinar plains has been abstracted since 1977 and 1978, respectively. Estimate of the annual safe yield from groundwater resources in the GAP Region amounts to 1.5 billion m^3/yr. Groundwater quality data for 1993 from the limestone aquifer show that the sodium (alkali) hazard is low with SAR values less than 1. The salinity hazard in the Ceylanpinar basin is medium.

A.3. Ecology

Due to its geographical location the flora of Turkey has been influenced by the Euro-Siberian, Mediterranean and Irano-Turanian phytogeographical regions. Within the country variations in topography and climate over short distances have further influenced the development of numerous species and subspecies. Consequently the flora of Turkey is very diverse (Turkey has one of the richest flora in Europe) including large numbers of species which are endemic to the country. Some of the mountain ranges have formed notable barriers to the distribution of flora and fauna; the Southeastern Toros Mountains which border the GAP Region are reported to be one of the richest areas in Turkey for endemic species.

Ecological conservation is an important issue in Anatolia because, in addition to its biodiversity, the ancestors of many agricultural crops are thought to have originated in the region. These include wheat, oats, barley, rye, chickpeas, lentils, peas, broad beans and vetches, onions, garlic, leeks, grapes, figs, cherries, pears, almonds, pomegranates, and apricots as well as ornamental plants such as tulips, crocuses and snowdrops. Wild forms of many domesticated plants are still found in the countryside. They form an important genetic pool. A gene bank was founded in Ankara in 1990 to collect and preserve the seeds of native plants which are thought to be the ancestors of cultivated plants. This includes the seeds of species of Graminae and Leguminosae families found in the GAP Region. A World Bank supported biodiversity program is under way in this area.

A.4. Habitats in Southeastern Anatolia

In GAP area there are two main vegetation types: wooded steppe and semi-desert steppe.

The wooded steppe is found in pockets around the perimeter of the GAP Region mainly in the mountainous areas. The wooded steppes support animals such as jackal, European beaver, eagles and vultures, which are of high conservation value.

The semi-desert steppe is more extensive over the GAP provinces. Some of the typical species are *Artemisia herba-alba*, *Eryngium noerium* and *Salvia spinosa*. However large areas have been degraded by overgrazing where less palatable species such as *Astralagus* and *Achantholimon* occur.

The grasslands in the GAP Region have among the lowest productivity rates in Turkey. Flora include grasses, bromes, and herbaceous plants such as various thistles, pinks and spurges. Invertebrates include butterflies, praying mantids, grasshoppers, crickets, and beetles. Avifauna are dominated by open country species including several species of larks and kestrels. Reptiles and amphibians include lizards and tortoises.

Dryland agriculture is practised in much of the semi-desert which typically incorporates a fallow period. Some of the more persistent plants occur in and around the fields. Cliffs, gorges, and water bodies provide smaller areas of habitats. The first two provide habitats for rare birds such as bald ibis, long-legged buzzard and lesser kestrel. Rivers and lakes support a diverse range of flora and flora and consequently are valuable habitats within a generally semi-arid environment.

A.5. Natural Resources

In 1986 the total forestry area in GAP was 11,991 km^2, of which 479 km^2 was forested and 11,512 km^2 was "energy forest" consisting of shrubs and bushes. Studies suggest that the quality of these resources has dropped due to overgrazing, felling for fuel, and agricultural expansion. It is estimated that the region's forestry resources only meet 47% of domestic wood fuel demand and 25% of the industrial wood demand.

Inland water fisheries tend to be confined to perennial natural and man-made lakes with rivers supporting subsistence. In the GAP Region there are an estimated 2,235 km of rivers and extensive areas of natural lakes and reservoirs. Further dam construction will increase the area of surface waters. Over 90% of the fish caught by weight were common carp. The GAP region only produces 2% of the national total, and fish consumption per capita is only about 20% of the national average. Limnological studies have been undertaken for Keban, Karakaya, Atatürk and Devegeçidi reservoirs to determine the suitability of the lakes for fishery development. Keban and Devegeçidi reservoirs have been stocked with cultured car, a large fishery facility is now partially operational at the Atatürk dam to serve the whole GAP area.

The soils in the GAP Region are classified into eight capability classes. The classes are defined according to soil texture, soil depth, water holding capacity, alkalinity, salinity, topography, vegetation cover, stoniness, and drainage. Classes I to III are suitable for irrigation, but Class IV is only suitable for irrigating certain crops. Over 90% of the land in Classes I to III and 65% of the land in Class IV is already being cultivated for dryland farming. Class V is a deferred classification where soils require further analysis. Classes VI to VII are not suitable for irrigation and Class VIII is non agricultural use. The surveys showed that salinity and alkalinity were not widespread problems being highly localised. Stoniness is a major problem in the region and stone clearing is a major operation in farming areas.

Wind erosion is limited primarily by the relatively low wind speeds in the region. On the other hand, the truncation of many profiles indicated that soil erosion by running water has been serious in the GAP Region. This is particularly the case on sloping ground where vegetation cover has been reduced.

A.6. Structure of Agriculture and Land Tenure

The total area of agricultural land in the GAP Region was estimated to be 3 million ha or 42% of the area in the GAP Master Plan (Nippon Koei and Yüksel, 1989). Of this 85% was dryland farming, 4% was irrigated farmland and 11% was for horticultural and special crops. Approximately 91% of farmers practise mixed farming and 9% are engaged in crop production alone.

In the land tenure structure, an average 37% of the farmers are landless, 43% own between 1 and 5 ha and 4.3% own more than 20 ha. A more recent survey (Sencer, 1993) suggested a decrease in the number of landless to 25% with the majority practising sharecropping and pure animal husbandry suggesting a change in land ownership towards a more equitable pattern of distribution.

In the cropping patterns in 1991 for the main field crops, wheat, barley and lentils account for 86% of the total area sown. Cotton and chickpeas are the next most widely planted crops accounting for 4.6% and 4.4% respectively of the total area. The main tree crops in the GAP Region are pistachios and grapes accounting for 45% and 36% of the total area of tree crops planted. The largest areas of vegetable crops are for watermelons, melons, tomatoes, peppers, and aubergine. Cotton becomes the main crop once an area receives irrigation water. The GAP Region produces a high proportion of the country's total production of some crops. For example 92% and 29% of the total area in Turkey under pistachios and grapes is in the GAP Region. In terms of production 68% of lentils and 32% of sesame are from the GAP Region.

A.7. Livestock

Livestock populations in GAP is comprised of sheep to a large extent followed by goats. Sheep and goats are raised extensively by herding them in areas unsuitable for cultivation such as hilly, stony and mountainous areas. The diet of sheep is usually supplemented by 20% with fodder.

Cattle are grazed extensively on higher quality pasture or reared semi-intensively by grazing them on fallow land, stubble, and supplementing their diet with fodder. Local breeds are most common for all types of livestock. These cope best with the environmental conditions such as high summer temperatures, drought, disease, parasitic infections and low nutrition. Local breeds have smaller carcass weights and low milk production compared to crossbreeds and exotic breeds.

A.8. Pests and diseases

The GAP region appears to be relatively free from plant pests and diseases. This is in part due to the arid conditions, particularly the summer drought and low humidity, which are unfavourable for many pests.

Livestock are affected by several infectious diseases such as foot and mouth disease, cattle plague, which has been eradicated from the GAP Region by strict vaccination policy although there are unconfirmed reports of outbreaks in Iran and Iraq.

A.9. Pesticides and Fertilisers

At present the amount of fertilisers and pesticides bought in Turkey is well below the average for developed countries. Within the GAP Region, amounts purchased are well below the national average. This is related to the relatively low levels of plant pests and diseases. Farmyard manure is widely used in many villages. It tends to be used where irrigation is practised particularly for vegetables. The manure is normally left to dry and then is spread on the soil surface and worked or ploughed into the soil. Crop chemicals and pesticides are also used widely in the majority of villages.

A.10. Human Environment

The total population of the GAP Region in 1990 census was 5.2 million, 63% of which lived in the three largest provinces. The average annual growth rate of population for the region was 3.48%, a figure significantly higher than the national average of 2.19%. Today, the region's population is estimated to have exceeded 6 million, with more than 60% living in urban areas. The influx from rural areas to cities is very high and is expected to continue.

The region has a very young population with half of the total being in the 0-15 age group whereas working-age group (15-44) constitutes 40%. This has resulted from high birth rates in the region. Household sizes are large with 39% of households having between 5 and 7 members and 33% of families having 8 or more members.

The GAP Region has been characterised by net outward migration, typically to large cities in Turkey. Also, substantial internal migration occurs from rural areas to urban centers, from mountainous areas to the plains and from east to west. Seasonal migration for employment both within the region and to nearby provinces (especially Southern Turkey) is common practice in rural areas.

The literacy rate in 1990 was 60% but is much higher for men (76%) than women (45%)

A.11. Environmental Health

Major environmental health problems are infectious and parasitic diseases aggravated by malnutrition. Malaria, trachoma and cutaneous leishmaniasis are vector borne diseases. Diarrhoea and intestinal infections are associated with inadequate water supply, sanitation and personal hygiene. There is evidence of malnutrition especially in the eastern part of the Region. However problems are partly cultural as malnutrition is due to diet imbalance rather than a lack of food.

The 1981 Village Level Survey also found that 60% of households had no sanitation. Only 11% of households in the GAP Region had indoor facilities and 27% had outside facilities. There is no tradition of using pit latrines in the region.

B. PREVAILING CONDITIONS

B.1. Economy

A comparison of gross regional product (GRP) of the Region in 1985 with the GDP of Turkey clearly indicates the level of its underdevelopment. In 1985, the Region accounted for 4% of GNP. Per capita income of the Region, was only 47% of the national average. Agriculture is by far the dominant production sector, accounting for nearly 40% of GRP. It contributes to over 9 % of the agricultural value-added of Turkey. Rain-fed agriculture is predominant in the region. Depending primarily on water availability constraints, crop diversification is limited and productivity is low. Crop pattern was 34% wheat, 18.5% barley, 19.7 lentils, 2.8% cotton, 9.4% multi-seasonal produce, and 2.2% sesame.

Nearly 70% of economically active population is engaged in agriculture, but it only generates 44% of total value-added. Similarly, the animal stock is large, but productivity is low. Traditional production methods still predominate, but agricultural modernization has started.

Only 2% of country's total value-added from the manufacturing industry was produced in the GAP Region during the 1980-85 period. In 1985, 95% of the manufacturing industry employed less than five workers. Main industries are textile (32%), metal products (21%), food-beverage (19%), wood products (15%), and chemical (5%). Industrial employment comprises 5% of the regional labor force as compared to 16% for Turkey. The growth rate of employment reached its peak in 1985, at 19%, which was 4.7 times higher than the national average. The public sector was more successful in generating value-added during this period. The annual growth rate of industrial value-added was 15.5% during 1980-85, but it declined later. Industry accounted for nearly 60% of the Region`s electricity consumption.

B.2. Social Services

National literacy rates increased from 67% to 77% between 1980 and 1985. The literacy level in the Region in 1985 was 55%. There was considerable difference between male and female literacy rates at 71.7% and 39%, respectively. Corresponding figures for the country were 86% for men and 68% for women.

Medical facilities and personnel in the Region were inadequate. Number of persons per doctor was 3631, and per nurse 2758, which compared unfavorably with the national figures of 1391 and 1630, respectively. Number of persons per hospital bed was 847 compared with 484 for Turkey in 1985.

There were 3500 rural settlements without drinking water supply, which account for 35 % of total rural settlement. This ratio increased to 55 %, if those with inadequate water supply were included. On the population basis, 22 % of rural population in the region did not have access to clean drinking water. 29 % of the villages had telephone services, 66.8 % were electrified and 90 % of the rural settlements were linked to the road networks.

Urban centers, having better living standards and services are attracting substantial rural migration. Urban infrastructure is therefore becoming rapidly inadequate.

GAP area is rich in water and soil resources: Tigris and Euphrates rivers represent over 28% of the national surface water supply, and the total economically irrigable area in the GAP Region accounts for over 20% of that of the country.

C. GAP AS AN INTEGRATED SOCIOECONOMIC DEVELOPMENT PROJECT

The Southeastern Anatolia Region is a part of Upper Mesopotamia, the cradle of the ancient Mesopotamian civilization. The recognition of the great water potential of the Euphrates and the Tigris Rivers led to plans for their sustainable development for irrigation and hydropower generation and at controlling floods and droughts. The work that was initially planned as predominantly a large-scale water resources development project was later transformed into an integrated multi-sectoral regional development program.

The water development program of GAP includes 13 main irrigation and energy projects, seven of which are in the lower Euphrates sub-basin and six in the Tigris sub-basin. There are 22 dams, 19 hydropower plants, and irrigation networks to irrigate 1.7 million ha of land. The installed capacity to be created is approximately 7,500 megawatts with an annual hydroelectric production of 27 billion kilowatt-hours. The aims and the main features of the integrated project are outlined in the GAP Master Plan (Nippon Koei and Yuksel Proje, 1989).

Project planning and implementation are done based on the Master Plan and an Action Plan. The Master Plan was prepared to determine the Region's potential, identify the bottlenecks for the development process, and to set the development objectives, goals and strategies. A three-phase program for development was initiated. The GAP Action Plan was prepared for a 5-year period, by considering interactions between sectors, population projections and spatial development forecasts on the basis of numerous studies. Macro-level planning and management, coordination, monitoring, evaluation and implementation in selected areas are carried out by the *GAP Regional Development Administration.*

Integrated project comprises not only the multi-purpose dams and irrigation systems but also investments in all development related sectors such as agriculture, energy, transportation, telecommunication, health care, education, urban and rural infrastructure development.

The strategy adopted in the GAP Master Plan for the region's development has the following four basic components;

(i) develop and manage soil and water resources for irrigation, industrial and urban uses in an efficient manner;

(ii) improve land use through optimal cropping patterns and agricultural practices;

(iii) promote agro-industry and those based on indigenous resources; and

(iv) provide better socialservices, education and employment opportunities to control migration and to attract qualified personnel to the area.

The GAP Master Plan's basic development scenario is to transform the region into an export base for its agricultural products.

When the Project is completed, the ratio of irrigated land to the total GAP area will increase from 2.9% to 22.8% while that for rain-fed agriculture will decrease from 34.3% to 10.7%. As a direct result of the introduction of irrigation, agricultural production and crop variety will increase substantially. Under the prevailing dry farming system, field crops such as wheat, barley, lentils, pistachios and grapes are widely cultivated. Cropping intensity will increase from 89% to 134%. The most striking change will be for land used for cotton cultivation, which will increase from 2.8% to 25 %.

Increase in agricultural production contributes to the infrastructure development and increased economic activities will accelerate development of agro-industry and other agricultural services. The region is fast becoming attractive for domestic and foreign investment projects. Initial developments are in flour, flour-based products, leather, margarine, cotton and textile industry.

As a direct result of the GAP investments, the living standards of many inhabitants have already started to increase. With progressive implementation, more and more people became direct beneficiaries of the project. Rural-urban interactions have increased following the construction of transportation and communication networks. The region will be more open to the outside world and thus attract additional investments. The population is expected to increase to 10 million by 2005, 66% of which would live in urban centers. Urbanization in the region will receive a boost, and rural migration would slow down considerably. Employment opportunities will have been created for some 3.8 million people in various sectors.

Education and health services in the Region will be improved to at least the current national average by 2005. Specifically, the enrollment ratios in schools and the levels of health facilities are planned to exceed the current national average by 2005.

The project is socially essential as it is intended to significantly improve the living standards and quality of life of the local people, increase their per-capita income, create new employment opportunities, and protect the environment. It is also economically viable as it would substantially improve the economic structure, increase production, and more than quadruple the GRP.

D. SUSTAINABLE DEVELOPMENT AND BASIC STRATEGIES OF GAP

Sustainable development was defined by the Brundtland Commission as one that "meets the needs of the present without compromising the ability of future generations to meet their own needs." Under this very broad definition, there are many issues which must be considered: social, economic, cultural, gender, educational, health, physical planning, agricultural, environmental, institutional, among others. At the hub of all these issues is people, either as object, or as the agent, or both. Hence, human development is the core of sustainable development of the GAP region. Consequently, GAP has adopted two main approaches:

1) integrated, regional development and multi-sectoral planning as opposed to project-specific development and sectoral planning and

2) sustainable development.

In order to define the scope and composition of sustainability for GAP, a participatory approach was adapted. A seminar was jointly sponsored by UNDP and GAP Administration in March 1995 attended by a large number of different stakeholders of the development process of the GAP region. Consensus was reached on the following issues.

1. Community participation in decision making process in project design and implementation; providing equity and fairness among population groups; providing a sustainable population structure; and developing human resources in the field of education, training and provision of health services.

2. Providing adequate shelter for all; improving human settlement management; promoting sustainable landuse planning; promoting integrated provision of clean water, sanitation, solid waste disposal etc.

3. Management of human activities geared to development goals and initiatives; controlling harmful impacts of human activities on the environment.

4. Land and water resources are used for a variety of purposes which interact and may compete with one another. It is desirable to plan and manage all uses in an integrated manner. Integration should take place at two levels, the first level considers social and economic factors and the second covers environmental and resource components (water and soil resources conservation and protection).

5. Sustainable agricultural development requires not only conservation, reuse, minimization of environmental damages, but also suitable production practices, appropriate technology, profitability, a system of reinforcing incentives and enforcement of relevant laws and regulations.

6. Use of economic instruments and development of means of institutional mechanism and incentives to encourage small-scale entrepreneurs and industry.

Based upon the results of this Seminar and the objectives and targets of the GAP Master Plan, following "sustainability" goals have been adapted for the development process:

1. Increasing investments to the best achievable level which would accelerate the economic conditions of the Region;

2. Enhancing healthcare and education services so that they reach national levels;

3. Creating new employment opportunities;

4. Improving the quality of life of the cities and improving urban and social infrastructure so as to create healthier urban environments;

5. Completing the rural infrastructure for optimal irrigation development;

6. Increasing the inter- and intra-regional accessibility;

7. Meeting infrastructural needs of existing and new industry;

8. Protecting water, soil and air and the associated ecosystems as a priority consideration; and

9. Enhancing community participation in decision-making and project implementation.

E. STATE OF DEVELOPMENT AND INTERIM RESULTS

As of the middle of 1996, the progress of the integrated, multý-sectoral development program has reached a global financial realization rate of 40%. Out of the total public investment requirement of $32 billion, $12.5 has been invested from the domestic resources of the country. In addition to this, a total of $2.1 billion's equivalent foreign money have been allocated for different projects in the GAP region; a $1.5 billion equivalent major dam and hydropower project, the Birecik Project, on the Euphrates River is under construction via a build-operate-transfer arrangement by a consortium of European firms.

Hydroelectric energy production in 1995 from the GAP schemes was 16 billion kwh, which corresponds to half of the national hydro production. Over 120,000 ha of land is now under irrigation, and another 200,000 ha is currently being prepared to receive irrigation.

The construction of the following projects has now been completed:

Karakaya Dam and hydroelectric power plant (HEPP), Atatürk Dam and HEPP, Þanlýurfa tunnels, Hancaðýz Dam, Derik-Dumluca Dam, Hacýhýdýr Dam, Devegeçidi Dam, Çýnar-Göksu Dam, Çað-Çað HEPP, Þanlýurfa STOL Airport, Gaziantep and Mardin Organized Industrial Districts, and 14 small scale industrial districts.

Following GAP projects are now under construction:

Kralkýzý Dam and HEPP, Dicle Dam and HEPP, Batman Dam and HEPP, Karkamis Dam and HEPP, Çamgazi Dam and HEPP, Kayacýk Dam and HEPP, Birecik Dam and HEPP, Þanlýurfa HEPP, Þanlýurfa-Harran irrigation, Kralkýzý-Dicle irrigation, Batman Left Bank irrigation, Çýnar-Göksu irrigation, Garzan-Kozluk irrigation, Þanlýurfa water project, Gaziantep water project, Diyarbakýr water project and other 47 urban water projects, 16 urban sewerage and wastewater projects, Gaziantep-Þanlýurfa motorway, Adýyaman airport, mass housing projects for cities of Gaziantep, Þýrnak, Diyarbakýr, Batman, Mardin, and Þanlýurfa and Þanlýurfa agricultural land consolidation project.

Over 98% of all villages have now been connected to the road networks, and 99.7% of villages were electrified by 1990. By 1990, all the villages have been provided with telephone connections. Television and radio broadcasts now reach rural areas extensively.

Since the initiation of the project, healthcare facilities have significantly increased. There were 53 hospitals, and 5658 beds in the Region in 1990, and 2397 doctors and 2169 nurses. Person/bed ratio was improved to 854, person/doctor ratio to 2152 and person/nurse ratio to 2353. However, health care services are still below national levels and an ambitious program is underway, with World Bank financing, to improve them rapidly.

Even though the literacy rates have improved markedly due to the GAP activities, they are still below national averages. The literacy rate has increased from 55% in 1985 to 60% by 1990. Male and female literacy rates have increased to 75.5% and 44.3% respectively. Enrollment ratio was 79% in primary school, 33% in secondary, 18% in high school and 3% in tertiary, as compared with 96%, 60%, 25% and 12% respectively in the country as a whole, indicating room for further development.

Municipal infrastructure services were still largely inadequate in the Region. The rapid urbanization and limited financial resources have resulted in low capacities and unmet demand. In 1987, out of the total of 89 municipalities, only 2 had adequate sewerage services, 15% adequate municipal water network, but 80% of them had maps and development plans. While conditions have improved, still out of 170 some municipalities, 33% have water supply networks, 18% water networks under construction, but only 4 adequate sewerage systems.

E.1. Impact of Irrigation

Lower Euphrates Project is one of the seven GAP schemes on the Euphrates River and consists of Atatürk Dam and HEPP, Þanlýurfa Tunnels, Þanlýurfa-Harran irrigation, Mardin-Ceylanpýnar irrigation, Siverek-Hilvan pumped irrigation and Bozova pumped irrigation (see Table). The pilot area which is used here to examine the impact of irrigation is in the Þanlýurfa-Harran irrigation scheme. Main public investments in the Lower Euphrates project have now been completed. One of them is Atatürk Dam and Þanlýurfa Tunnels. Atatürk Dam was completed in 1990 with a reservoir capacity of 48.5 billion m3. Water reaches the Þanlýurfa-Harran plains via Þanlýurfa Tunnels system, which consists of two parallel tunnels each 26.4 km long, and 7.62 m in diameter. One of the tunnels was opened in 1995, and irrigation was practiced in a 30,000 ha area in 1995 (the size of this area was increased to 40,000 ha in 1996). Þanlýurfa-Harran plain has two main canal systems. Þanlýurfa main irrigation canal will irrigate 43,000 ha of land by gravity and 5,000 ha by pumping. The Harran main irrigation canal will irrigate 98,500 ha by gravity.

The 30,000 ha pilot area is located on Þanlýurfa main irrigation canal system. 51.3 km of main irrigation canal, 69.9 km secondary canal, 1,040 km of tertiary canal, 45.5 km main drainage, 2,100 siphons, and other related facilities have already been constructed. Land consolidation activities have been completed in 20,000 ha. There are 62 villages, and 8000 families, having over 26,000 population.

Dryland agriculture was prevalent until irrigation started in 1995. The total production in 1994 accounted to $ 31.5 million with a crop pattern comprised of mainly wheat, barley and some vegetables. The value-added was $60 per decar. With irrigation , cotton became the main crop with still some wheat and barley, and secondary crops were also introduced by the farmers. The most striking change has been in the land used for cotton, from 21% to 45%. Production value rose to $121 million and the value-added per decar to approximately $182, both showing significant improvement in only one year. Value-added per decar increased 3 times and the annual per capita income increased from $1034 in 1994 to $3963 in 1995. This area is now monitored by the GAP Administration via a socio-economic monitoring project to assess the impact of irrigation on different facets of life and economy.

F. STUDIES AND PRACTICES TOWARDS SUSTAINABILITY

A large part of the GAP Administration's program, budget, and activities has been devoted to ensuring a sustainable development in the GAP area. This is further supported by the fact that the Administration is attached to the Prime Minister's Office so decision-making is fast and efficient, and by the authority vested in the Administration to land-use, urban planning and zoning, which provides the basis for integrated water and land development as well as environmental protection.

The existing laws and regulations require that any public investment project have a favorable environmental impact statement before even proposed for implementation.

F.1. GAP Master Plan

The Master Plan has provided the global framework for environmental policies and issues, among other things. It has categorized the potential problem areas into two general classes, i.e. those that can and are to be handled at project level, and those that require a holistic approach.

Project-level areas include industrial wastes, urban sewerage and disposal, solid wastes, air and water pollution due to mining, industrialization, urbanization and other reasons; sedimentation and siltation in dam reservoirs, land slides alongside reservoirs , impact of created water bodies on aquatic life, effect of changes in the flow regimes on river beds and shores, and conflicts in land use for different purposes.

Areas requiring a holistic approach include soil and wind erosion, water accumulation and salination due to insufficient drainage, loss of forest resources to fuelwood and agriculture, overgrazing, water pollution due to overuse of agrichemicals, ecological changes in vegetation and animals, climate change, and water-borne diseases.

The GAP Master Plan proposes two groups of measures to mitigate potential negative environmental impacts.

1. Environmental impact assesments for GAP and related projects,

2. Efforts by public, private and non-governmental organizations.

Upon the completion of the Master Plan in 1989, a number of studies and implementations have been initiated which are described in the remainder of this section.

F.2. Environmental Evaluation of Water Resources Projects
As stated above, individual public projects including those involving water resources have to have a positive environmental impact assessment according to the existing legal frame. The GAP Administration has, in addition, initiated a number of projects with a view to enhancing different aspects of sustainability in GAP. One of these projects involves a model study and its implementation for the management, operation and maintenance of irrigation networks in the GAP area with a participatory approach through the establishment of water users groups.

As a part of the project for implementing management, operation and maintenance of irrigation, an Initial Environmental Evaluation (IEE) has been carried out considering hydrology, pollution, soils, sediments, ecology, socio-economics, health, and imbalances.

The assessment method was based on the International Commission on Irrigation and Drainage publication "Environmental Effects of Irrigation, Drainage and Flood Control Projects: Checklist for environmental impact indication". A number of studies have been conducted in 1992 and 1993 for this purpose and the following reports and technical papers have been prepared.

- *Potential Environmental Impact of Large Scale Irrigation in the GAP Region*
- *Agronomic Factors*
- *Assessment of Current Irrigation Projects in Turkey*
- *Review of the scope for Environmental Studies*
- *Assessment of potential impacts upon ecolog*
- *Drainage requirements*
- *Assessment of Groundwater Resources in Harran and Ceylanpinar plains.*
- *Environmental Health*
- *Soil Conservation and Water Quality*
- *Socio-economic Studies*

F.3. Environmental Evaluation for Euphrates-Tigris System
In collaboration with the Ministry of Environment of Turkey, the environmental assessments of the two rivers and their respective basins are handled separately; the one for the Euphrates by the Ministry and the Tigris by the GAP Administration. The inventory-taking of flora and fauna as well as the pollution maps for the Tigris part has been completed by the GAP Administration through a contract signed with the University of Dicle. The one for the Euphrates as well as the remaining part of the Tigris study are under way. The project was carried out in 7 subgroups-air, water, soil, solid, waste, noise, flora and fauna- and implemented in 3 stages:

1. Preparation of inventory for flora and fauna resources within the project area,

2. Identification of the size of air, water, soil, solid waste and noise pollution together with pollutant sources,

3. Formation of an appropriate monitoring and evaluation model for the measured environmental parameters in various stations within the project area.

F.4. Land Use Planning, Transportation and Infrastructure

The GAP Administration holds, by law, land use authority in municipal and non-urban areas and as such planning power from macro to application scales. In a comprehensive program to complete the land use plans for the whole project area, the Administration has started a large-scale program in which 1/25,000 scale plans for the whole area in the form of seven sub-regions have been completed. The zoning (1/5,000) to implementation (1/1,000) scale plans for all settlements with a projected 2005-year-population of 5,000 or over are now being prepared according to a program based on urgency.

A regional transportation development plan has been completed that resulted in plans and designs for a regional highway-expressway combination, local airports and an international airport, as well as an investment program for the completion of the transportation system that will serve the needs of GAP.

1/5,000 scale designs of water supply and distribution, urban sewerage, treatment, solid waste facilities, electricity networks, and in-city traffic have been completed for the above-mentioned settlement and been reflected in the investment program for GAP.

The land use powers held by the GAP Administration have been used cooperatively with local municipalities and proved to be an effective tool in ensuring land-water development integration and preventing agricultural areas from urbanization and industralization as well as keeping any development away from protected and environmentally sensitive areas.

The authority to land use have been exercised with the same approach in the selection of industrial zones, mass housing projects, major structures and the like.

F.5. Re-use of Return Water and Conjuntive Use of Surface and Ground Waters

In GAP irrigation projects, return water and ground water are used in conjuntion with surface water wherever proven economically and quality wise applicable. Based on the initial feasibility report of the Euphrates by Electrowatt Engineering Co. and subsequent studies, the use of return water once more for irrigation is possible and as such enhances water use efficiency. In the irrigation of the Sanliurfa-Harran Plains both return water and ground water are utilized. The re-use of the drainage water for the irrigation of the Urfa-Harran plain will result in benefits in the form of:

- reduction in the quantity of water needed to be diverted from the Atatürk Dam,
- decrease in the problems about the disposal of drainage water,
- reduction in the salt load to be transferred downstream.

F.6. Re-cycling of Urban Wastewater

Another water resource is the utilization of wastewater in watering parks, lawns and irrigating farms after filtering/treating it to the extent where it will not pose a hazard. A real-world application of this has been materialized by the GAP Administration for town of Siverek, a large town with a population of 100,000. Expansion pf this practice to other urban areas is planned.

F.7. Land Use Planning, Transportation and Infrastructure
In a project widely based on the development of water and soil resources, protection and enhancement of the area's watersheds is of vital importance. A comprehensive watershed rehabilitation program financed by the World Bank is under implementation that covers not only erosion control and afforestation but social and environmental components such as income-generating projects for the population living in forest areas.

F.8. Participatory resettlement and sustainable redevelopment
Some 100,000 people are estimated to be subject to complete or partial resettlemnt as a result of inundation of their villages by the 22 dams to be built. The Turkish Law well compansates these people. However, in recognition of the fact that these are the population group that is affected by development in a direct and compulsary manner, a survey has been commissioned by the GAP Administration to a Turkish NGO (Sociology Association) to look at the sociological and socioeconomic aspects and propose an action plan. The action plan that involves local people in the decision-making process actively, including the site selection, planning, design of redevelopment in a participatory manner as well as consulting services in social and investment aspects has been put into implementation.

F.9. Eco-City and Eco-Village Planning
In line with the philosophy of Habitat II held in Istanbul earlier this year, two pilot planning exercises have been programmed, one for the historical town of Harran and the other for the city of Adiyaman, which is a major town adjacent to the Atatürk Dam.

F.10. Planning for Atatürk Reservoir and Surroundings
An integrated planning and design study has been initiated, with a grant from the Canadian Government covering navigation in the reservoir, tourism and recreation development, land use and transportation as well as afforestation of the large area surrounding the 814 km^2 lake.

F.11. Biodiversity Project
The center-south of the project area is one of the richest zones in Turkey in flora. A World Bank supported biodiversity project has been put under implementation in this area. In addition to this, the GAP Administration has placed on its implementation program the establishment of an arboretum for GAP.

F.12. Regulation of Irrigation Canals/ Water Saving Irrigation Method and Techniques
This study and its implementation was carried out in two parts. In the first part aim is to improve the regulation techniques of GAP irrigation canals. For this purpose Harran Main canal which is the largest irrigation canal that is under construction in Turkey now, was selected and different canal regulation solutions are designed and compared to find a solution with minimum water losses, ease of operation and economy. A mixed regulation which relies on downstream control principle was selected. This new canal regulation method using reliable automatic canal regulation equipment for the most efficient use of water resources, is used in GAP and in Turkey for the first time. The experience gained in this irrigation system will influence the design of future projects.

In the second part of the project, the aim was to improve field water distribution and irrigation techniques. For this purpose 5 different irrigation water management applications are proposed for the distribution network of a large pilot zone (30,000 decars in the Þanlýurfa irrigation project) for the reduction of water losses, ease of management and acceptance by farmers. In these 5 different applications, gravity versus pressurized irrigation, on-demand versus rotation system and upstream versus downstream control combinations are to be analyzed and compared qualitatively and economically in a real-world setting.

F.13. Management, Operation and Maintenance of GAP Irrigation Systems Study

Irrigated agriculture will be the foundation for the sustainable development of the GAP Region. It is understood that sustainable irrigation development requires not only sound design and good implementation of the engineering structures but also proper management, operation and maintenance of irrigation systems. The principal objectives of this study are:

- to identify appropriate water resources management regimes that will ensure the effective development of irrigated agriculture in the Region.

- To ensure that such regimes are technically sound, socially acceptable, financially and economically attractive to the country and to the farmer respectively.

F.14. Atatürk Reservoir Environmental Impact Assessment Study

The aim of this project is the establishment of the necessary monitoring and evaluation system to identify the positive and negative environmental impacts of the Atatürk Reservoir Lake and its surrounding activities to the environment and to determine the measures required for the avoidance or mitigation of the negative impacts.

F.15. Environmental Impact Assessment for Organized Industrial Zones

The objectives of this project are as follows;

- identification of the positive and negative environmental impacts of the activities in the existing or planned organized zones of the GAP Region,

- determination of the measures necessary for the avoidance or mitigation of the negative environmental impacts,

- monitoring and control of these activities during the implementation.

F.16. Major Watershed Rehabilitation in Upper Basins

"Eastern Anatolia Watershed Rehabilitation Project" was initiated in 1993 with the following objectives:

- protection and improvement of the flora, soil and water resources,

- prevention of erosion,

- improvement of the living standards of the villagers.

Through this World Bank-financed implementation, the degraded watersheds of the Euphrates River is developed and improved.

F.17. Formation of Water User Groups

For the sustainable development of irrigation, farmer groups are established in the form of "irrigation groups" in the GAP Region with the following purposes:

- farmer participation and auto control,

- economic and efficient operation and maintenance,

- decrease in the operation and maintenance expenses of the government,
- provision of equitable distribution of supply,

- efficient use of human, time and water resources.

The State transfers the responsibility of the irrigation system operation and maintenance to the irrigation group, but still has the ownership of the system. The irrigation group has the authority to collect water charges from the farmers for the services they provide. In the GAP Region, all of the networks are turned over to the users once irrigation is introduced.

F.18. GAP Geographic Information System Feasibility Study and Pilot Implementation
Geographic Information Systems are the major digital tools for handling spatial data, They are designed to accept large quantities of spatial data derived from a variety of sources and to efficiently store, retrieve, manipulate, analyze and display these data.

Modern technology is used for sustainable water resources development of GAP and for the use of GIS in the GAP, a feasibility study and pilot project implementation study was carried out. This project has 3 stages. In the first stage, the applicability of the GIS to the Region was evaluated from data sources, institutional structure, financing and the potential implementation areas were identified.

In the second stage, a pilot study was carried out in the selected pilot implementation area. In this part, a cascade set, i.e. the whole Region at 1/250,000 scale, a province in 1/25,000 scale and a city at 1/5,000 scale was developed with the natural resources, infrastructure, planned and existing implementations and socioeconomic data.one of the implementable areas identified in the first stage. In the last stage, a terms of reference was prepared for the upcoming general GAP-GIS covering a large spectrum of models.

F.19. Investigation of the Climatological Condition of GAP Region for Near Future
The large irrigation areas and large dam reservoirs in the GAP Region will cause important changes in Region's climate. Consequently, it will be important to know the effects of the climatological and hydrological changes on the future state of water resources for the sustainable development of water resources. For this purpose, a project for the investigation of the climatological condition of the GAP Region for today and near future is initiated.

The studies that will be made in this project are:

- development of climate models and calibration of these models with historic climate data,

- investigation of the Region's climate for the period of 2020-2060 considering the GAP water resources development projects,

- definition of the future hydrological state of the Region and determination of the effects of water resources development projects,

- determination of the river flows by using the obtained climatological data and definition of the behavior of the underground water.

G. CONCLUSION

Turkey is implementing a large-scale development program in its southeast region, with the principal objective of improving the living standards of the 6-million local residents of this 75,000 km^2 area. The comprehensive socioeconomic development project covers a large number of sectors in an holistic manner where the backbone is the integrated development of the region's water and land resources.

The project is planned, programmed and implemented with special emphasis given to an expanded definition of sustainability.

The $32-billion GAP enjoys a very large popular and political support and as such, has been able to secure funding even through the periods of economic difficulty in Turkey.

GAP, with its many different aspects, has earned positive publicity. *Time Magazine* (Jan 1994) and *Infrastructure and Finance* (Summer 1993) have listed GAP as one of *the modern wonders of the World.*

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Water Use Management in Mexico

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IS WATER USE MANAGEMENT NECESSARY?

The 777 mm mean annual precipitation over the 2 million sq km of the country's surface produce 450 cu km of renewable surface and groundwater, which should be enough to satisfy the needs of 90 million Mexicans. The equivalent *per capita* mean annual available water of 5,000 cu m is well above international scarcity standards. However, its uneven space and time distribution, along with waste and pollution, is making water with suitable quality for specific uses an increasingly scarce resource. This scarcity explains the multiple conflicts which occur all over the country, specially in dry regions, among uses, users, states and regions.

An estimated annual withdrawal of 203.45 cu km is distributed among the different uses as shown in Table 1. On the other hand, a reasonably reliable estimate shows that there are almost 300,000 users of national waters[1] in the country. Examples of users of national waters are:

- Irrigation modules which have been transferred to users organizations[2]. Each one cover on average 5,000 ha (individual users are clients of the module's users organization)
- Public or private water utilities (domestic, industrial or other individual users connected to the municipal distribution network are clients of the utility)
- Individual self-supplied agriculture or livestock users, industries, services, hydro and thermal power plants, aquaculture, recreational users, or others who have their own intake or well.
- Users who utilize national water bodies to dispose waste water.

	volume (cu km/yr)			Estimated number of users
	Withdrawal	Waste water	Treated discharge	
Hydropower	129.01	na	na	75
Agriculture & livestock	61.20	12.00	na	121,000
Urban & domestic	8.50	7.30	0.53	157,000
Industry & services	2.50	2.05	0.17	14,000
Aquaculture	1.30	1.30	na	1,000
Thermopower	0.94	3.98	na	47
	203.45			293,122

Table 1. Water uses

There are two important reasons to regularize those 300,000 users: to provide them with legal certainty and to have a reliable data base for water resources planning and management.

It should be clear then why it is mandatory to manage water uses in the country. To do so, the National Water Commission (NWC) carries on the following activities:

- Grant, modify or cancel concessions of national waters, federal zones, and utilization of gravel and sand from river beds[3]
- Grant waste water disposal permits.
- Operate the Water Rights Public Register (WRPR).
- Monitor water abstractions, quality of waste water disposals, as well as users compliance with their legal obligations.
- Define sanctions.
- Monitor water levies payment and send reports to fiscal authorities.
- Reconciliation or arbitration in water users disputes.

LEGAL AND INSTITUTIONAL FRAMEWORK

The Constitution of 1917 establishes two basic principles for water use management. The first one states that the only legal way to use national waters is through a concession granted by the Federal Executive. The second, specifies that planning should be coordinated by the Federal Executive with state governments and agreed with individuals. The National Waters Law (NWL) and the Federal Tax

Law (FTL) define the three main instruments for water use management (Figure 1): regulatory, economic and social participation.

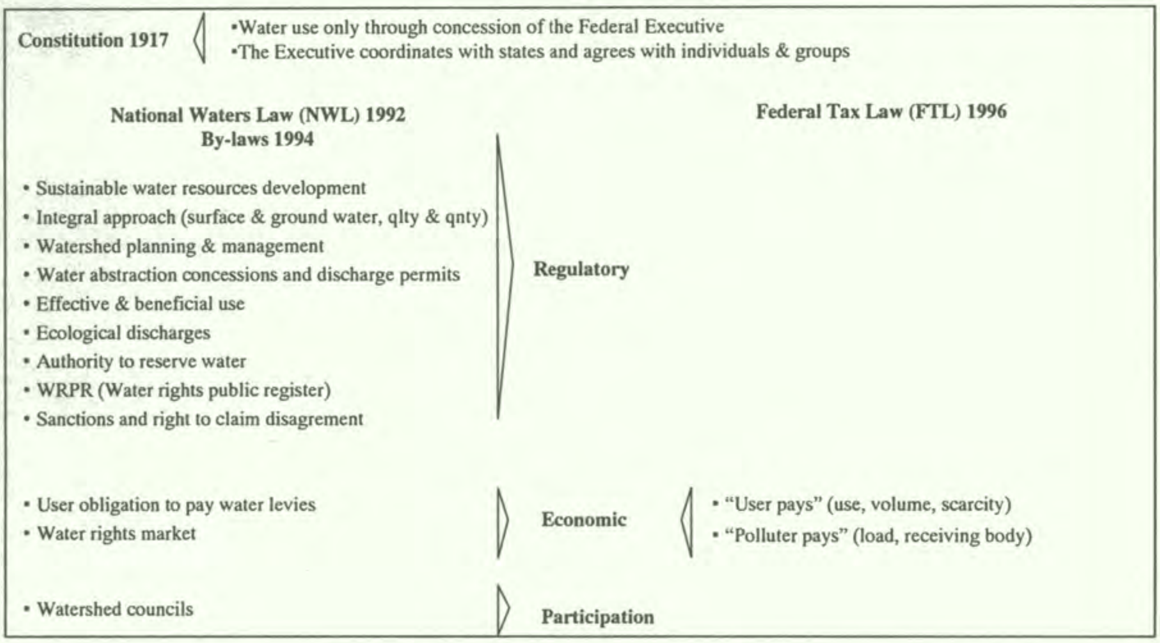


Figure 1. Legal framework

The objective of the NWL is to achieve sustainable development of water resources. It calls for an integral approach of both quality and quantity of surface and groundwater, within watersheds which are considered to be the ideal geographical units for planning, development and management of water resources. Some of its main regulatory features are the requisite of effective and beneficial use for a user to keep his concession; the obligation to register his concession in the WRPR, and his right to claim disagreement with decisions of the NWC. On the other hand, it gives NWC the right to reserve water for uses of public interest or for ecological reasons. Finally, but probably the most important feature of the law, is that it defines NWC as the sole federal water authority in the country.

The economic instruments are defined also by the NWL, namely the users obligation to pay water levies for abstraction and waste water disposal, and the possibility of buying and selling water rights, provided no third-party or environmental negative effects are produced. The FTL complements the definition of the economic instruments by making operational the "user pays" and "polluter pays" principles. That is, the tariff for abstraction water levies depends on the specific use and the relative scarcity of the water source; and the tariffs for waste water disposal levies depend on the pollutants load and on the use and vulnerability of the receiving body.

Water management in Mexico did not start with NWC, which was created in 1989, but goes back more than a millennium to prehispanic times. Its modern institutional tradition started in 1926 with the National Irrigation Commission, which was succeeded by several institutions, even by a Ministry of Water Resources from 1946 to 1976. Their main objective was to build and operate irrigation and water supply infrastructure. The NWC is the first national institution which was designed also to cope with water use management. However, the Law was designed with a more advanced approach including most of the water management paradigms which have gained consensus in international meetings and now the Commission organization has to come up to those standards[4]. In fact, it is now recognized that water use management will be probably its more important task in the near future.

A first step was taken in this direction. In 1995, under the present administration, the scope of the Subdirectorate of Water Management was radically reshaped. Formerly, it covered a very wide spectrum, namely:

- Issuance of water abstraction concessions and waste water disposal permits, and their register in the WRPR.
- Looking after water markets.
- Development and O&M of the National Weather Service, stream flow gaging and water quality monitoring.
- Dam operation during normal and emergency periods.
- Looking after environmental emergencies related to water.
- Design and operation of the Clean Water Program (Drinking water disinfection monitoring and elimination of irrigation of vegetables with raw sewage).
- Water quantity and quality assessments.
- Water resources planning.

Nowadays, the Subdirectorate is responsible for:

- Issuance of water abstraction concessions and waste water disposal permits, and their register in the WRPR.
- Looking after water markets.
- Levies collection.
- Control of water abstractions, waste water disposals and water taxpayers.

This reorganization has integrated the administrative and fiscal aspects of water use administration, providing thus for a single counter for the water user. Within NWC, this requires a permanent interaction with the technical area of the Commission, who provides the water balances and quality considerations required to issue concessions and permits. Also, coordination is required with the legal and fiscal departments of NWC. However, the most important, demanding and complex interaction is that of NWC with water users, which is schematically shown in figure 2.

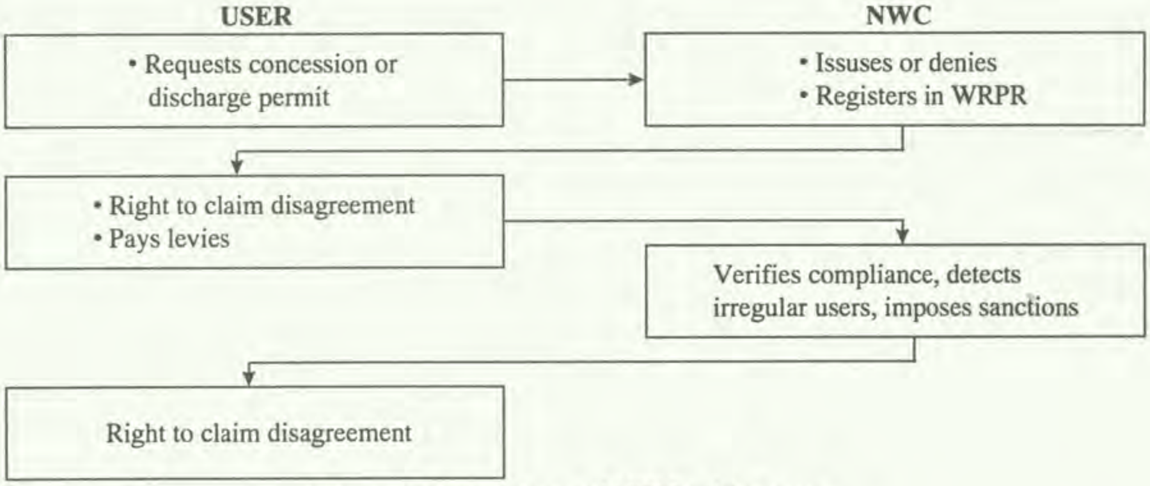


Figure 2. Interactions of NWC with users

An important feature of this relationship is the right of water users to claim any disagreement related to actions or decisions of the authority, whether it is the water volume granted, the allowable values of pollutants stated in a permit for waste water disposal, or a sanction imposed by NWC. This may be done either through administrative means with the Commission itself or by judicial means. Hence, the Commission must produce excellent technical, administrative and legal founding and motivation of each of its acts. Also, when conflicts arise among users or states, the Commission may play a reconciliation or arbitration role. All these activities require very well trained and balanced interdisciplinary teams all over the country, and this in turn calls for permanent capacity building of the institution.

In order to provide the above mentioned services to its users, along with the rest of its tasks, the Commission is structured with six subdirectorates and several central units, as well as with six regional agencies which group several states each, and 33 state agencies. A further step that is now being taken is the substitution of those six regional agencies with 13 watershed agencies whose boundaries are municipal limits as close as possible to water divides instead of the present state boundaries.

WATER ABSTRACTION CONCESSIONS AND WASTE WATER DISPOSAL PERMITS PRIOR TO THE 1992 LAW

Issuance of water abstraction concessions has of course been influenced by politics and social pressures all along Mexico's history, as well as limited by the available information and human, economic and technical resources. Figure 3 shows the main features of such evolution.

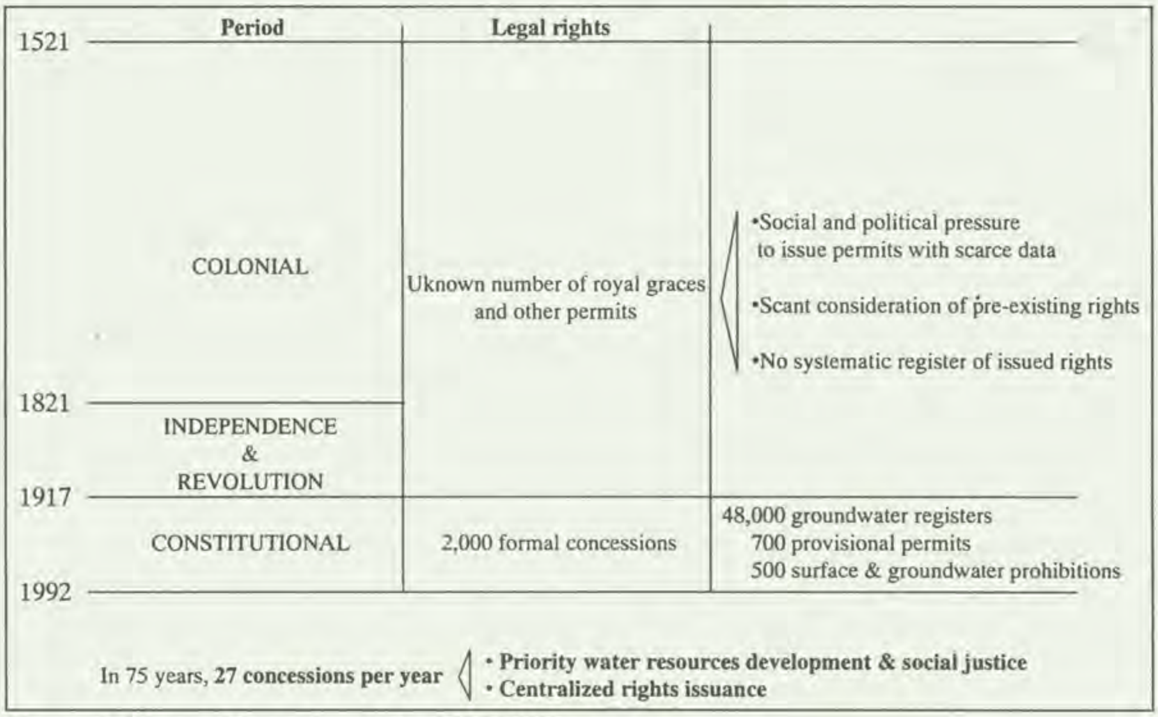


Figure 3. Water rights prior to the 1992 NWL

During the colonial period, water rights were issued according to different legal frameworks which were shaped both by indigenous tradition and by Spanish regulations. Later, water rights responded to Mexico's first efforts of developing as an independent Nation and to the needs of social justice and construction of incipient irrigation works and water supply infrastructure.

Mexico's water legislation after 1917 and until 1992, was influenced also by the need to develop the main irrigation districts, as well as to supply fast growing cities and industries with water. As a result, insufficient attention was paid to water use management and the Federal Executive was the only person in the country with authority to issue concessions. In recent years this authority was also invested in the Water Resources Minister and afterwards in the Agriculture and Water Resources Minister and one of their Sub Ministers. In any case, this excessive centralization and other priorities related to infrastructure and social justice, lead to a very limited number of formal concession titles: 2,000 in 75 years!. During this period, several thousands of registers and provisional permits without the complete legal, technical and administrative supports of a concession title were issued.

Water pollution control has suffered also from a similar lack of resources and from a permanent conflict between development and sustainability. As a result (Figure 4), it was not until 1971 that formal waste water disposal control started to be enforced and only 2,800 formal permits were issued in 20 years.

	Period	Legal permits	
1521			
	COLONIAL	None	• Several laws and regulations forbidded solid and liquid wastes, particularly from mines, into rivers, but no enforcement • Insufficient enforcement
1821	INDEPENDENCE & REVOLUTION		
1917	CONSTITUTIONAL		
1971			
1992		**2,800 permits**	• Identification of 100,000 waste water disposals to severage materials and to national receiving bodies

- **Only 20 years of formal discharge control**
- **Frequent authority and standards changes**
- **44 different standards for specific industrial or municipal discharges**
- **Receiving body classification required**

Figure 4. Discharge permits prior to the 1992 NWL

Moreover, influenced by foreign practices, 44 different discharge standards were issued for specific industrial and municipal disposals and legislation required to classify receiving bodies according to their assimilative capacity them. This latter requirement placed a technical burden impossible to be managed because of lack of reliable data and water quality models which could be suitably calibrated. A further limitation was that the standards were not realistic because they did not allow for gradual compliance according with the real economic and technical possibilities of users. Also, the institutional capacity to enforce those standards was not taken into account.

EXPERIENCES IN ABSTRACTIONS AND DISPOSALS REGULARIZATION FROM 1993 TO 1996

The NWL was passed by Congress in December 1992 and its By-laws were issued by the Federal Executive in January 1994. The National Water Commission was thus only four years old when the law was approved and five when the By-laws were issued. The first implementation step regarding water use management, was to decentralize water abstraction concessions and waste water disposal permits to the Subdirector General, six regional managers and 33 state managers. Also, they were all invested with full authority to look after the rest of the water use management functions in their geographic jurisdiction. They were given powers according to water scarcity, volume of the abstraction or disposal volumes requested by users and third party effects. That is, state managers deal with requests of minor volumes in zones with relatively abundant water, which do not affect other states. Regional managers have authority in dryer zones and on issues that affect more than one state and involve greater volumes; and the Subdirector General deals with even larger volumes in the driest zones, issues which affect more than one region, and with international waters.

By June 1995 it was necessary to design simpler procedures and to exempt users from the payment of titling and registering services, as well as to forgive sanctions to water supply utilities for using water without concession titles (Figure 5). As a result, by November 1995 27,554 concession titles were registered in the WRPR.

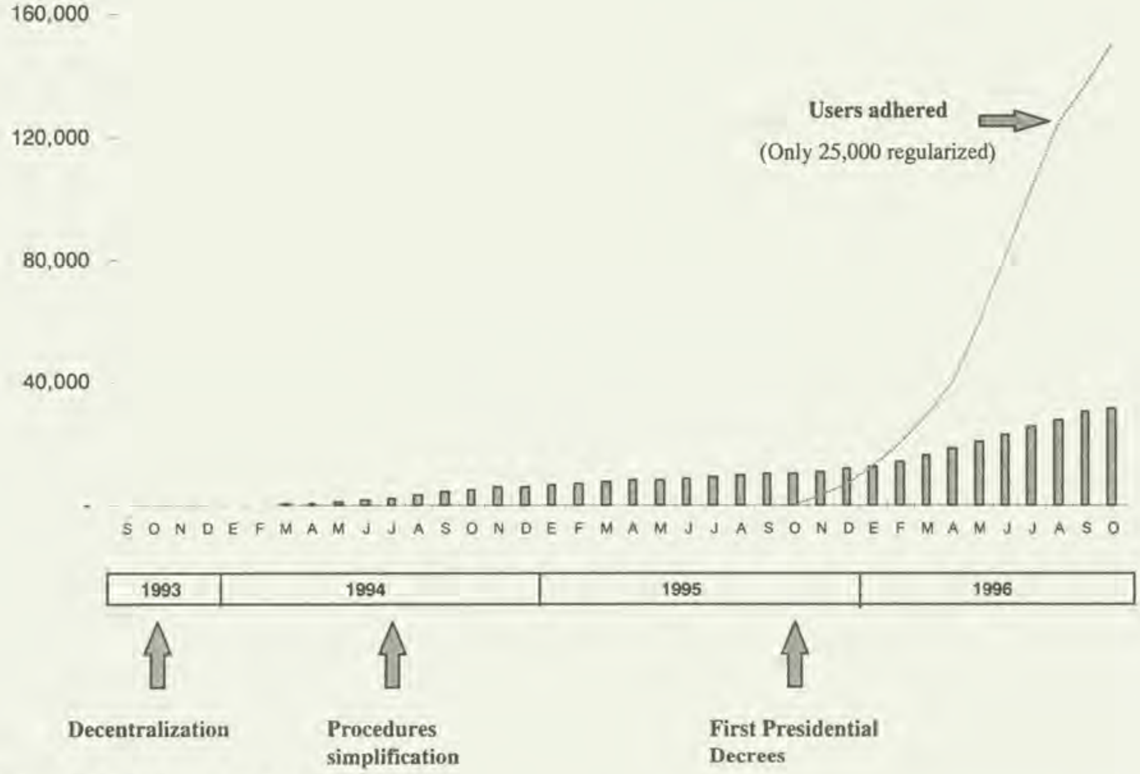


Figure 5. Concession titles in WRPR

The present administration recognized the priority of regularizing all water abstractions and waste water disposals by issuing concessions and permits, so the Federal Executive issued three decrees (for agriculture and livestock, industries and services, and water supply utilities) on October 1995, which further simplified procedures; partially or totally condoned levies debts; forgave sanctions for abstracting water without concession title and disposing waste water without permits[5]; and exempted certain service costs. More benefits were given to agriculture, livestock, aquaculture, water supply users, and micro enterprises than to large enterprises. Moreover, the latter received more benefits if they adhered promptly to the presidential decrees. The result was that after the one year period during which the decrees were in effect, 175,902 of the estimated universe of 300,000, had adhered to them. The capacity of the NWC was not enough to evaluate all those requests and only 25,000 titles were issued. Nevertheless, considering the titles issued prior to the decrees, the WRPR has now 40,000 concession titles. This means 10,000 titles per year as compared with 27 per year during the period from 1917 to 1992, and it also means that with 13% of the estimated users being registered, 71% of the total estimated withdrawal is now controlled.

It is interesting to observe the duration composition of the titles which have been issued. According to the NWL, they can be issued for periods from 5 to 50 years and users may ask for renewal five years before their titles expire. Regional and state managers were instructed to issue shorter periods when in doubt of water availability or where there was evidence of a negative hydrological balance. Figure 6 shows that 32% were issued for 10 years and only 9% for 50 years. Most of the titles with 50 years duration correspond to non-consumptive use in hydroelectric plant and to water supply utilities. This analysis will help in designing communication programs for users to be aware of their expiration dates, and in monitoring programs to cancel those titles which are not renewed on time.

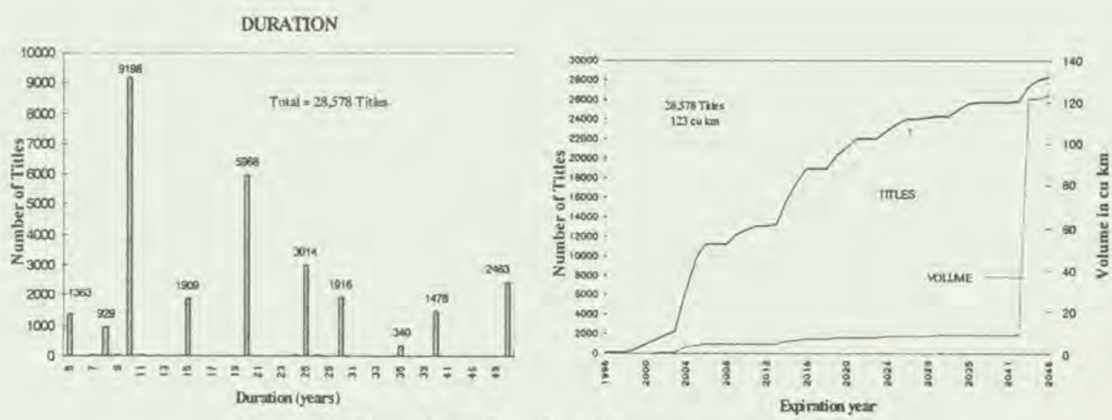


Figure 6. Duration of national waters concessions

Taking into account the relative success of the first decrees, the Federal Executive issued three new ones, based on even simpler procedures and, more important, on a different approach which relies on trusting the user and limiting the discretionality of the water authority. Table 2 compares both sets of decrees. In the two cases only users who used water or disposed waste water prior to October 15, 1995 may adhere to the decrees. Users who, prior to that date, were legally using water, either because they had their formal concessions and permits or some other authorization recognized by the Commission, will be given preference in federal programs, for instance, financial support to make more efficient use of water or when times come to reduce abstraction volumes in a watershed in order to balance withdrawals with availability.

	Oct 12, 1995 - Oct 11, 1996	Oct 12, 1996 - Dec 31, 1998
Users with concession	Preference in support and water use management programs	
Administrative regularization	Obtain concesión	Comply with requierements
Fiscal regularization	Pay water abstractión and levies since Jan 1, 1995	
Volume	• Accordiny to availability and external effects • Users must demostrate effective use	• Declared to be using or needed for installed capacity • NWC can verify
Duration	5 to 50 years	10 years
Waste water quality improvement	• Treatment plant • NWC approves program	• Treatment plant or process improvement • NWC receives and monitors program
Fiscal benefits	Condoning of partial or total debt according to use: • agriculture and livestock • municipal • industry and services and to promptness in adhering to decrees	

Table 2. Presidential decrees

In the first set of decrees, a user was considered to be regularized only after obtaining his title from the Commission. Now it is enough to comply with the NWC requirements for a user to be considered to be administratively regularized and hence to benefit from the decrees. Fiscal regularization means that a user must pay the debts which are not condoned and start paying water levies since January 1995. According to the first decrees, users had to demonstrate they were effectively using the volumes they claimed, and it was up to NWC discretion, taking into account water availability and possible third party or environmental effects, to define the granted volume and the duration of the concession. The new decrees state that in all cases NWC must issue concessions for 10 years and for the volume which a user claims, under oath of telling the truth, either to be using or to need for his installed capacity. This means that instead of having to evaluate each single request, NWC will have to implement the capacity to verify the truthfulness of users claims only in a statistically representative sample. Of course, users who do not declare truthfully may be imposed penal sanctions and their abstractions could be canceled. With respect to waste water disposal under the first decrees, users had to obtain approval from the Commission for their treatment plants construction programs. Now, it is enough for them to present their programs which are not limited to “end of the pipe” solutions, but they can also propose to improve their production process in order to reduce pollution. Similarly to the case of water abstraction, NWC will monitor the progress in waste water quality improvements programs and users will not get the benefits of the decrees if they do not progress according to their programs.

It is expected that the implementation of the decrees will result, by the end of 1998, in the regularization of most of water abstractions and waste water disposals. The price that will be paid is that by then many watersheds in dry regions will probably be over-concessioned. But one has to recognize that nowadays those watersheds are in fact overexploited in the case of groundwater, and that most users in the case of surface water suffer from lack of reliability because of variability of runoff. The ten year period for the concessions will allow for councils, with due representation of water users, to be operational in watersheds all over the country. It will then be feasible to establish water use regulations and programs to reduce water abstractions with the consensus of users, within the participation framework that will be provided by watershed councils.

With regards to waste water disposals, since the approval of the NWL and also with help of the decrees, almost 3,000 new permits have been issued under the standards in force. But the most important recent achievement is the approval of a single new standard for all industrial and municipal waste water disposals, which substitutes the former 44 standards.

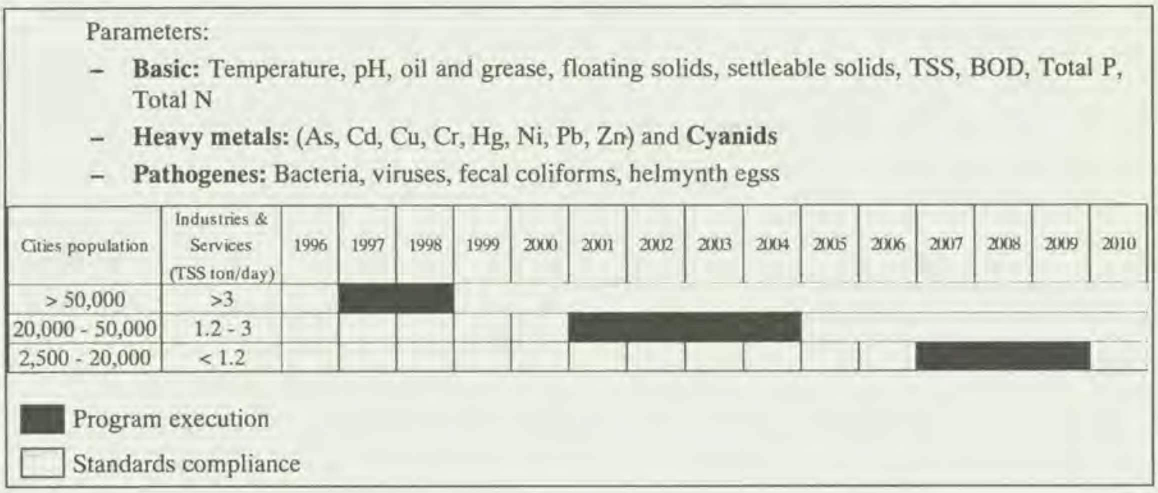


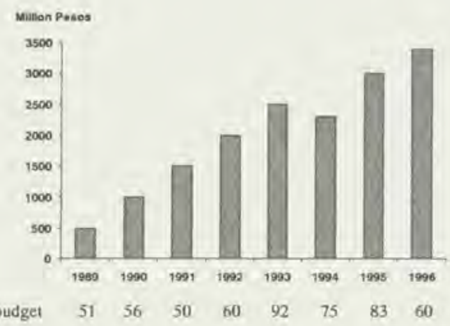
Figure 7. New wastewater disposal standard

Users will have to comply only with the limits established for those pollutants they produce. The new standards takes into account both the use of the receiving body water as well as its vulnerability. It incorporates gradualism (Figure 7), by stating that major polluters must comply on the year 2000, intermediate ones in 2005 and minor ones in 2010. However, existing plants must continue operating according to their original discharge permits or the new standards, depending on the user's will. In case the quality of their discharge exceed the new standard, they can apply for a bonus. Polluters who exceed in more than five times the limits for any of the parameters of the new standard, have to present immediately a program to improve their wastewater quality. The rest of them, have to present a similar program several years before their target compliance date. If they do, they will be exempted from paying discharge levies during the construction period given they progress according to their programs.

The design of the new standard is such that it is feasible that users comply with it and that the authority will be able to enforce it. Once the watershed councils are operating, it will be up to the users to agree on quality standards for the water bodies within their geographical jurisdiction, and to enforce them.

EXPERIENCES IN WATER LEVIES COLLECTION FROM 1989 TO 1996

The Federal Tax Law considers water abstraction levies according to the kind of water use and to the relative scarcity of the water source, as well as charges for titling and other services, and for irrigation and drinking water provided by the NWC itself (Figure 8). The collected amount has increased yearly in current pesos, with exception of 1994, because in that year the Federal Power Commission obtained an exemption and Mexico City didn't pay on time its water supply charges. The yearly income has represented a substantial percentage of the Commission annual expenditures budget; in 1993 it reached 93%. In real terms, it has decreased due to inflation and increases in parity. It is interesting to mention that periodic increases in water abstraction levies have induced water savings in industry and a more rational geographical allocation of water demanding activities. Also, the threat of waste water discharge levies to users who don't comply with standards, has induced construction of many treatment plants.



Distribution 1996 (% of NWC income)

	Water abstraction	O & M	Waste water discharge	Others
Industry & services	44		3	
Water supply	6	18		
Hydro & Thermalpower	13			
Irrigation	0	4		
Debts	2		4	
Various				6

Figure 8. Water levies collection

The income distribution shown for 1996 has remained practically constant. From a purely economic standpoint, it could be argued that the structure of water levies induce cross subsidies from industry and services to water supply whose tariffs are substantially less, and to irrigation which is fully exempted from this contribution even though it is responsible for 80% of the consumptive use in the country. A future gradual decrease in these cross subsidies will have to take into account social and political considerations as well as the need to fund with federal money the various programs of water resource development and management.

The NWC income distribution also shows a very low participation of levies collection from waste water disposal. There are three explanations. One is that industries and municipalities are exempted while they build their treatment plants. Second, the financial weakness of more water supply utilities. And third, insufficient resources for full law enforcement.

FUTURE CHALLENGES

Actions are being taken to improve the legal framework, information systems, enforcement tools and capacity building. Regarding the legal framework, a detailed study is being carried on in order to modify the NWL by-laws, in order to remove the main following restrictions:

- Users, specially those from the rural sector, have difficulties to fulfill cumbersome requirements to obtain their concessions.
- NWC should cancel those volumes that users with concession don't utilize during three consecutive years. In some cases, for instance, decrease in industrial production due to lack of demand caused by economic recession, or decrease in unit consumption due to investments in use efficiency, it could be justified not to make use of the full concessioned volume during a number of years.
- Water rights market transactions are limited by present regulations.
- Social participation through the watershed councils needs a better definition. The present regulations may hinder NWC interventions in emergency situations which require immediate action.

So far, four main independent information systems have been implemented in order to monitor the attention given to users requests, issue concession titles, operate the WRPR, and register and control water levies payments. At least one more system must be developed to follow-up on field monitoring of water abstractions and waste water disposals. Because of the enormous amount of legal and *de facto* users, the complex procedures involved, and the need to link central offices with six regional agencies (which soon will become 13) and at least one user-oriented office in each of the 33 states, the following actions must urgently be started:

- Optimization of existing systems, in order to improve day-to-day operation.
- Gradual modernization including e-mail and full integration of the independent systems, without jeopardizing daily operation.

These actions will be carried on considering the best available technology, but carefully phasing the process with the required institutional capacity building, and giving priority to the following needs:

- Information required to support administrative and fiscal law enforcement.
- Information required by decision makers at all levels and geographic locations.

With regards to law enforcement, and taking into account the 300,000 users who are expected to be regularized during the following 26 months, sound statistical sampling must be carried on in order to verify that users are in fact complying with:

- Abstraction volumes and duration stated in their concession titles.
- Parameters limits stated in their waste water disposal permits.

- Payment of their self-declared levies.

In particular, in the very near future, NWC will have to verify, also in *ad-hoc* samples, that, while adhering to the presidential decrees, users in fact declare truthfully the water volumes they are using or need to supply their full installed capacity, as well as their rate of progress in their proposed programs to improve the quality of their waste water discharges.

Also, it will be necessary to use the best available technology (direct, remote sensing and real time), for flow measurement and water quality monitoring, but again, phasing it properly with institutional capacity building.

Throughout this paper "capacity building" has been mentioned many times. In fact, it is probably the most important future challenge that must be properly faced if the water use management process is to be implemented in a successful and sustainable manner. The following are the main aspects of capacity building that are being implemented or will be developed in the near future:

Regarding institutional development, the legal framework will be improved to overcome some drawbacks that have been identified while implementing laws and by-laws during the past four years. A better geographical organization will be soon achieved by substituting six state-oriented regional agencies with 13 watershed agencies. So far three new agencies have already been implemented. Also, several operative functions have been transferred to users organizations, such as O&M of most of the irrigated surface in the country ; as well as to state governments, as part of a national federalization process. This last action will speed up as state governments establish water offices to take care of many of the functions now carried on by NWC. However, the Commission will retain the functions related to water use management which, according to the Constitution, are federal responsibility in order to assure that water is used for the benefit of all Mexicans, specially for future generations.

Human resources development is not an easy task, mainly because water use management has not caught yet the interest of universities and research institutions. There are many mathematical, economics, and computer models that are indeed useful for parts of the processes involved in water allocation, or in simulation of the behavior of complex surface and groundwater systems. But very little has been developed and written on the practical tools that are needed to solve, with an interdisciplinary approach, complex water use management problems that deal with social, political, technical, historical, legal, economic, administrative and fiscal aspects. It is urgent to develop a water use management discipline and to catch the interest of academia in this task.

Nevertheless, we cannot wait. On the job training of specialists must continue until a formal discipline is developed, procedures must be re-engineered and user-oriented total quality managerial techniques must be implemented at central, regional and state offices. There is also the need to develop a civil service career and adequate retirement programs.

Water use management would be an impossible task without social participation. The implementation of watershed councils will be enforced by fora with water users, as well as mass communication and formal education to rise consciousness on water problems.

Finally, it must be recognized that capacity building is needed not only for NWC, but for the whole water sector. In fact, as more operative functions are transferred, as water rights market becomes a more important tool to allocate water more rationally, and as water conflicts among users increase, there will be more need to improve the capacity to deal with water problems of users organizations, water utilities, consulting firms, universities and research institutions, and even of the legislative and judicial powers and private lawyers as well.

The time frame to face the challenges which have been delineated cannot be measured in months, but in decades. Figure 9 shows a program for the next 15 years, considering that 2010 is the target date for minor polluters to comply with the new waste water disposal standard. After most water abstractions and wastewater disposals are regularized, watershed councils implemented and the legal framework as well as the water availability database substantially improved, it will be feasible to implement, with users participation, regulations for water allocation and use as well as pollution control. It is estimated that this process might take more than ten years, but it is conceived as the only way to recover hydrological balance in overdrafted aquifers, establish rational rights that take variability of surface water into account, and set up water quality standards for lakes and rivers which may be feasible to reach. In other words, it is the only way to set the basis for water resources sustainable development.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Regularization of water abstractions (10 years concessions)															
Regularization of disposal permits															
Implementation of watershed councils															
Improvement of water availability database															
Improvement of legal and fiscal frameworks															
Implementation of regulations for water allocation and use															
Improvement of wastewater quality															
Intensive monitoring of water abstractions and discharges															
Capacity building with "user oriented" approach															

Figure 9. A 15 years program

But ecological sustainability is not enough. The capacity building required for social and institutional sustainability must be a permanent activity during the whole process.

CONCLUSIONS

The Mexican experience on water use management during the last four years shows the need for a trial and error approach for water legislation implementation. Practice has provided plenty of elements to feedback the legal framework. The process has been first to try to solve implementation or enforcement problems modifying procedures which are approved by the Director General of the NWC. If this proves insufficient, propose changes to the NWL by-laws, which are approved by the Federal Executive. Only after trying these two ways, propose changes to the law itself. But also political support at the highest level has been very important. Without the Presidential Decrees, the regularization process would be impossible.

Legal regularization of all water abstractions and wastewater disposals, as well as a better knowledge of water availability, along with social participation are necessary to achieve water sustainability from the ecological standpoint. However, permanent capacity building of the whole water sector is mandatory to achieve social and institutional sustainability.

The best available measuring, computing, and telecommunications technology should be utilized to support water use management, but again capacity building plays a key role, in order that the technological instruments are properly maintained and fully utilized.

Finally, the most important lesson on is that laws, by-laws and procedures should be designed and permanently reviewed in such a manner that users can comply with them and the authority is able to enforce them.

FOOTNOTE

[1] According to the 1917 Constitution all surface and groundwater, excepting a minor percentage of surface water which originates and stays within a state, are national property.

[2] Up to date, almost 90% of the 3 million ha in irrigation districts has been successfully transferred to users organizations.

[3] Federal zones along rivers and contours of lakes and reservoirs are defined as the strip of land formed by 10 m measured from the level of the maximum normal flood. By itself, its management and concession of river beds materials, deserve a separate paper and are not considered in this one. However, it is worth mentioning that, according to the law, they should be integrally managed along with national waters.

[4] Important steps in this direction are being taken by the present administration, but again this would be a topic for another paper.

[5] Environmental damage is sanctioned.

Integrated Water Resources Management in the Metropolitan Region of Sao Paulo

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ABSTRACT

In recent years the subject of sustainable development has gained a substantial evidence among water resources professionals. It is clearly accepted that sustainable development will be achieved in the water sector only after the recognition that the traditional water quantity supply and demand analysis alone is not sufficient for good water resources planning and management. An effort should be made to develop methodologies that encompass both, quantitative and qualitative aspects of water resources management. Besides that, social, economic and political aspects must be explicitly considered in the analysis. This lead to the development of the concept of integrated water resources management in which all the multidisciplinary aspects are taken into account. In this paper the necessary measures to achieve integrated water resources management are discussed. These include technical, legal and institutional aspects. Recent developments in the Brazilian context are presented showing that even in less developed countries the concept has a great potential for implementation. Special attention is given to the situation of the metropolitan region of São Paulo with its serious conflicts of water use and the importance of public participation in the decision process. It is emphasized the flood control issues including the need for non-structural measures as important mitigating mechanisms for countries with lack of capital resources.

INTRODUCTION

Water resources management plays a definite role in the development of any society, specially in the developing world. Excess or deficit of this precious and vital resource are equally important and of concern to any responsible government. In the past the question of development was treated from an economic standpoint alone. Lately, due to public awareness towards environmental preservation the situation has changed drastically. It is not uncommon to find, even in less developed societies, examples of projects that have been restrained due to failure in passing environmental impact statements. Besides that, social and political issues tend to be more explicitly considered in the decision process.

It is clear that the age of analyzing water resources development plans from a quantitative point of view alone has passed. Water quantity and water quality are absolutely tied together and sustainable development imposes social, political and environmental considerations at early stages of the analysis. The Brazilian experience is no exception to this rule. Public pressure, after the democratization process in the early 80's, forced congressmen to propose a new Federal Constitution in 1988 in which environmental and water issues have an specific chapter (chapter 21).

The metropolitan region of Sao Paulo, located in the upper Tiete river basin, presents a multitude of water use conflicts involving economic development and environmental conservation. In this paper it is presented the legal, institutional and technical aspects of the integrated water management system implemented in this region. Emphasis is given to conflict resolution techniques including the flood control issue and the associated non-structural measures in use to mitigate the effect of frequent flooding in this large urban area. A multiobjective decision support system for decision-making involving conflicting objectives is presented.

INTEGRATED WATER MANAGEMENT

Integrated water management may be understood as a process of complex allocation of limited resources among competing uses. On top of this, the decision process involves multiple objectives and multiple decision-makers. In general the basic conflict of objectives arises between economic efficiency and environmental preservation. Moreover, in less developed countries this issue is particularly complex due to the fact that basic social welfare needs are not yet fulfilled and the world ecological conscience calls for preservation of the natural environment. It is clear that if the natural systems in these less developed countries are to be left in a "laisser-faire" style, the result, according to the second law of thermodynamics, will be maximum entropy and consequent deterioration of the natural ecosystems in the same manner as it has been observed in the developed countries of the western world.

There are basically three important aspects that, from a technical point of view, must be considered in integrated management. First, is ***water charges*** to incentivate proper use and efficiency. Second, is ***cost allocation*** in multipurpose developments and third is an appropriate system for issuing ***permits***. The latter is the basis of water management at the watershed level. Geographic information systems coupled with remotely sensed information play a definite role in establishing a ***Decision Support System*** for water permits. These simulation models with no clear objectives defined, generate a series of possible scenarios that can be properly analyzed by the decision-makers. Recent advances of informatics are propitiating the frequent use of this technique for integrated water resources management (Labadie et al., 1989; Vlachos and Fontane,1990; Braga and Barros, 1992; Wolbring and Schultz, 1995; Loucks, 1995). It is clear, however, that implementation of alternatives analyzed under DSS can only take place if an appropriate legal and institutional framework is available.

A multitude of methodologies have been proposed to systematize the decision process in such a complex environment. Cohon (1978) review critically these techniques, Goicoechia et al. (1982) propose the use of a particular method (ELECTRE) which can accommodate the consideration of a large number of objectives for watershed planning. Common to all these proposals is the existence of a clear set of objectives and decision-makers. This, however, is not sometimes the case in many decision process in water resources. The difficulty in capturing the subtleties of socio-political factors and the difficulty of quantifying these factors are major drawbacks in the existing multiobjective and multiple decision-maker techniques. In this paper it is presented a decision support system that operates with ELECTRE II and compromise programming which has been applied to such complex decision situation with multiple objectives and multiple decision-makers.

STATE OF SãO PAULO WATER RESOURCES PLANNING AND MANAGEMENT

The metropolitan region of São Paulo is located in the eastern part of the State of São Paulo in the upper Tiete river basin (Fig. 1). Its present population of approximately 16 million is responsible for 27 percent of the industrial output of Brazil and 62 percent of the industrial output of the state. Water resources planning and management in this area is inserted in the context of the integrated management system of the State of São Paulo. The metropolitan region of Sao Paulo is located in the water management unit (WMU) of the upper Tiete river basin. The state was divided into 22 of these units which boundaries coincide with the watershed. The size of each unit was defined considering the economic output, population, environmental issues, number of municipalities in the unit, etc.

The highest decision level in this system is the State Water Resources Council (**SWRC**) created by State Government Decree 27.576 in November 11, 1987 having the mission of formulating the **State Water Resources Policy** in Sao Paulo State. The State Water Resources Council has a composition of 18 members including the state government, municipal governments and non-governmental organizations with equal rights of voting The principles ruling the State Water Resources Policy are: a) water resources management must be performed in an integrated and decentralized view with public participation, b) the river basin should be adopted as the basic unity for planning and management of water resources, c) water resources should be recognized as a public good, with economic value, which implies charging for use and for discharging (polluter-pays), d) the allocation of costs associated with multipurpose projects among all users, e) anticipated identification and prevention against adverse effects from pollution, flooding and soil erosion processes, f) to guarantee the compensation against damages for municipalities whose lands have been inundated by reservoir construction and also for municipalities which lie inside areas of environmental protection and g) to couple the water resources management with the regional development and the protection of environment.

IMPLEMENTATION MECHANISMS

The implementation of the State Water Resources Policy is done through a **State Water Resources Plan (SWRP)**, an **Integrated Water Resources Management System (IWRMS)** and a **Water Resources State Fund (WRSF)**. The preparation, implementation, evaluation and control of the State Water Resources Plan creates a planning process which is dynamic and iterative, with periodic updating guided by mechanisms of follow-up and appraisal of the results. In this way, the SWRP contains the state guidelines for water resources management for medium and long range targets considering interbasin interference and using the watershed as the basic planning unit an the annual and multi-annual programs of works and services for multipurpose water resources development in addition to forecasting the control, restoration, protection and conservation of water resources.

In 1991 the first SWRP was proposed and approved by the State Congress for the 1992-1996 term. Incidentally, this term does not coincide with the Governor and State Congressperson terms which started in 1995. In this way the overlapping allows sufficient time for the newly elected officers to get acquainted with existing plan and to prepare the new plan for the next 4-year period. The evaluation of the plan is done through an annual report prepared by the executive office of the SWRC for each WMU.

The procedure for preparing the plan is given in Fig.2. It is important to notice the interaction between the State Plan and the basin plans developed for the various Water Management Units (WMU). boundaries. The State Plan provides directives and technical and economical mechanisms for orientation of basin plans and programs. The basin plans, on the other hand, provide different programs for sustainable development of the WMU's. Other important points in the process are: decentralization of the planning process allowing the WMU to propose their own development programs, requisite of consolidation and integration of basin plans at State level and the consideration of interfaces with other State, regional, municipal and urban plans. Once the State plan is established it is submitted to the State Congress and becomes a law.

The IWRMS was designed to allow the integrated, decentralized and participative water resources management assuring that water be utilized and controlled in quantity and quality by the present users and future generations. At the basin level, the **Basin Committee** is the decision board in charge of approving the basin plan and deliberating on all issues related to water management in the basin. The Basin Committee has 48 members in its composition: the state, municipalities and non-governmental organizations each one of them with 16 members. The administrative support of the basin committees is provided by the **Basin Agencies**. These agencies have an administrative board with representatives of the three segments earlier mentioned and are in charge of generating the plan for the basin committee, collect the charges for water use and pollution and finance programs for sustainable development of the basin. Water users , individually or in association, will take part in the basin committees. This will be important in the definition of the financial contribution they will be making towards the effective implementation of development plans. Universities, research institutions and technical-scientific associations have a seat in the basin committees. Fig. 3 illustrates the complex involvement of the different institutions in the IWRMS of the State of Sao Paulo.

The financial support to the effective implementation of the basin plans is provided by the SWRF. This fund receives contributions from the Federal government, the State government, the municipalities and specially from the water users and polluters through water charging. The State financial support to the fund is done according to the regular budgeting procedure of the State, that is, consideration is given to the multiperiod State planning, the Law of Budgeting Directives that antecipates the discussion on budget priorities and defines goals and priorities of the multiperiod planning for the subsequent term and the annual budget, that defines the incomes and expenditures for the fiscal year. Incomes of SWRF include provisions made by enterprises controlled by the State, public utilities that are water users, private users and national and international loans. In this way the SWRF establishes criteria for participation of the State in fomenting regional programs. Figure 5.4 presents a more detailed explanation of the structure of the SWRF.

LEGAL AND INSTITUTIONAL ASPECTS

The proper instrumentation of good water resources planning requires adequate technical and legal instruments. In the Sao Paulo State Water Resources Plan three instruments have been proposed: water permits either for derivation or for dilution of wastes, water charging and cost sharing of multiple purpose or common use water resources projects. The basis for implementation of all the mechanisms aforementioned are given by the constitution of the state of Sao Paulo of October 1989 and the Water Resources Law 7763 of December 30, 1991. The relevant sections of the State Constitution for water resources management are:

"Section 205 - The State will institute by law, an integrated water resources management system, congregating State and municipal organisms and nongovernmental organizations and will assure financial and institutional means for:

I - rational utilization of surface and groundwater and its priority for domestic use,

II - multiple use of water resources and cost sharing of respective civil works,

III - protection of waters against actions that may impair its present and future use,

IV - defense against critical events, that may pose risks to health and public safety and economic or social damages,

V - celebration of agreements with municipalities for management of waters of local interest,

VI - decentralized, p8articipatory and integrated management with respect to other natural resources and considering the peculiarities of the respective watershed,

VII - development of navigation and its economic development.

Section 211 - In order to guarantee the actions described in section 205, the utilization of water resources will be charged according to the peculiarities of the watershed and the product applied in services and civil works referred in paragraph 1 of this article.

Paragraph 1 - The result of the state participation in the exploitation of the hydroelectric potential in its territory, or from federal financial compensation will be used mainly in:

1 - services and hydraulic and sanitary works of common interest as described in the state plans for water resources and sanitation,

2 - in the financial compensation to the municipalities affected by reservoirs of the state or that have had restrictions to their development by environmental regulations in their territories."

It becomes clear the commitment of the State with the proper management of its water resources. The supreme law of the State, its Constitution, has an entire chapter on water resources. Section 211 recognizes that proper integrated management requires water charging as a mean to raise appropriate funds to implement the basin plans and the state water resources plan.

Water charging has been used in the developed world for some time now. This has been an excellent instrument to provide economic rationalization in the use of water. Water charging is also a mechanism of generating financial resources for works and services related to the protection, conservation , restoration of water resources. In the federal legislation the polluter-pays principle is declared in the sections 110 through 116 of the Federal Water Code of 1934 and section 4 item VII of the Federal Law 6.938 of August 31, 1981. The user-pays principle, mentioned in section 211 of the State Constitution of 1989 has support from section 36, paragraph 2nd of the Federal Water Code. Water permits are anticipated in the Federal Water Code (sections 43 through 52). DAEE (Departamento de Aguas e Energia Eletrica) is the State agency responsible for issuing these permits on a quantitative basis. CETESB (Companhia de Tecnologia Ambiental) is the State agency responsible for issuing the environmental permits and consequently taking care of the water quality in the state watercourses.

Law 7763 of December 30, 1991 regulates the general principles stated in the Constitution. The law clarifies the different mechanisms of plan development and implementation including water permits, water charging and cost sharing. Besides it regulates the creation of basin committees and basin agencies. The harmonization of the federal water resources law, recently approved at Federal Assembly and in discussion at the Federal Senate, and the State water resources law, approved in December 30, 1991 is essential for implementation of the process in the State.

UPPER TIETE RIVER BASIN AND THE METROPOLITAN REGION OF SAO PAULO

The MRSP includes the Sao Paulo city plus 39 adjacent cities occupying an area of 8,050 km^2 , with 1,500 km^2 of urbanized area. The present population is approximately 16 million, with estimates of about 21 million for the year 2005. This region (Fig.4) is the largest urban concentration of South America and the largest industrial complex of Latin America. Its industrial output encompass around 27% of the national total production and 62% of the state total. The population represents approximately 50% of state total of 33 million inhabitants. The growth of this population took place at an explosive rate as can be appreciated in Fig. 5. Demands for different water uses have grown accordingly as shown in Table 1.

From Fig.5 it can be seen that it was not until 1930 that the city of Sao Paulo became an important urban center. At that time the basin water resources were mainly used for hydropower generation and water supply for domestic consumption. By 1955 the city achieved the status of an industrialized urban society. More critical water and energy shortages occurred, as well as floods, with growing socio-economic losses. Water pollution begins to call the attention of decision-makers who prepare several plans without any concrete action in practice. It was not until 1967 that regional water supply plans emerged due the creation of the National Housing Bank, which provided limited funds for sewage treatment works and pollution control alternatives.

The driving force of this very high rate of urban development experienced in the region from the 30's on, is due to the Serra do Mar project. This project, implemented after the severe drought of 1927, increased the number of reservoirs from the original Parnaíba (built in 1901) and Guarapiranga (built in 1912) to a set of 5 reservoirs, namely Pedras, Edgard de Souza (at the earlier Parnaiba site), Pirapora, Billings and Guarapiranga, plus the pumping stations of Traição, Pedreira and Edgard de Souza. The idea of the system was to reverse the natural flow of the Tiete and Pinheiros rivers by impounding water at Edgard de Souza dam, and pumping it back to the Billings reservoir (Fig. 4). From Billings reservoir, water was transferred to the Pedras reservoir and to the Henry Borden power plant, generating electricity with a hydraulic head of 750 m allowing an installed capacity of 800 MW.

The backwater profile of Edgard de Souza dam, when its gates are closed, extends some 37 km upstream, thus creating a lake, within the urbanized area. In the event of a flood the gates at Edgard de Souza must be opened with the due antecedence to lower the river depths and consequently avoid greater damages in the urban area. Presently, there are several points along the Tiete river which are inundated several times a year on the average. The solution to the severe flooding problems in the region involves three phases: informational, structural measures and sustainable non-strucutural control measures.

In the first phase it is proposed the establishment of a flood warning system to mitigate the present effects of the floods. Structural measures are costly and and must be considered in a second phase. An important component of this new approach towards urban drainage management in the region is the flood warning system developed by Braga et al. (1995b) depicted in Fig. 6 . It involves the collection of all the data generated by the telemetric network and meteorological radar, processing of the data for consistency and storage. This data is then used by rainfall and river stage forecasting models to issue quantitative rainfall (up to 3 hour in advance) forecasts and subsequent flows an river stage forecasts. A considerable amount of data has been stored since the beginning of the operation of the system. Approximately, 80,000 weather radar volume scans are stored in 650 magnetic tapes from May 1988 when the Ponte Nova weather radar began its operation. As of March 1991, storage of telemetric data was systematized comprising 120 Mb of ASCII information.

The Information Management System (IMS) in operation at University of São Paulo through an agreement with the Departamento de Aguas e Energia Eletrica has several users varying from hydroelectric power companies, cities administrations, civil defense commissions, environmental control agencies, TV stations, and the general public. These users communicate with the system either through dedicated telephone lines or through regular telephone lines under a menu operated software that allows the user to request different products generated by the IMS. These products include: rainfall intensities and accumulated rainfall, CAPPI, rainfall forecast and river stage forecast. Since 1990 a regular program of reliability assessment of the system has been implemented. In terms of flood forecasting using the hydrologic state model (HSM) for the city of Sao Paulo a previous survey by Braga,et al. (1992) indicates a margin of error in the range of 10 percent. It is clear from these results that even very simple models can provide reliable results once a good spatial rainfall estimation is available.

The second phase is related to the building of canals, dams, detention ponds, reservoirs and similar hydraulic strutures which will allow greater flows at the existing drainage system. These works, part of the so-called Tiete Project, have already been object of a biding process for the Cabuçu river and Tiete river dowsntream of junction with the Pinheiros river, with financial resources of the state of São Paulo and OECF of Japan in the value of approximately US$ 600 million.

The third phase emphasizes the non-structural measures which should basically guarantee that the design floods of the second phase above will not increase significantly with time. These measures are mainly legal and administrative including regulations to encourage infiltration in parking lots and houses, urban drainage tax, municipal building code requiring permeable areas in new constructions, etc.

Water demands for domestic and industrial consumption have grown significantly (Table 1). Interbasin transfers from the Piracicaba basin at a rate of 33 m^3/s (Braga et al. 1992) have been in place since the 70's to increase water availability in the Tiete river basin. Despite all the efforts, the current water supply deficit in the region is of the order of 4 m^3/s. The Tiete project has planned the increase in water availability in the headwaters of the Tiete river basin in 6 m^3/s through the construction of reservoirs (Fig. 4) at a cost of US$ 400 million to be financed by the State of São Paulo and OECF of Japan. Additionally the government of São Paulo is considering the re-use of wastewater through the transfer of 4 m^3/s from the Billings reservoir to the Guarapiranga reservoir.

The resulting untreated wastewater is discharged into the Tiete river at a rate of 28.0 m3/s. This results in severe water quality problems in the system. The Tiete project has an environmental restoration component aimed at ameliorating the water quality in the upper Tiete river basin. Industrial pollution control has been enforced by the environmental control agency of São Paulo (CESTESB). Investments of US$ 500 million were shared by the industries and the Brazilian Development Bank. Municipal pollution control involves the construction of 5 swage treatment plants at secondary level (activated sludge) with costs of Us$ 1 billion to be shared by the water supply utility of São Paulo (SABESP) and the Interamerican Development Bank.

CONFLICTS OF WATER USES.

From the scenarios previously outlined, it is clear at least two conflicting issues emerge:

(a) the high requirements of water supply in contrast with low availability at the Tiete river basin and (b) the disposal of untreated wastewater, towards to continental lands (following the natural flow of Tiete river downstream) or towards to Billings reservoir through diversion (pump stations) along the Pinheiros river. It is hoped that the second problem will be gradually reduced with the program of environmental restoration aforementioned. Pressure groups representing the interests of local population are trying to avoid the wastewater disposal into their regions. Until 1992 there existed a operational practice that allowed to pump 50% of Tiete river flow at confluence with Pinheiros river (Figure 5.9) into Billings reservoir . Despite the large active storage capacity of Billings reservoir (1,200 million of m3) it became a very large oxidation lake. Thus the main problem associated with this way of operating the system is the anaerobic condition at Billings reservoir. On the other hand, if wastewater is dicharged only to Tiete river downstream, this will present a similar problem mainly for the cities along the water course. Actually this situation occurs nowdays since the diversion of river flow to Billings reservoir has been prohibited since 1992 due a legal device which was obtained thanks to pressures from ecological groups claiming for Billings preservation.

The water supply problem also presents a spatial conflicting situation between two important regions: the upper Tiete river basin versus the Piracicaba river basin. As previously mentioned, since the 70's the water supply system of the MRSP uses an inter-basin transfer system that pumps water from Jaguari, Cachoeira and Atibainha rivers (Fig. 4) into Paiva Castro reservoir, where water is pumped to a large water treatment station (33 m^3/s). This system (Cantareira system) has been the main source of water supply for the MRSP. The system design was done at a time when the rate of industrial development in cities in the countryside of Sao Paulo state was low when compared with the MRSP. Thus, in the beginning of the 70's, water transferred from the Piracicaba river basin was a minor problem. Presently, however, the situation of Piracicaba river basin reveals an opposite scenario in terms of development. This river basin includes 12,400 Km2, encompassing around 8.5 % of total population of state with distribution highly concentrated (87%) in urban areas. Based on studies developed for the SWRC (1990), an estimate of water demands for urban, industrial and irrigation purposes at Piracicada and upper Tiete river basins is presented in Table 2.

BASIS FOR AN INTEGRATED MANAGEMENT APPROACH

The physical, socio-economic and political complexities of water resources systems described before required an integrated view to formulate an inter-regional plan taking all water resources issues into account. The three basin committees involved produced an integrated plan. Seven planning alternatives were generated derived from studies made by the consortium of consulting engineering firms. A briefly description of each one is presented in Table 3. The final decision about the planning alternative to be selected is the charge of the State Water Resources Council (SWRC), after hearing the River Basin Committees.

The planning alternative PA-1 is an extreme solution that preserves Billings reservoir but brings all pollution to the cities and reservoir along Tiete river downstream. On the other hand, the planning alternative PA-7 pumps back all water to the Henry Borden power plant. This alternative emphasizes the electric power generation and also avoids the wastewater disposal to downstream Tiete river but imposes serious pollution problems to Billing reservoir. The remaining alternatives are placed in an intermediate position between the previous ones. Each planning alternative has a proper potential to satisfy water supply requirements, as shown in Table 4, where the flow availability is grouped in two types of treatments required for water supply (II. requires a higher treatment level than I). It should be clear that more water flow availability from an alternative will allow less water transfers from Piracicaba river basin.

MULTICRITERIA FORMULATION

The decision making process was supported by a multicriteria methodology, which uses the ELECTRE I algorithm, developed by Benayoun et al. (1966) and its expanded version ELECTRE II., developed by Roy and Bertier (1971). Several advantages (Hipel, 1992) and also some critiques (Hammadeh et al., 1990) of the current state of art in multiobjective decision theory have been reported in literature. Despite some theorethical controversies, ELECTRE models have been recognized as an appropriate ranking technique for river basin planning problems which are characterized by a discrete set of alternatives that are to be evaluated with qualitative as well as quantitative criteria. That is the case of the decision making problem of the MRSP.

The idea in ELECTRE I is to choose those alternatives which are preferred for most of objectives and do not cause an unacceptable level of discontentment for any one objective. Three concepts are developed in ELECTRE-I: concordance, discordance, and threshold values. The concordance between any two alternatives i and j is a weighted measure of the number of objectives for which alternative i is preferred to alternative j (denoted i P j) or for which alternative i is equal to alternative j (denoted i E j) and is given as:

$$\mathrm{C(i,j)} = [\sum_{k \in A(i,j)} w(k)] / \sum_{k} w(k) \qquad (1)$$

in which $w(k)$ is a weight on objective k and $A(i,j) = \{ k / i \text{ P } j \text{ U } i \text{ E } j \}$. By definition, C(i,j) is in the interval (0,1).

The discordance index is defined as:

$$\mathrm{D(i,j)} = [\max_{k} \ \{Z(j,k) - Z(i,k)\}] / \boldsymbol{R^*} \qquad (2)$$

in which $Z(j,k)$ is the value of objective k under alternative j, and R^* is the largest difference value of objectives among k alternative vectors. Obsviouly, D(i,j) is also a number in the interval (0,1).

To synthesize both the concordance and discordance matrices, threshold values (p,q) are defined, both being in the interval (0,1). When choosing a value of p, usually larger than 0.5, the decision maker specifies the amount of concordance desired. By choosing q, he specifies the amount of discordance he is willing to tolerate. The result of ELECTRE-I is a preference graph which presents a partial ordering of the alternatives. ELECTRE-II is then used to obtain a complete ordering.

Eight macro-objectives were defined to evaluate the seven planning alternatives presented in Table 3, as shown in Table5. The measures of objectives were translated in a common ordinal sacale varying from 1 (worst situation) to 5 (best situation). Based on this scale several distinct groups of specialists evaluated the performance of each planning alternative to satisfy the macro-objectives and criteria, thus constituing a matrix of evaluation. This matrix plus selected threshold values for *(p,q)=(0.8,0.2)* are the basis for application of ELECTRE algorithm. Therefore, a decision maker's structure of preference, defined by the weight vector **w=(w1, w2...w8),** will determine the ordering of the planning alternatives.

The sensitivity of the model was tested using two extreme cases. Decision-maker 1 (DM1) has a greater preference for the water supply objective and also prioritizes the preservation of Billings reservoir rather than any other place. The second one (DM2) represents someone with prioritizes water quality objective and the lower Tiete river basin. Table 6 shows the weights adopted by each one of decision-makers and corresponding results.

These results and other tests also performed reveals a good consistence of the model. The decision maker DM1 puts a greater weight on water supply objective and also (not showed here) had preference to protect Billings reservoir. In this case it is easy to realize (Table4) that planning alternatives PA-5 and PA-6 are the best options since they offer the greatest water supply values.

The decision maker DM2 chose water quality as the main objective wanting to protect the lower Tiete river rather than Billings reservoir. Thus, the planning alternative that better accomplishes this preference is PA-7 (Table 6) since it pumps all wastewater to Billings reservoir. On the other hand the worst situation to DM2 is found with PA-1 since all wastewater disposal goes Tiete river downstream.

The proposed methodology has been used as a decision support system aiming the selection of a planning alternative in the context of river basin committees. The DSS is implemented in a laptop computer and has a user-friendly interface to facilitate the interaction of members of basin committees and of the SWRC. Before assigning weights to objectives, the members of the river basin committees attend to a general presentation showing the water resources problems and specific instructions about their participation in the decision-making process using the multicriteria model. Besides the advantages that comes from the improvement of information for all participants, the process of assigning weights to objectives, rather than choosing directly a planning alternative, represents a way of avoiding, or at least minimizing, the inclusion of self-interest of persons and groups as unique components of decision making process.

CONCLUSIONS

Integrated water resources management is a major issue towards sustainable development in any region of the world regardless of its degree of development already achieved. Quantitative and qualitative aspects should be considered with equal emphasis. Equivalently technical aspects should be treated together with legal and institutional aspects to form a model that is truly applicable. Essential instruments to effective implementation of integrated water resources management include: an efficient water permits system that encompasses modern technology of geographical information systems and legal expert systems, a water charging scheme that allows the existence of a water resources fund to finance actions in the watershed and a cost sharing mechanism for multiple use hydraulic works.

The case study presented in this paper shows that many important steps have been taken towards the effective implementation of integrated water resources management in the metropolitan region of São Paulo. Legal instruments including sections in the Federal Constitution provide the base for a sound implementation of integrated water management in the region. Care must be exercised, however, since the proposal of law instituting the national water policy and management system gives excessive power to federal agencies. This will make it very difficult to effectively implement the decentralization of the decision process. In this respect, the participation of non-governmental organizations of the water sector is fundamental to provide guidance to the political sector responsible for analyzing and approving the project.

The evolution of demands for water supply and other purposes in the Metropolitan Region of Sao Paulo has occurred at fast rates in the last decades, thus resulting serious problems concerning the expansion of infrastructure to water resources management. The lack of treatment of effluents has created problems to public health and also, originated the need of inter-basin transfers to satisfy growing water supply requirements. Nowadays there is a new organizational and institutional structure aiming to give an integrated management solution to those water resources problems. After in depth studies, seven planning alternatives were generated. The socio-political decision process about the selection of an alternative has been conducting with support in a multicriteria model that encompasses the major issues of the problem. The first results show consistence of the proposed methodology, not only in terms of the modeling process, but also in the phase of interaction with the users that is, the members of river basin committees.

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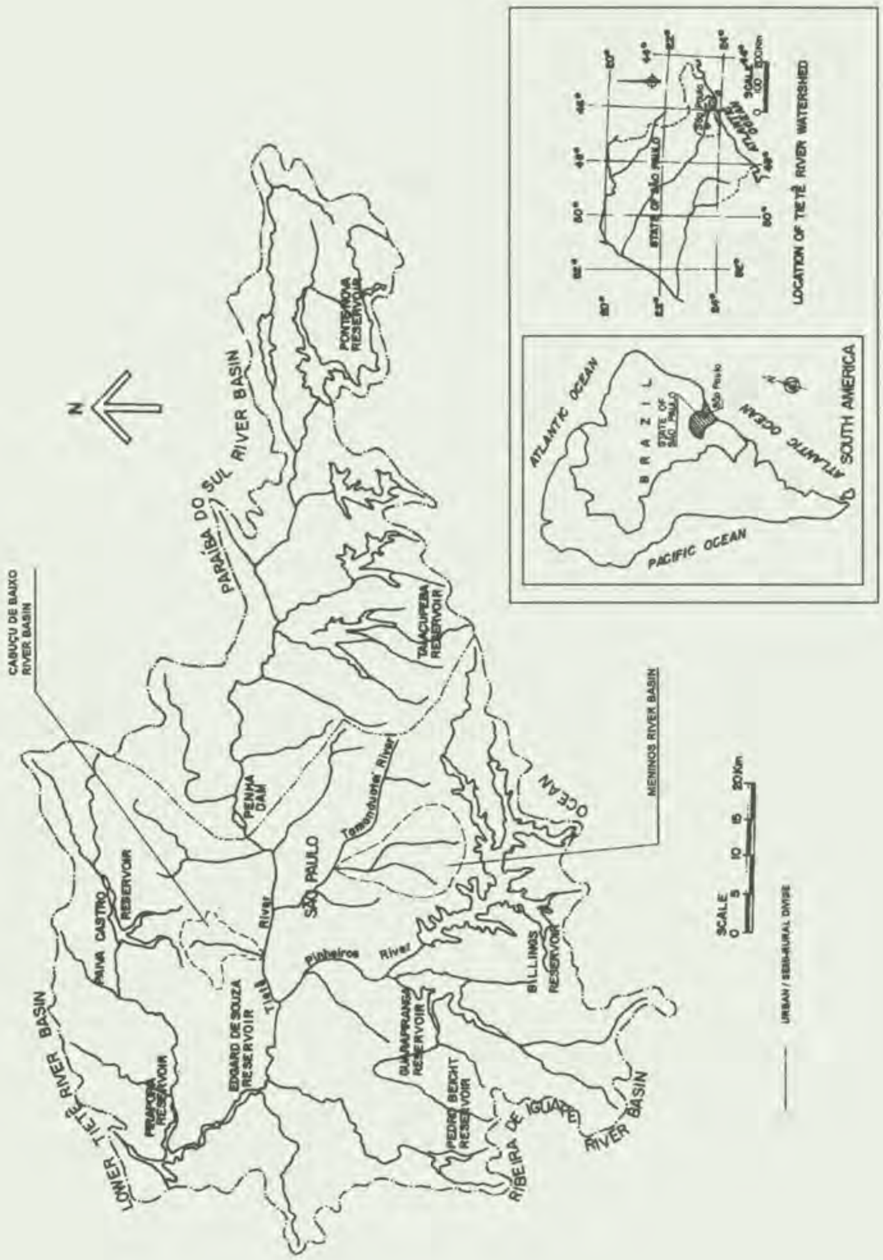

Figure 1. Location of the upper Tiete river basin and the metropolitan region of São Paulo

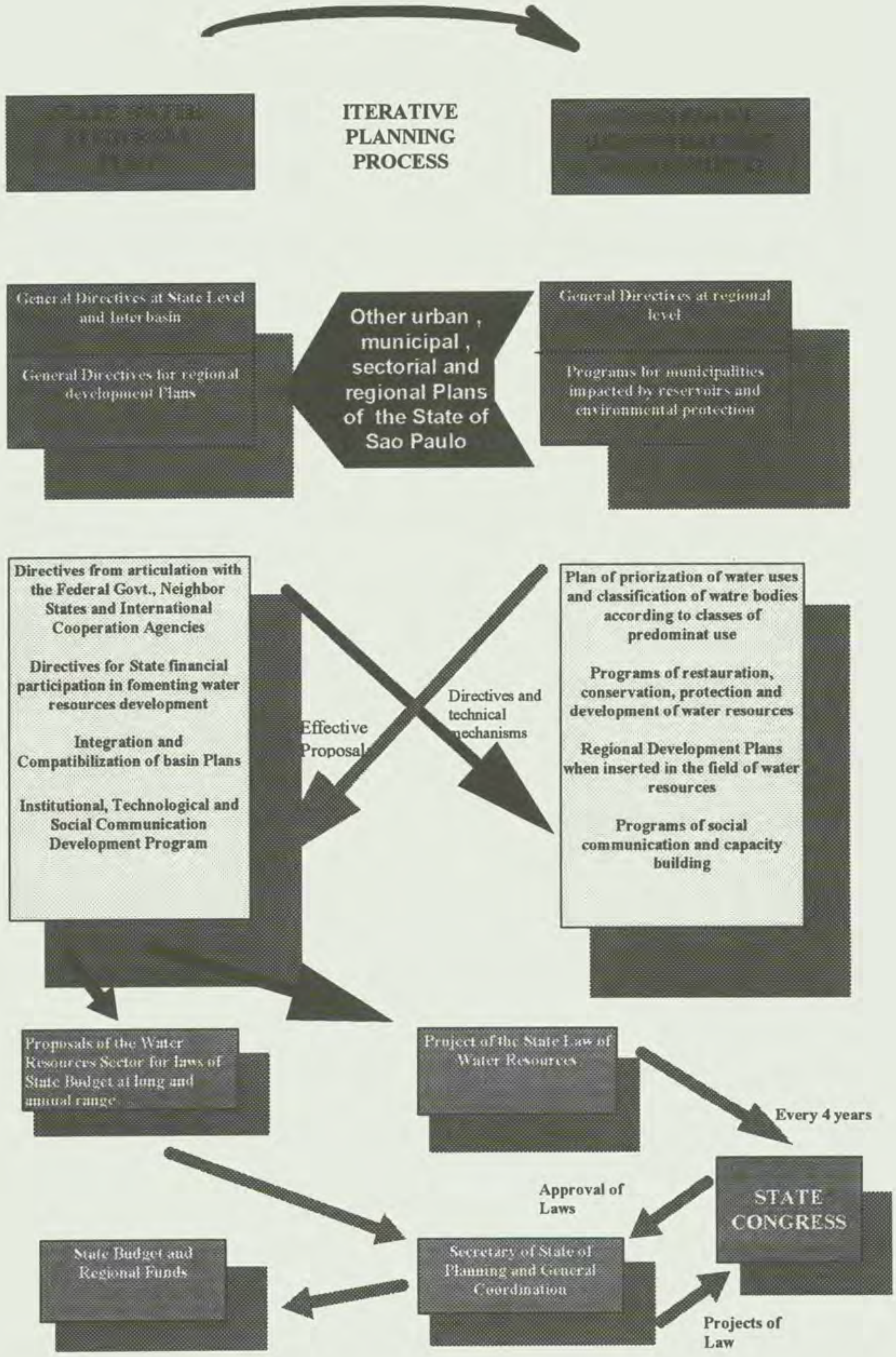

Figure 2. The integrated water resources management system of the state of São Paulo

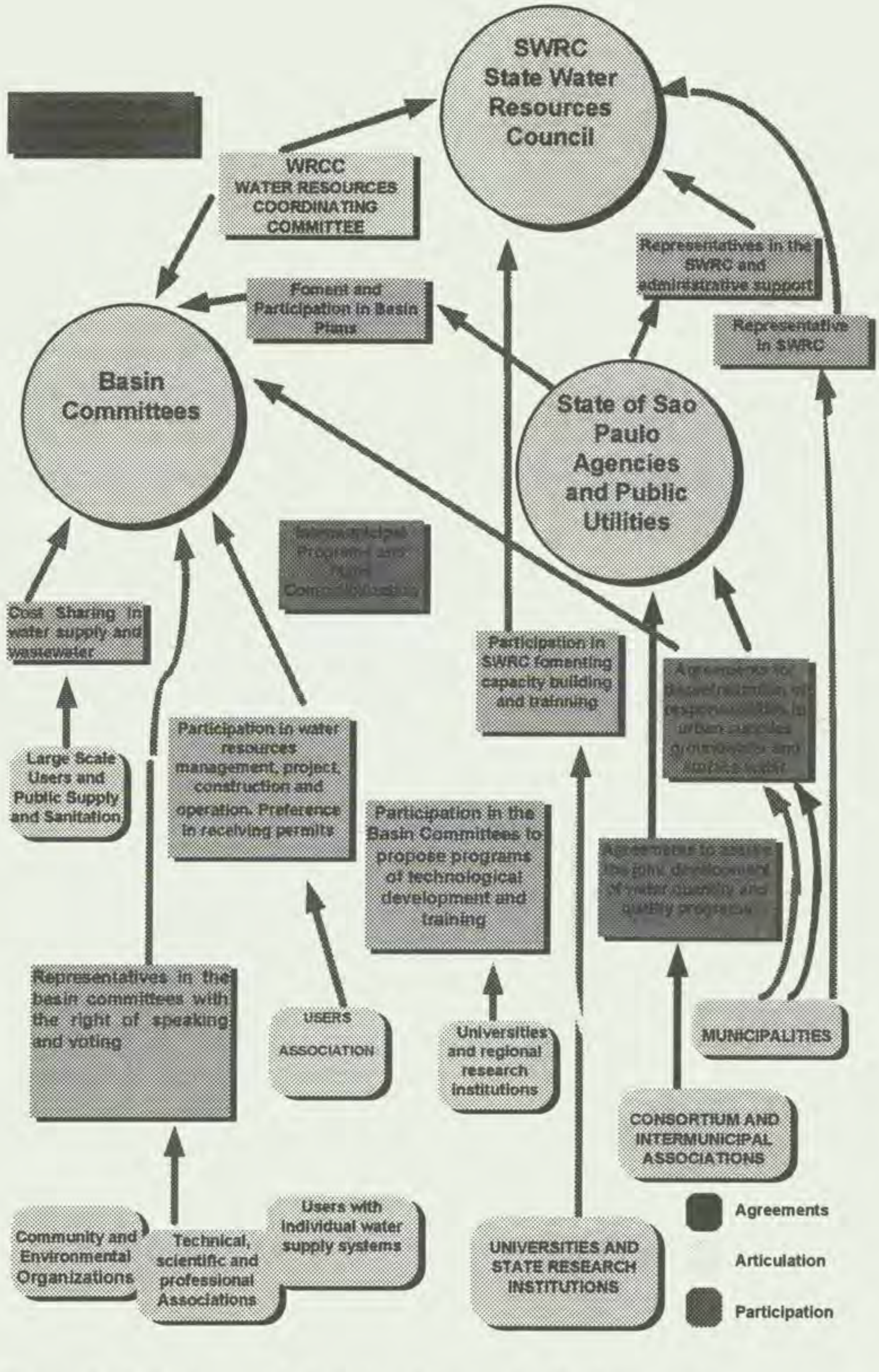

Figure 3. Intitutions and their involvement in the integrated management system

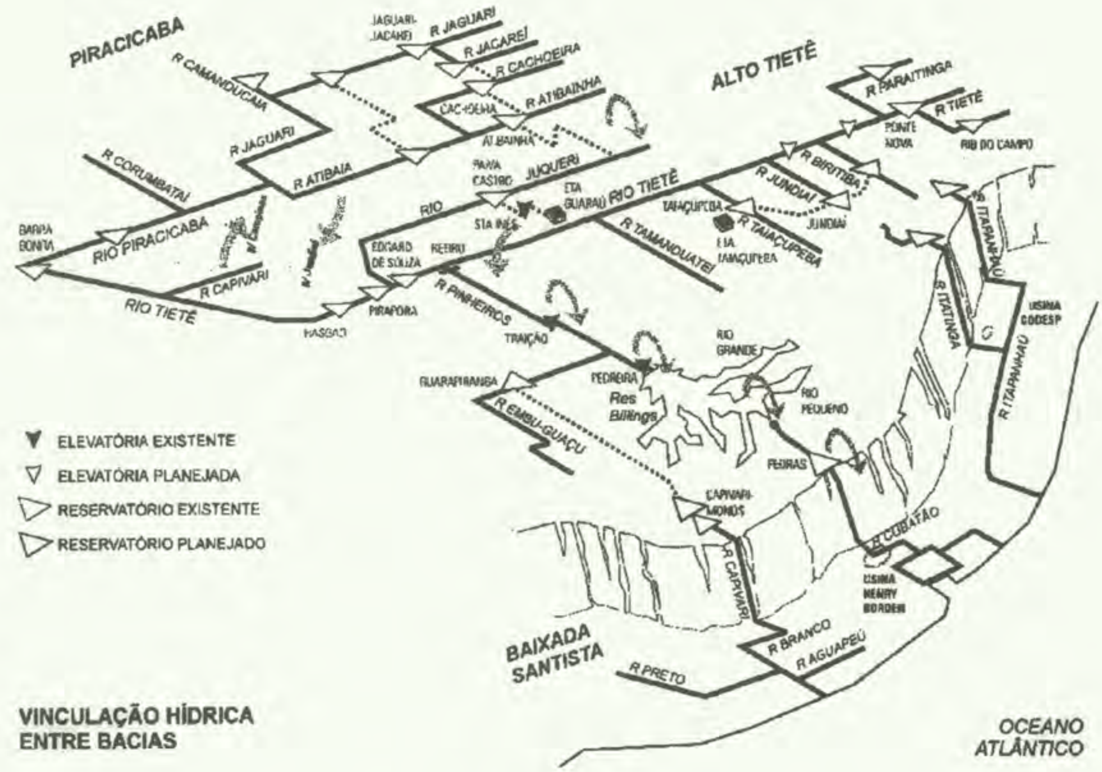

Figure 4. The metropolitan region of São Paulo and inter-basin transfers

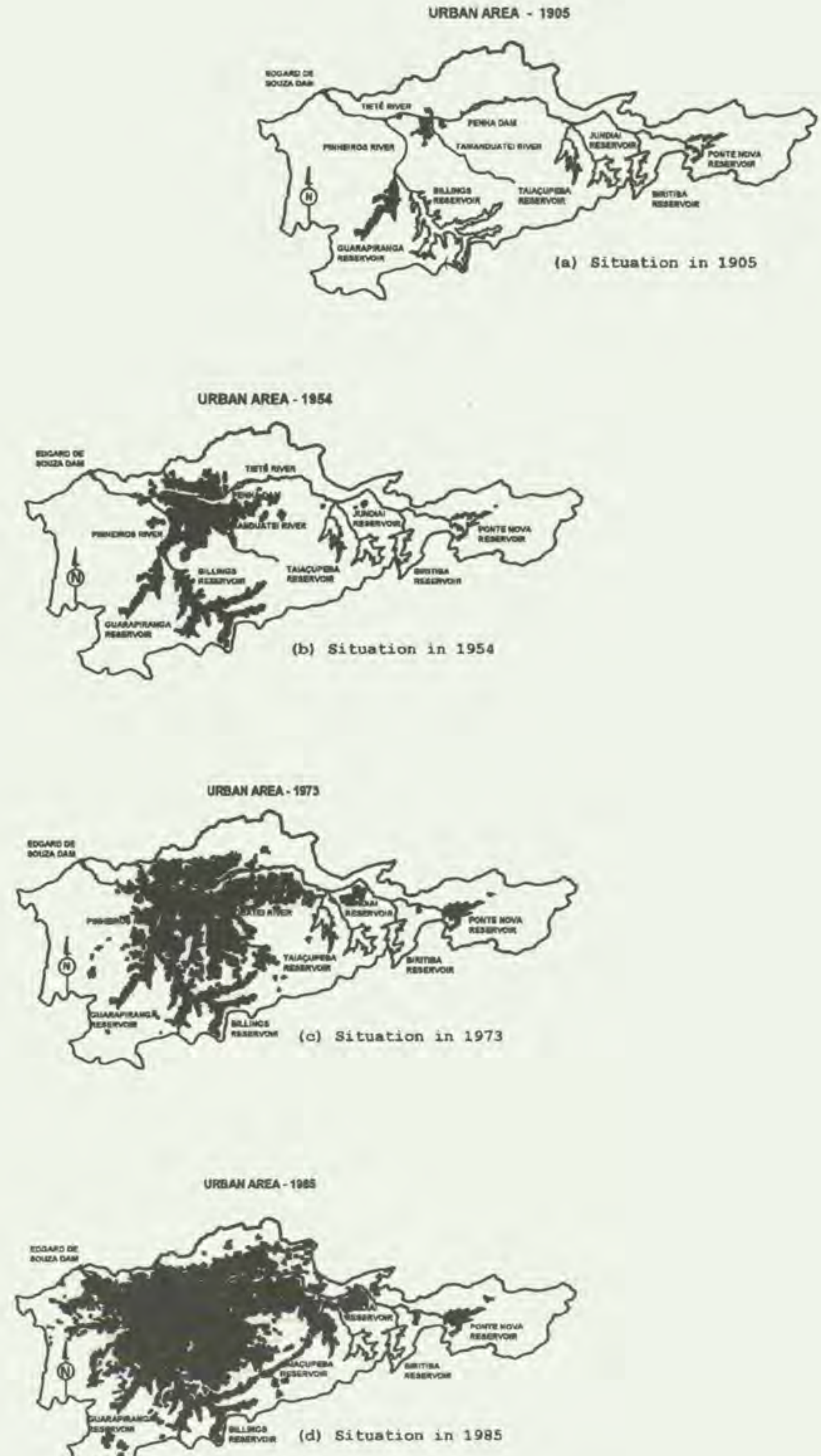

Figure 5. Urban expansion in the upper Tiete river basin

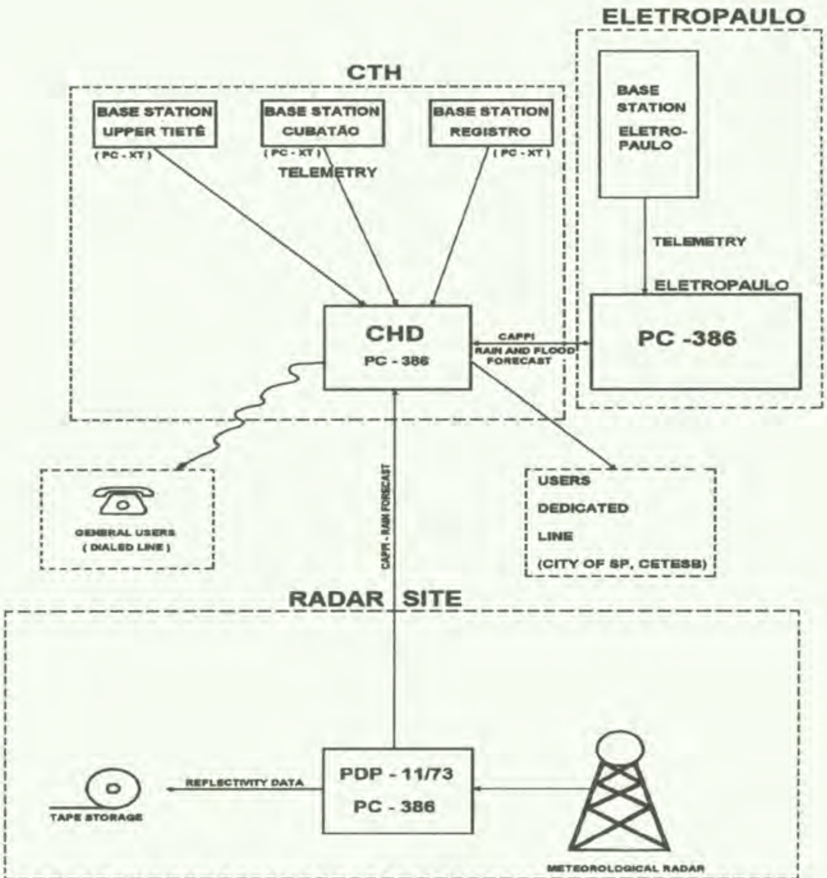

Figure 6. Flood warning system of the metropolitan region of São Paulo

Table 1 Growth of population, urbanized area and water supply requirements in metropolitan region of Sao Paulo

Year	Population	Urbanized area (km2)	Total water supply require-ments (m3/s)
1880	40,000	2	0.1
1930	200,000	14	0.4
1940	1,000,000	130	5.0
1970	6,500,000	550	15.0
1985	13,000,000	900	31.0
1990	16,000,000	1500	43.0

Table 2 Demands for water in upper Tiete and Piracicaba river basins

	Urban demand (m3/s)			Industrial demand (m3/s)			Irrigation demand (m3/s)			Total demand (m3/s)		
Year:	1990	2000	2010	1990	2000	2010	1990	2000	2010	1990	2000	2010
UpperTiete	43.5	58.6	73.9	10.0	12.6	14.9	4.6	3.1	3.0	58.1	74.2	91.8
Piraci-caba	7.3	9.8	12.3	14.9	18.2	21.6	9.8	9.3	9.0	32.0	37.3	42.8

Table 3 Planning alternatives for water resources development of MRSP and its neighbouring river basins

Planning Alternative	Description	Cost Estimate (U$ billion)
PA-1	No diversion of upper Tiete river flow to Billings reservoir, and no pumped flow along Pinheiros river. Total interruption of electric generation at Henry Borden power plant (HBPP).	3.963
PA-2	Pumped flow upstream along Pinheiros river only for flood flows situations. Partial interruption of electric generation at HBPP.	3.145
PA-3	Parametric pumped flow subjected to monitoring feedback derived from water quality situation at Billings reservoir	2.733
PA-4	No pumped flow during drought periods and parametric pumped flow during rainy season (also subject to monitoring)	2.641
PA-5	Construction of isolated lateral lakes along Billings reservoir, keeping the wastewater disposal only in the central body of this reservoir. The isolated lakes will contribute to fulfil water supply requirements.	2.441
PA-6	Construction of other isolated lateral lakes along Billings reservoir, keeping the wastewater disposal only in the central body of this reservoir. The isolated lakes will contribute to fulfil water supply requirements.	2.434

PA-7	Construction of a tunnel to convey water flow pumped from Pinheiros river at Pedreira pump station directly till an isolated lake (Pedras lake) at the end of Billings reservoir, where the water flows to Henry Borden Power Plant.	3.303

Table 4 Water supply availability for each planning alternative

Planning Alternative	Flow Availability for Water Supply (m3/s)	
	with treatment type I	with treatment type II
PA-1	10.0	---
PA-2	10.0	6.0
PA-3	---	30.0
PA-4	---	30.0
PA-5	6.6	30.0
PA-6	6.3	30.0
PA-7	10.0	6.0

Table 5 Objectives considered to evaluate planning alternatives

Macro-objective	Measure	Number of associated criteria
1-Water supply	flow availability (m3/s) as defined in Table 4	2
2-Water quality	water quality parameters (DO, coliformes, etc.)	8
3-Environmental Health	Parameters associated with public health and natural ecosystem	15
4-Energy Generation	MWh	1
5-Socio-economic aspects	subjective, based on opinion of a multidisciplinary group	6
6-Institutional and legal aspects	subjective, based on opinion of a multidisciplinary group	4
7-Flood control	level of protection against floods	2
8-Total costs	U$ billions	1

Table 6 Weights and ranking of planning alternatives for two decision makers

Decision maker DM1			Decision maker DM2		
weight *Wi* to macro-objective i	Ranking Position	Planning Alternative	weight *Wi* to macro-objective i	Ranking position	Planning Alternative
W1=3	1	PA-5	*W1*=*1*	1	PA-7
W2=1	2	PA-6	*W2*=3	2	PA-3
W3=1	3	PA-7	*W3*=1	3	PA-4
W4=1	4	PA-2	*W4*=1	4	PA-6
W5=1	5	PA-1	*W5*=1	5	PA-2
W6=1	6	PA-4	*W6*=1	6	PA-5
W7=1	7	PA-3	*W7*=1	7	PA-1
W8=1	---	----	*W8*=1	---	---

Management of Irrigation and Drainage in India (MID)

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DEVELOPMENTAL OBJECTIVES

Rapid expansion of irrigation facilities along with consolidation of the earlier established irrigation services was the main strategy of India for increasing production of foodgrains after gaining independence. With systematic development, irrigation service area was increased from 22.6 million ha in 1951, to about 90 million ha at the end of 1995-96. In the past few years, it has been increasing at the rate of about 2ォ million ha per year.

Initially, the development effort was motivated by the single most objective, of food security. Expansion in domestic production of foodgrains to meet the growing demand due to rising population and better incomes from the new economic growth was the principle objective. The production base of agriculture was therefore enlarged through large public investments in irrigation schemes, soil and water conservation works and land reclamation activities.

DEVELOPMENTAL ACHIEVEMENTS

For purposes of planning and accounting, the irrigation projects in India are classified as major projects when irrigation service is for more than 10,000 ha of cropped area. Those with a service of more than 2,000 ha and upto 10,000 ha are called medium projects. Irrigation is also provided by a very large number of small- scale irrigation schemes from tanks, by direct diversions from the streams, by lifts from rivers or by pumping of groundwater.

Beginning from the sixties, irrigation from private tubewells grew spectacularly from almost nil to 11.3 million ha by 1984-85 showing a 7 per cent annual growth in the 70s and thereafter. Alongwith the growth in the number of dug wells also, the net area irrigated by well irrigation stood at 20 million ha by 1984-85 and 40 ha by 1996.

In aggregate terms 64 per cent of the India's ultimate irrigation potential has already been developed. There has been a decline in the share of the irrigation sector in the public investments in the period after 1980, partly because of the comfortable food position of the country with sufficient food reserves to make it a food surplus country from a food importing country in 1950. Further expansion is also slowing down as it turns out to be financially expensive and in some places environmentally controversial. Irrigation in India takes place under widely diverse climatic and socio-economic conditions and also from widely different types of sources of water. Rainfall intensity, duration and reliability has a pronounced influence on the nature of irrigation requirements. In dry regions, irrigation is the main source of water for the crop growth.

The analysis and the performance of the major and medium irrigation projects has received considerable attention, because of extensive areas serviced by them and also because, the Government's expenditure on these projects form a major component of the public expenditure in irrigation. Roughly 60 per cent of the public expenditure in irrigation has gone into the major and medium irrigation projects.

LEGACIES OF THE COLONIAL PERIOD

In the pre-independence period, irrigation projects were taken up basically as famine relief measures. After the catastrophic famine of 1899, the Government of India appointed the First Irrigation Commission (1901) to report on irrigation as a protective measure against famines in India. The recommendations of this Commission when received in 1903 gave a great impetus to the construction of new public canal systems to cover large drought prone areas in the country. They served the purpose of drought proofing, but did not add substantially to the productivity as such. At the time of independence in 1947 with an irrigated area of 19.4 million ha., coming with the partitioned India, the country was producing only 50 million tonnes of foodgrains and was deficit in food. The annual utilisation of water was 140 billion m^3 from surface sources and 40 billion m^3 from underground sources constituting the use of about 20 per cent of utilisable surface water and 10 per cent of groundwater respectively.

The canal systems of the pre-independence days were mostly fed from the direct diversion of water from the river. There were very few storages behind large dams. The management rules adopted during the colonial period had also a new different style. Each farmer had to apply to the Government individually for water. Tight administrative command blended with philanthropic gesture of the rulers towards the natives was the guiding principle. Cooperative efforts or collective action by the farmers in the management of waters were not provided for in the operational strategies of the canal systems introduced during the colonial period. India is continuing to suffer from this patronizing approach. Some traditional systems of collective management in the pre-colonial period have survived on small-scale irrigation works established earlier. But the magnificent large-scale irrigation works introduced during the colonial period were totally devoid of any participatory approach to management of irrigation. In spite of many efforts over the past 5 decades, it has not yet been possible to set right the position and promote farmer managed irrigation systems in a large way. The irrigation bureaucracy continues to have a great stranglehold on the public irrigation systems.

The Government canals accounted for almost 30 per cent of the irrigation area at the time of independence. They were held in great awe and respect, because of their technical excellence and fine administration. Management on the private canals and tanks, which provided service to 10 per cent and 25 per cent of the irrigation areas, respectively, got progressively ignored resulting into deterioration of the physical health of these systems and degeneration of social coherence in the irrigators. After independence, even though large number of small-scale irrigation works were newly introduced throughout the country, their management got patterned exclusively on the lines of the Government - run large canal systems rather than through farmer's associations. The result was that collectivism of the beneficiaries did not get nurtured even after independence. The large size public canal systems now irrigate 33 million ha against 8.6 million ha at the time of independence; that is a four fold increase in the irrigation area. It has led to the perpetuation of the earlier pattern of governmentalised management rather than ushering in a new era of farmers involvement and self help.

PRODUCTIVITY OF IRRIGATION

The production of foodgrains has increased from a 50 million tonnes in 1950 to about 200 million tonnes in 1996 partly through the expansion of the irrigated area under the grain crops and partly from increase in the productivity of the irrigated lands (almost doubling in five decades). But the new productivity is still nowhere near the true potential of irrigated agriculture. Irrigated area contributes 55 per cent of the agricultural output, but it has a much greater latent potential. It has not yet been fully brought into use. Average yields under irrigation are more than two and a half times of those under rainfed conditions. For example, in cereals, it is 2 tonnes per ha compared to 0.8 tonnes per ha under rainfed situation. Even therein at least 25-30 per cent better irrigation yields are achieved under privately managed well irrigation.

PHASES OF IRRIGATION DEVELOPMENT

With the advent of dam engineering, a large number of new storages and/or a dependable back up reservoirs for the earlier run of the river irrigation schemes came to be constructed after independence on Indian rivers providing a regulated support to the new canal irrigation schemes by holding back the flood waters during the rainfall period and making it available later during the dry fair weather period. In India, rainfall takes place over a short period of two to three months, causing excessive floods in that period, but leaving the rest of the year dry. Even with a dependable back up from the controlled reservoirs, however, the canal operational rules as laid down under the pre-independence acts and manuals mostly continued to remain in force even in this second phase of irrigation development.

In the meanwhile, after sixties, the 3rd phase in irrigation development came in by
a spurt in groundwater development, introducing a powerful new source of water for the canal command areas. Earlier irrigation acts had frowned upon the irrigated land receiving water jointly from the public canal system as well as from a private well, because of difficulties in the assessment of revenues from the two different sources of supplies. But, on account of the greater flexibility in the application of water to the land from the wells, which provides for better productivity, farmers preferred to have a suplementary supply from the wells and went ahead to put in a large number of wells in the canal commands and obtained the benefits from the conjunctive use of surface and groundwater together. The legislative system has not kept pace with this rapid change. Though the National Water Policy adopted in 1987 emphasized the importance of the conjunctive use of water, formal guidelines for the conjunctive use of surface and irrigation water came to be laid down by the Central Water Commission only in 1993.

Modern pressure irrigation techniques made there debut in India in the 80s, ushering in the new fourth phase of irrigation development. Progressive farmers started resorting to sprinkler and drip techniques for diversification of their crops as well as for better use of the scarce water. But while the irrigation development passed through four different phases, namely, the one of unregulated diversions from the natural river flows in the early decades of this century to reservoir backed irrigation systems and then to conjunctive use of groundwater and now to propagation of more sophisticated pressure irrigation systems, the formal management and operation rules have been so far very slow to respond to the new situations.

KNOWLEDGE BACKUPS

In the Irrigation research institutes established in the early 20s and thereafter up to 60s in the Independent India, the subject of hydraulics was the dominant one, as the principle objective of irrigation development was storage and conveyance of waters to the needy dry areas. Soil sciences and water application techniques at the farm level appeared on the scene thereafter when agricultural universities got established. Even then, the principle attention was initially only to the physical process of handling the irrigation water. The specific biological needs of the agricultural plants and the fine tuning of the water application techniques to those needs was considered by the agricultural research system in India rather recently but with very revealing results. The earlier physical systems planned and developed with a different objective have not yet been able to adjust to the newly fine tuned requirements.

With better knowledge about the phenomena of salinity and drainage, new operational strategies have also been suggested by the research stations like the Central Soils Salinity Research Station at Karnal. But their incorporation in the operational rules for the management of the governmental canal systems or their adoption in the privately managed irrigation has been rather slow. It is not that only the public canal systems have shown the adverse impacts of irrigation like waterlogging and salinity. In intensely irrigated areas of the sugarcane belt of Maharashtra, even the clusters of privately managed cooperative lifts have led to the problems of waterlogging, because of lack of appreciation by the irrigation community about the right type of irrigation practices and on account of the absence of enabling legal and administrative provisions for preventing the misuse of irrigation facilities.

OPERATIONAL RULES

One of the problems of Indian irrigation has been that it is too large and diverse a sector. On account of the different characteristics of the different sources of irrigation water, different rainfall patterns and soil conditions, and differences in the individual's preferences for the crops, generalised simpler operational rules are not useful for meeting with the specific requirements of the different irrigation supply systems. Detailed operational rules for each individual system are necessary to obtain the best results.

There also can not be a uniform system of irrigation management in the country as a whole. Broadly, the existing systems can be classified under four categories : (a) localisation of irrigation areas as is prevalent in the Southern States; (b) rotational supplies (Warabandhi) prevalent in Northern India; (c) Shejpali for regulated supplies to approved crops prevalent in Western India and (d) the field to field irrigation (mostly for rice) in Deltas and in the Eastern India. All these systems have recently been under considerable strain, because they have not been able to meet with the new aspirations of the farming community for a more assured and better managed services which can help them in improving the productivity of the irrigated crops.

World Bank and the International Commission on Irrigation and Drainage published in 1989 a guide for the preparation of strategies and manuals for planning the management, operation and maintenance of irrigation and drainage systems, worldwide. In a national level workshop held in India in February 1992, the adoption of the principles outlined in the World Bank - ICID Guide were discussed in details and thereafter a national guide based on the Indian experience was published in 1994 by the Indian National Committee on Irrigation and Drainage (INCID) adding more expanded details as are required by the local operational staff, so that systematic plans for operation and maintenance could be prepared by them for each canal system large or small meticulously. A follow-up action is now required at the field level by the irrigation management agencies.

RIVER BOARDS

While the project level management of the irrigation supplies is getting fine tuned, there has been an increasing necessity on account of acute shortages of water in some of the river basins to operate the irrigation systems keeping in view the requirements of the basin as a whole for diverse uses of water such as for municipal and industrial purposes rather than only for irrigation. Out of the 13 billion m^3 of water available in the Upper Yamuna Basin (Catchment area 43,913 Sq.Km.) 9.66 billion m^3 are required for irrigation alone. 2.32 billion m^3 are wanted for municipal and industrial uses and 0.32 billion m^3 are in demand for general environmental purposes to ensure a minimum flow of 10 cumecs in the river all the year round.

Having thus reached the brink of availability, the Central Government had to step in for establishing an inter-state mechanism for day to-day sharing of the water of the basin and for coordinating the operation of the basin's canal systems for the purpose. The five co-basin states have signed a Memorandum of Understanding on 12 May 1994 providing for the establishment of a Upper Yamuna River Board to regulate the available flows amongst the beneficiary states. A ministerial level Upper Yamuna Review Committee for supervising the working of the Board has also been provided for. This Board is a pre cursor to similar arrangements that would be required progressively in many other basins and sub-basins where water use has been already stretched sufficiently and conflict in allocation for different purposes, to different areas and to different canal systems from the same river or from the same storage dam is required to be resolved under the conditions of hydrologic variability.

GROUNDWATER MANAGEMENT

Systematic physical regulation of surface water is possible by introducing control structures, measurement devices and a regulatory organizational setup in the field. But the management of groundwater is not possible through such physical controls. In addition, strong legal measures are also necessary. With rapid rural electrification and liberal availability of electrical and diesel pumps in the market, the number of wells and consequently the groundwater draft has increased very fast in the last 3 decades. Because of the complex scientific and technical issues associated with the different hydro-geological conditions, a liberal electricity subsidy for the farm sector and political influence of the irrigator's lobby, it has not yet been possible to have very clear legal and administrative provisions for managing the groundwater.

A model bill for management of ground waterwas recommended to the states in 1970 by the Government of India. It was revised and recirculated in 1992 recommending the establishment of groundwater authorities for regulating extraction of groundwater. On the basis of the responses to these revisions, the model bill has been further revised recently in 1996 to provide that all the wells sunk will have to be registered. So far only four states, namely, Gujarat, Madhya Pradesh, Maharashtra and Tamil Nadu have somewhat acted on these suggestions and have notified some of the proposed legal provisions for regulation of groundwater. But a full scale regulating scheme for groundwater is not in vogue anywhere as yet. The states have been rather diffident and reluctant to go ahead with such measures. Irrigated farming with 45 million ha dependent on groundwater is at the crossroads.

IRRIGATION ACTS

Immediately after independence, India was faced with the problem of multiplicity of laws and regulatory rules that were prevalent in the different parts of India. After the States' reorganisation carried out between 1956-60, there was an urgent need for harmonising the different legal provisions then applicable to the different parts of the newly reorganised states. Irrigation Commission in their report of 1972 had pointed out the multiplicity of statutes covering various aspects of irrigation management and administration and had recommended simplification and unification of the laws. With the help of the Indian Law Institute, Government of India developed a model legislation for the guidance of the States in 1976. It provided for the water users associations in the form of water committees for management and supply of water from minor irrigation works and also for the levy of water rates and betterment contribution.

The earlier laws in the colonial period were basically oriented towards administrative discipline and collection of revenue. Managerial innovations, promotional or developmental aspects, or principles of collective management for better productivity were not covered by them. Hence all those acts needed a serious review to make them cope with the new requirements. Some states have followed the lead given by the Govt. of India in 1976, though in a somewhat disjointed manner. In the meanwhile, irrigation scenario in India is changing so rapidly that a second look at the provisions in the model bill has become necessary.

COMMAND AREA DEVELOPMENT PROGRAMME

The Irrigation Commission appointed by the Government of India tried to grapple with the changing irrigation scenario in the country and made many useful suggestions in their report published in 1972. It emphasised the need for greater agricultural orientation of the irrigation agencies and faster and better utilisation of the irrigation infrastructure being added in the country. A nationwide command area development programme came to be launched in 1974 for hastening the fuller utilisation of the irrigation facilities provided by the newly developed major canal systems. The programme envisaged a wider multidisciplinary approach to the management of irrigation area. Supply of all inputs and services including credit, strengthening of extension services and selection and introduction of suitable cropping pattern were included as the components of the programme along with land levelling, realignment of field boundaries, consolidation of holdings and rotational distribution of water. Command Area development authorities were accordingly established for the major irrigation projects to undertake such comprehensive programmes on the ground.

Beginning with 60 projects in 1974, the programme has now extended to cover 202 projects servicing 21.44 million ha through 54 command area development authorities. The hardware components of the programme comprising the physical works on the farm such as the field channels and field drains, land levelling and shaping got the real boost, while the soft components like the work on adoptive trials for development of suitable crops and for proper application of fertilizers lagged behind along with the promotion of participatory irrigation management.

NATIONAL WATER MANAGEMENT PROJECT

Later, these efforts were further supplemented through a National Water Management Project (NWMP) designed to promote the process of improved water management through upgradation of the tertiary delivery system of selected irrigation schemes with support from the World Bank. The basic objective of the project was to improve irrigation coverage and agricultural productivity and thereby increase incomes to farmers through a more reliable, predictable and equitable irrigation service. The first phase of the programme lasted from June 1987 to March 1995. The project has been modestly successful. Irrigation management has improved significantly in the schemes handled under this project. They have shown an increase in crop yields ranging from 15 to 67 per cent due to improved irrigation supplies and better water use efficiency. Because of the encouraging results from such a project, NWMP-II has been formulated and is under discussions with the World Bank for support.

PRICING POLICIES

The growing concern over the large and increasing magnitude of recurring losses on the operation and maintenance of the public irrigation schemes led to the constitution of a Committee on Pricing of Irrigation Water in 1992 by the Planning Commission of Govt. of India. The Committee recognised that the quality of service must be ensured to motivate the users to pay for the service. The Committee recommended the revision in the level and structure of water rates and an eventual switch to the volumetric pricing along with improvements in the quality of service. The Committee also led stress on greater irrigator's participation in the management and maintenance of the irrigation systems.

On the basis of this report, the Planning Commission of the Government of India have recently approved the following reforms- (i) Irrigation water rates should be levied per number of watering per ha in lieu of the prevalent crop based water rates; (ii) there should be two tariffs - one levied from individual irrigators and another concessional one applicable to water users associations which are entrusted with the task of management and maintenance of local irrigation network. It has been reiterated that the irrigation revenue should cover operation and maintenance expenses and atleast one per cent of the capital cost as was envisaged earlier to account for the physical depreciation of the assets.

India has had a tradition of providing irrigation water atleast partly as a public good recognising that the society at large draws a variety of benefits from the network of irrigation canals in addition to the increase and stability in food supply. But currently, the value of water delivered to farmers far exceeds what they pay to get it. The actual gross receipt per ha of area irrigated by public canal systems is barely 2 per cent of the gross output per ha of irrigated area and is less than 4 per cent of the difference between the irrigated and non-irrigated. But in the new climate of economic reforms, there are pressures for increasing the irrigation revenues. With liberalisation, there are also greater opportunities for farmers to grow high value crops instead of traditional cereals. Reforms in canal irrigation should be able to provide assurances for better performance of the system and thereby also promote higher willingness to pay for irrigation.

WATER AND LAND MANAGEMENT INSTITUTES (WALMI)

In parallel with the command area development programme, a set of new institutions quite different from the traditional hydraulics oriented research stations were established under the name of WALMIs to cater to the new types of managerial and socio-economic requirements of the Indian irrigation scenario. With the support from the World Bank and the USAID, a series of WALMIs (11 of them together) came to be developed in India between the period from 1980-88. They provide multidisciplinary in service training for the staff engaged in irrigation management.

Upto March 1996 these institutes have provided training to more than 3,000 senior officers, 13,700 middle level officers, and to 14,700 junior officers along with 57,000 farmers. More than 500 officers have also been trained abroad to expose them to different patterns of irrigation development and modern practices in irrigation management. These efforts have helped to change the earlier administrative climate and made it more conducive to the formation of farmers organisations, for simplification of procedures, for legislative support to farmers organisations and for adoption of more refined methods in the operational and management plans for the irrigation systems.

WATERLOGGING AND SALINITY

The problem of waterlogging had attracted attention in India right since the beginning of this century when large canal schemes conveying river water to extensive agricultural land were introduced. A special drainage research division was established in the State of Maharashtra and considerable work was also undertaken on drainage research in Punjab in the early decades of this century. There is considerable volume of information on the nature and extent of waterlogging that appears after the introduction of the canal irrigation. In Maharashtra, the Directorate of Irrigation Research and Drainage regularly monitors the drainage and groundwater status of all the major command areas and publishes an annual report giving the health of the commands. This practice has considerably helped to attract advance attention to the possibilities of impending damage and the need for undertaking remedial measures well in time like introduction of specially designed drainage schemes. That has helped Maharashtra to keep the waterlogging and salinity affected area to less than one per cent of the irrigation area.

For India as a whole, compared to the 90 million ha of cropped area under irrigation, the area affected by waterlogging and salinity can be considered to be not very high, only about 3 million ha by waterlogging and about 2 million ha by salinity. Schemes with special incentives are now required to be formulated and implemented early for remedying the situation. Currently, the maintenance and management of the drainage channels is attended to by the government irrigation agencies. To what extent farmers associations will be successful in handling the drainage systems or a part thereof is yet to be seen. In any case, systematic monitoring of the status of the soils and the groundwater levels in the command will have to be undertaken by the Government irrigation agencies and may have to stay with them only for quite sometime.

India introduced the scientific irrigability classification of the farms quite early in the sixties. But awareness about the differences in the capabilities of the lands under irrigation could not reach the farmers, because of lack of extension efforts. The result was that the crops grown by the farmer and the water application techniques used by him on the farm have not been in proper conformity with the irrigability status of his farm. The irrigability classification came to be used only as a planning tool rather than as an operational and management support. With improved extension in the irrigation service area, if the farmers are made aware about the true potential or handicaps of their farm land, productivity of their farms will get enhanced substantially and there will also be a better sustainability for irrigated farming.

EQUITY IN IRRIGATION

Amongst many other important provisions, the National Water Policy adopted in 1987 also stressed the need for equity in irrigation. But the concept of equity yet remains to be properly defined for different types of irrigation systems working under different physiographic and agro-climatic conditions. Adoption of the concept of equity under variable conditions of supply from year to year and season to season is beset with many operational problems.

The age old Phad (Group) system of irrigation prevalent in some of the small-scale canal schemes serviced from river diversions in the districts of Dulia and Nasik in Maharashtra contains some very useful ingredients of equity by providing irrigation for perennial, two seasonal and seasonal crops or even denial of irrigation in years of acute distress on the basis of a three or four year rotational cycle amongst the three or four groups of irrigation beneficiaries. Similar grouping of irrigators for a fair allocation of water under variable conditions of supply will have to be promoted for the different categories of irrigation projects. The block system of irrigation initially developed in Maharashtra on the principles of the Phad System, unfortunately degenerated into a system of irrigation rights and privileges rather than a system of flexible and fair allocations.

FLOOD PRONE AREAS

The greatest challenge for scientific management of irrigation is faced in the flood prone area, because of the suceptibility of the physical infrastructure for water distribution to damage during submergence under floods. Irrigation technologies suitable for flood submergence area have not yet been properly developed. The systems that are useful for dry areas have more or less been wrongly extrapolated to the flood prone areas also. The International Program for Technology Research in Irrigation and Drainage (IPTRID) sponsored by the ICID, World Bank and the UNDP will have to address this question and promote the development of the right type of technologies for such areas early, because such areas are the poverty pockets of the country.

The irrigation systems in the flood prone areas of North Bihar in particular have been performing poorly inspite of the availability of assured adequate flows in the river. This is also the area falling in the South Asian poverty triangle of the Ganga - Brahmaputra - Meghna basins. The management of irrigation and drainage is closely inter-twined there with the flood control measures and poses a great challenge. The channels for supply of irrigation water as well as the drainage lines get extensively damaged and choked under conditions of flooding. Repairs and renovation of the network is prohibitively costly and places a heavy organisational and financial burden on the public agencies responsible for managing the systems. How far the farmers and their associations would by themselves be able to undertake this responsibility is not yet clear at the present juncture.

In this triangle, the groundwater table is not very deep. It is just at two meters at many places. Availability of cheap power from hydro-electric networks and use of dismantalable small size pumps by millions of farmers having small size agricultural holdings may provide the answer. New irrigation development plans on these lines will have to be tried.

PARTICIPATORY IRRIGATION MANAGEMENT

The centuries old long history of the South Indian tanks has shown that they were subject to recurring cycles of decline and rehabilitation and often required infusion of state or other outside funds to restore the tanks to proper operation. With an expansion of the role of the state during the colonial era, the earlier traditions of farmer's involvement in maintenance and management was substantially eroded in the age old tank systems as also in other irrigation systems. But the desirability of developing farmer managed irrigation systems has been by now well appreciated by the Indian irrigation agencies, because of a continuous followup on this aspect by the Command Area Authorities and the WALMIS. The progressive states like the Government of Maharashtra have already issued formal guidelines for the formation and registration of farmers' associations for distribution of irrigation water. But the tension between the new efforts for involvement of farmers and the habits of dependence on the government still persists.

Depending upon the local climate for cooperative life, the nature and size of the water utilisation associations will differ from region to region. No single pattern as such is likely to fit into the variety of situations that exist in the different parts of India for the different types of irrigation systems. Government of India has been providing a management subsidy of Rs.275 over a three year period for stabilizing the work of such associations and is also considering the enhancement of such subsidy. But financial support alone will not be enough. Some operational guidelines for the development and working of these associations will be necessary for the speedy multiplication of such associations. Changes in irrigation acts will also be necessary to facilitate farmers participation in the operation and management on an extensive scale.

A consultation workshop on Farmer - Government Partnership in Irrigation Development and Management was held in the State of Gujarat in February 1993 where several NGOs participated. The State Government of Gujarat has thereafter taken several organised steps for promoting participatory irrigation management. Under the new orders promulgated in November 1995 the water users' associations are given a rebate of 25 per cent on the water bill for collection of water rates and a further rebate of 30 per cent for carrying out the specific system maintenance. It has also been provided that the farmers of the water users' associations will be given a crop compensation, if the loss in yield occurs on account of failure to supply water on demand for reasons within control.

Central Ground Water Board of GOI in association with the National Bank for Agriculture and Rural Development organised a two-day workshop on emerging role of cooperatives in groundwater development and management in October 1995 at New Delhi. The workshop addressed the importance of cooperative ownership of groundwater utilisation structures by a group of people. Such an arrangement may avoid individual heavy capitalisation otherwise required by small land owners and optimise the benefits. But, a proper social climate will have to be generated for establishing cooperatives of this type in large number.

It is an encouraging signal that the Non-Governmental Organizations are comingforth in a vigorous manner to address the related issues. A seminar on `Irrigation Water Management' was held at Roorkee in January 1985 by the Water Resources Development and Training Centre of the University of Roorkee (WRDTC) followed by a national seminar on Human Resources Development in Irrigation Management, by the Water and Land Management Training and Research Institute, Hyderabad in 1993. The second national symposium on Irrigation Management in 1993 at Delhi organized by the Central Water Commission was followed by a National Seminar on `Irrigation Management Policy' organised by the Indian Water Resources Society in collaboration with WRDTC in 1995. It covered a very wide range of topics including organisational and procedural changes and the role of media in this respect. A national seminar on `Participatory Irrigation Management' is due again in January 1997.

AUTOMATION OF CANAL SYSTEMS

Automated operation of the canal irrigation systems in India is being supported by many external support agencies like the UNDP, the World Bank and the French donors. The UNDP is helping the Central Water and Power Research Station, the apex hydraulic research station of the country to develop capabilities in automated operations by training abroad their research officers. The interface between technology and management is getting increasingly important with the modernisation of the canal systems. In the Sardar Sarovar Project's Canal Network automation with central control and telecommunication have been made an integral part of the newly developing canal network.

DRIP IRRIGATION

Drip irrigation was introduced in India in early 70s through the agricultural universities and research institutes who worked for developing indigenous applications and adaptations. The adoption of drip irrigation by farmers has gained considerable momentum in the last few years. From a mere 1,500 ha in 1985 the area under drip irrigation rose to over 70,000 by 1994 and to 1,40,000 ha by 1996. This has been possible due to encouragement given by the central and the state governments through subsidy schemes starting from 1982-83. Recently, Government of India has further stepped up the subsidy. Almost half the area developed so far under drip system has received support from the Central Government's Subsidy Scheme. INCID has brought out a status report on the subject of drip irrigation in India in 1994 to cover the various aspects including research activities, experiences and the economics.

Although this growth looks phenomenal in absolute terms, in relative terms, the coverage is just 0.15 per cent of the irrigated area of the country.

Drip irrigation has been successful mainly for growing flowers, nuts, oilseeds, orchards, vegetables, spices and cotton. Even for the high value crops like fruit crops, vegetables, sugarcane, cotton, tobacco, tea and coffee which occupy 20 million ha in the country, the coverage by drip system was only 45,257 ha by 1990. Interestingly enough, much of this area was not under any traditional irrigation system and most of it came to be added as an irrigated area only because of the adoption of the drip technology. The potential for the application of the drip techniques is estimated to be 10.5 million ha. Initially a target of 2 million ha by 2000 has been kept in view. But, because of various constraints including linkages required with the established canal and tubewell systems and related procedural and operational changes, it has not been possible to proceed fast in that direction.

SPRINKLER IRRIGATION

In addition, about 1,00,000 sprinkler sets have been installed in the last four years. Most of these cover the land which would not have been otherwise covered by the traditional irrigation systems. In other words, new pressure irrigation technology like drip and sprinkler is adding new irrigated areas and new crops which were otherwise not receiving support from the earlier irrigation facilities. This segment of irrigation service is likely to be a major industrialized part of irrigated farming in the years to come, because of the indigenous manufacturing capabilities for such equipment developing in India.

SATELLITE REMOTE SENSING TECHNIQUES (SRST)

Because of increasing capability of India in developing, manufacturing, launching and operating its own satellites, use of SRST for irrigation management is likely to increase fast. Moreover, satellite remote sensing is moving towards much greater spatial and spectral resolution. The availability of high resolution data is likely to revolutionise the remote sensing applications. Indian Remote Sensing Satellite (IRS 1-C) already has a six meter resolution. The IRS follow-ons will provide a four meter resolution.

Indian pilot studies have shown that SRST is able to throw light on the status of the irrigation area and on improvements in crop productivity. Equity between distributories, and between head reach and tail reach within a distributory can get highlighted. Temporal analysis of history and current data can point out the extent of improvement or degeneration through the years. The changes in the crop pattern can also be properly identified.

Under the NWMP, monitoring by SRST has been successfully tried, on the Bhadra Project with a command area 97,360 ha in the Karnataka State and for the tank irrigation in Tamil Nadu under a project sponsored by the International Irrigation Management Institute (IIMI). Both these trial applications have shown excellent results and have pointed out the great potentiality in this new technology. On the basis of vegetation index value, yield value for the crops could be successfully developed. The yield model that is currently developed for paddy could be extended to other crops with further experiments and trials.

The trial work done so far has clearly proved that the satellite remote sensing application has been quite cost effective. Monitoring cost per irrigation season is less than 1/10 of the US dollar (Rs.3 per ha) for a command area larger than 1,00,000 ha. This is likely to decrease further to 1/30 of dollar (Re.1 per ha) for more extensive commands over 3,00,000 ha). For small command area of less than 10,000, the unit cost may be upto 1/3rd of a dollar (Rs.9 per ha). But even then the extent of data that becomes available and the speed with which it becomes available more than justifies the cost.

THE PROCESS OF REFORM

Thus Irrigation sector in India is in an interesting phase of rapid transformation on account of many organizational and social changes, new technological capabilities and the new economic climate. As the Indian irrigation sector goes through the new reform process rapidly, care will have to be taken to see that no single reform activity is out of step or far too much ahead or far too much behind of others. Reform is required in a variety of directions and the entire process will have to be a coherent one matching in steps. Not transfer of management, nor water pricing, or the improved delivery system alone will be able to remedy the earlier deficiencies. All these measures will have to work in tandem and will have also to be implemented in phases to see the entire reform operation through smoothly. The reform process is also not likely to be uniform throughout India, because of the inherent differences in the status of development and the differences in the essential characteristics of the irrigation systems in the different regions. It is hoped that the National Institute of Irrigation Management - which is in the offing and which will coordinate the WALMIs will be able to lead this process effectively in the coming decades.

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Water Management in Egypt

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ABSTRACT

Irrigation water management is the means of efficient use of water in both the system and the farm in order to maximize the economic return per unit of water. This implies maximum economic satisfaction of human needs and minimum idle resources. Egypt practices artificial irrigation since the dawn of history, where some inherited irrigation lifting tools from ancient Egyptians are still used.

At present, Egypt faces the beginning of a water scarcity era due to the limited Nile water share, increasing population, continuous uprising demands and negligible rainfall amounts. The groundwater exists in the deep aquifer but being a non renewable resource, continuos lowering of the water table levels is expected Opportunities for additional water amounts are mainly from; the upper Nile water resources development projects, abstraction of more deep groundwater, harvesting the limited coastal rainfall and the recycle and reuse of drainage water. However economic, social, political and environmental considerations are always limiting factors. According to priorities proper management of the available water resources, mainly the Nile water, deemed of first priority. Planners of water in Egypt will soon face challenging water scarcity problems. Therefore efficient and effective management programs are important remedies towards savings any controllable losses and preventing the misuse of water and the degradation of its quality. This paper is evaluating current water saving efforts and presenting future management programs.

INTRODUCTION

Rainfall in Egypt is yery, scarce and the country is almost entirely dependent on the Nile River to satisfy its various water requirements. The Nile provides about 95% of Egypt's water demands. Control and management of the river waters have become possible after the construction of dams and barrages on the Nile and its two branches. The last two centuries of modern Egypt have witnessed considerable development in the control and management of Egypt's major fresh water resource; the Nile. It started by the construction of the Delta Barrages in the last decade of the 19th Century, to assure summer cotton irrigation in the Nile Delta, the establishment of an intensive network of canals and drains, and ending by the construction of the Aswan High Dam (AHD) in the 1960s. AHD was constructed to ensure the long term availability of water for Egypt and Sudan. However, the average annual flow during the last decade has been slightly decreased affecting most water use sectors.

The fact that should be realized is that almost 85% of Egypt's water is allocated for agriculture and the overall irrigation efficiency lies between 65-75% after water recycling, whereas, water allocated for domestic and industrial uses is less than 15%. The effluent produced from domestic and industrial uses is highly polluted.

Increasing demands urge the conservation of the Nile irrigation water and augmenting it with other water resources; such as fossil groundwater, treated sewage and industrial effluents, and desalinated brackish and sea water. Non-conventional water resources are becoming more important in achieving future demand-supply balance.

Conservation of the Nile water can achieved by improving the system performance through proper management and applying appropriate technologies. However, engineering solutions only are not always the tools to solve such multi-disciplinary problems. It should be supported by and complemented with legal, economic, and social measures.

Economic considerations must be based on a thorough review of agricultural land taxation scheme, free cropping pattern situation, and the nature of the agricultural market for goods and services. Social and traditional habits considerations must take into account the belief that natural water is a gift from God to mankind, and hence it is free if accessible without management and control services. But since water needs to be conveyed, distributed, and then partially collected in the drainage system, such services must be shared among the government and the different water users. Legal measures are necessary to maintain and conserve the water quality to ensure reuse and recycling sustainability and to have better environmental quality.

PRESENT WATER SUPPLY SITUATION

Egypt's water share from the Nile is limited to 55.5 billion cubic metres (bcm) per year according to the 1959 agreement wit Sudan. This share was set on the basis of the long term average yield of the river estimated at 84 bcm at Aswan. This amount of water is not expected to increase in the near future as it requires great political efforts and agreement with the different African countries sharing the river. Proposed Upper Nile conservation projects; including Jonglie Canal project, the Machar Marshes project, and the Bahr El-Ghazal project, if completed, are expected to add a volume of water of about 18 bcm what will be equally divided between Egypt and Sudan.

Aside from the Nile waters, Egypt has no effective rainfall except for a narrow strip along the northern coastal areas where the averacre rainfall does not exceed 200 mm. This scattered rainfall along the northern coastal region participates to the supply with 1.0 bcm per year. The recycling of the Nile water occurs through pumping from the Nile Valley and Delta shallow aquifer. This groundwater aquifer underlying the Nile Valley and Delta is entirely recharged from and is dependent on deep percolation of irrigation water and seepage from the irrigation network. Another form of Nile water recycling is the official and unofficial agriculture drain water reuse. At present, the quantity of groundwater abstracted for domestic, industrial, and agricultural uses is about 5.3 bcm. Meanwhile, about 4.0 bcm/year of drainage water are officially reused in irrigation. Fossil groundwater withdrawals are estimated by 0.5 bcm annually.

Demand Management as a New Challenge facing Irrigated Agriculture

Due to the fact that renewable fresh water resources are finite, the rapid increases in population and their growing demands for more water resources are putting a lot of pressures on the available allocated water quotas for irrigated agriculture. Agriculture is getting relatively the highest ratio of quotas allocated to the other uses and users such as water for drinking, industry, navigation, hydropower and the new consumer which is the environment to minimize the hazards and risks of the other uses and users on the environment.

Agriculture industry is facing and will be facing a new challenge plus, the set of challenges which it has already, of which is producing more production with less water, Table 1 shows the Sectoral water withdrawals, by country income group.

Country income Group	Annual withdrawal per capita	Withdrawals by sector		
		Agri.	Ind.	Dom.
	(m^3)		(%)	
Low-income	386	91	5	4
Middle-income	453	69	18	13
High-income	1,167	36	47	14

Source: World Bank, 1992.

PRESENT WATER DEMANDS SITUATION

Agricultural water demands are considered as the largest water user sector. The total irrigated area amounts to about 7.8 million feddans (one feddan = 4200 square meters). Surface irrigation is practiced in most old agricultural areas in Egypt, with an application efficiency between 40-60%. Because of groundwater pumping and drain water reuse in agriculture the overall irrigation efficiency is estimated at 65-75%.

Present annual municipal and industrial demands are estimated at 3.1 and 4.6 bcm respectively. Future requirements depends very much on the rate of population growth. The population of Egypt according to the last census in 1991 is about 58 millions and is expected to increase to 70 and 90 millions by the years 2000, and 2025 respectively (Reference). By improving distribution efficiency from 50% in 1990 to 90% in 2000, municipal water use is expected to remain constant.

From February to September water releases for irrigation are sufficient to maintain water levels in the Nile for navigation. However, irrigation requirements are not enough during the period from October to January to maintain appropriate draft for navigation in the river. Special water used to be released for this purpose during the low requirement season. Also, canal network and hydraulic structures maintenance are usually performed during this period. The released water used to flow directly through the river channel to the Mediterranean as all irrigation canals were closed typically for maintenance. But, since 1987/88 releases for navigation are being reduced and MPWWR is planning to reach a release to sea value of 0.3 bcm, which accounts for leakage from Edfina barrage.

Hydroelectric power generation was considered for many years as a major product from AHD for the errowing industry in the country. Lately, thermal power station have been producing most of the energy required by the country industrial activities and the hydropower production from the dam contributes only about 20% of the annual required energy.

When preparing MPWWR's water policy for the future, Abu-Zeid and Rady (1991) suggested three scenarios which provide water supply and demand estimates till the year 2025. The first scenario (A) is based on achieving an improved field irrigation efficiency of 75% and an efficiency of 90% for potable water use, with complete control in water transport and distribution to minimize non-consumable uses. In the second scenario (B), the current low efficiencies would prevail, which in turn would imply a strong need for re-use of water. The third scenario (C) is a combination of scenarios A and B; with irrigation field efficiency improved at 65%, and potable water use efficiency of 80%, improved control on water transport and distribution, and storage of non-consumable water for use at appropriate times. The three scenarios assume that Jonglie Canal phase 1 would be completed by then. Groundwater withdrawal would reach its maximum exploitable capacity of 3.5 bcm. The potential for agricultural drainwater to be reused is estimated at 8.0 bcm, and treated sewage to be 2.5 bcm.

Table 2 Present and Future Water Supply and Demand Situation

Item	1987	1990	2000	2025 Scenarios A	2025 Scenarios C	2025 Scenarios B
Available Resources						
Nile Water	55.5	55.5	55.5	*57.5	*57.5	*57.5
Fossil Groundwater	0.5	0.5	2.5	3.5	3.5	3.5
Reused Drainwater	3.5	4.7	7.0	4.7	8.0	5.0
Delta & Valley Groundwater	2.3	2.6	4.9	2.6	4.9	3.6
Treated Sewage		0.2	**1.1	**1.5	**2.5	**2.0
Total Available	61.8	63.5	71.0	69.8	76.4	71.6
Water Requirements						
Irrigation	50.2	49.7	59.9	43.5	49.7	46.6
Municipal	3.1	3.1	3.1			
Industrial	2.5	4.6	6.1	9.6	14.6	10.8
Navigation		1.8	0.3	0.3	0.3	0.3
Hydropower	2.0	1.0	0.0	0.0	0.0	0.0
Evaporation	2.0	2.0	2.0	2.1	2.1	2.1
Total Demands	60.0	63.5	71.0	69.8	76.4	71.6
Surplus or Deficit	1.8	1.3	-0.4	14.3	9.7	11.8

Irrigated Agriculture Systems and the need for Water Users Association

Irrigated agriculture systems of the world are different from other systems such as rainfed agriculture systems in many ways, of which is that the process as well as practices of the farming system of the first are centered around irrigation practices which have to be planned ahead of time and dependent on many physical structures such as storage facilities, network of canals, control structures and gates which are to help both the managers and the operators of the system in delivering the needed water for irrigation in terms of quantity, quality, timing of use and location, and their ultimate objective is to satisfy the demands of the users of such systems fairly and equitably.

The nature of the irrigated agriculture systems of the world are dynamic as long as the demands of markets, communities and individuals are changing plus that the settings and the context of these systems are also subject to changes, these facts imply that the users and the beneficiaries of these systems are key players in the process of the decision making such as what crops to be grown and when to grow regardless of the impact of these decisions on both the availability of the water resources, the pressures on the managers of these systems and the expected conflicts between users, managers and or managers and the users.

Individual solutions of the users of these systems are to float on the surface whenever water availability is a constraint and for sure these solutions would have its impacts on the philosophy, structures, roles and rules of operation and management where these changes do require creative thinking and non-traditional solutions of which is the genuine idea of involving the users in the management of these systems.

In order to solve these associated problems related to the management of the irrigated agriculture systems, many ideas and proposals are being implemented and tested all over the world of which is the inclusion of the users in the management of these systems and the related decision making process which is the topic of the paper and the ground is in Egypt.

PROGRAMS FOR WATER SAVINGS

The Egyptian irrigation systems extends over 1,200 km south of Aswan to the Mediterranean Sea. The agricultural areas are served by over 31,000 km of public canals, 80,000 km of field canals (mesqas), and 17,000 km of public drains. Irrigation departments of XP administer the system. The main features of the Egyptian irrigation can be summarized as:

- operation and control of the water are based on the elevation of the water upstream or downstream of the off-take structure (mostly in old irrigated land);
- water supplied to farmers, on a rotation basis, varies according to the season and copping patterns rather than the precise crop requirements of water;
- requirement of farmers to lift water at least once, either from the canal to the mesqas or the mesqa to the farm ditch, as a way of discouraging over-Irrigation;

- a drainage system for removing excess water from cultivated land consisting of open drains, tile drains, and pump stations (Abu Zeid, 1995).

Therefore, the chances to increase the available Nile water are very few. The efforts should be directed towards raising the rate of water recycling, as long as quality permits, improving the efficiency of various water uses, minimizing the releases for non-beneficial uses such as navigation, and conserving the Nile and the irrigation system water quality.

The present water saving programs have two dimensions; the first deals with the hardware part of the irrigation system (the physical canal and drain network with all hydraulic structures on it), and the second deals with the software part of the system in areas related to the planning, operation, management, and administration issues. Each is implemented on the different levels of the system; macro, mezzo, and micro levels. The identified constraints on the irrigation water management as well as improvements in the performance of the system have been tackled through different programs of the intensive USAID funded Irrigation Management System (IMS) project and other foreign funded projects.

Irrigation Management System Programs

The components of IMS project are: Regional Irrigation Improvement Project (RIIP), Structural Replacement (SR), Preventive Maintenance (PM), Main System Management (MSM), Planning Studies and Models (PSM), Professional Development, Research and Development (Water Research Center), Project Preparation (PP), Survey and Mapping (SM), and Miscellaneous TA and Commodity Procurement.

These 10 components involve a large number of participating departments, acenc'es within MP and farmers. The main features of some of the important components are presented in the following sections.

Regional Irrigation Improvement Project (RIIP)

The RIIP is established after the success of research program (Egypt's Water Use Program) that was carried out by the Water Research Center during the period 1978-1984 on a pilot scale. The main objective of the project is to make the system more responsive to famers' need, and to minimize various types of water losses during the distribution process resulting in availability of water with respect to time, location and quality needed. It resulted in increased agricultural production, fairness and equity among water users, and higher water use efficiencies were achieved. The Irrigation Improvement Project started in 1984 with an area of 40,000 feddans and its extension for the 1992-97 MPWWR additional 350,000 feddans with an estimated cost of 120 million dollars.

The project identified the importance of water users involvement in decision making process concerned with water distribution resulting in forming the Water Users Associations (UYTUA): Irrigation Advisory Services (IAS) are governmental authorities also formed to provide technical assistance to farmers to help them achieve the highest possible production.

The improvement and modernization works to carry out ILP vary from re-alignment of water courses and distributary canals, reconstruction of cross section, lining and use of elevated mesqas, and use of buried pipeline mesqas. The project has proved to be successful and MPWWR has established an organization within its structure to expand the project activities to cover most of the old agricultural areas in Egypt.

Structure Replacement (SR)
The Structure Replacement project is aimed at replacement of old and non-functional small and medium sized structures in the irrigation system, intake regulators, head regulators, weirs, tail escapes, spillways, bridges, and crossing structures on branch and distributary canals. It is also aimed at improved quality of construction to assure that replacement structures are built up to MPWWR specifications. The program was completed by the end of 1994 covering about 20,000 structures. Rehabilitation of these structures yielded better operation and control over the water distribution process.

Main System Management (Telemetry)
The Main System Management (MSM) project is designed to improve the efficiency of water use through eliminating excess water supplies in some areas, and augmenting water deficiencies in other areas. This is done by providing water distribution managers with real-time knowledge of the status of the irrigation system, at various key locations along the distribution network, so they can match crop water requirement with adequate and timely water supplies without waste or shortages in the system.

MSM project telemetry system is composed of two sub-systems; a meteor burst data collection system, and a Voice-Data Communication system employing VHF radio communication. Both systems collect water levels automatically and record and display this data at the local Irrigation Directorate office and at the Ministry Headquarters. Data collected issued for monitoring, operational, and planning purposes.

When completed, MSM project will provide real-time water level information from over 830 sites along the Nile, main branch canals, main drains, and pump stations serving over 6 million feddans of irrigated old land in Egypt.

Planning Studies and Models (PS&M)
MPWWR through its water planning group has developed a number of computer models that were designed to help water resources and plans will cover irrigation engineers in allocating and distributing the irrigation water, and operating the hydraulic structures on the network. These models include: 1) optimization models to determine the optimal operating policies for AHD or the optimal water distributing plan among the irrigation canals; 2) simulation models, that stimulate the behavior of the reservoir lake under various water release policies, to stimulate the irrigation network behavior after adopting a certain water distribution policy, or to obtain the gate movement schedule under specified set of system constraints, and 3) statistical models to predict the river flow based on hydrological information collected from different stream flow gauging stations in the basin.

In 1991 a new project was initiated via PS&M; the Monitoring, Forecasting, Simulation Project (MFS). The primary goal of this project is to monitor hydro-meteorological condition in the Nile Basin and provide forecasts for the Nile inflows into ADH reservoir with as much lead as possible. With this information optimum decision making is possible to achieve the maximum benefits for the country. To reduce uncertainty of predicting Nile flows, the latest technology and advances in this specific and highly specialised field are applied including GIS, Satellite images, Neural Networks, and Distributed Watershed models.

The Water Research Center (Research and Development)

The scope and complexity of the MPWWR responsibilities for the irrigation system involves a wide range of scientific disciplines and widely varying subject areas. The main objective of Water Research Center is to carry basic research and to be the reservoir of knowledge on all aspects of the water resources, hydrology, hydraulics, irrigation, and drainage areas. To serve this purpose eleven research institutes are branched under the center. WRC and its institutes are established to support all sectors and authorities of MPWWR in many areas starting from decision making, technology transfer, planning, modernization, etc., and ending at helping in solving day to day operational problems of the system.

Training and Manpower Development (TMD)

Professional development institutionalize a multi-disciplinary training program to serve manpower development requirements of MPWWR through establishing the National Irrigation Training Center (NITC). NITC concept was founded to be the best cost effective alternative to meet MPWWR training requirements. The center is completed now and is already serving Egypt and the region.

Different courses are being offered to irrigation, water resources, hydraulic engineers, hydrologists, agronomists, agro-economists, geologists, other participants from various disciplinaries within MPWWR. Ambitions are directed towards making NITC as a leading institute for serving the Middle East and Africa.

Survey and Mapping (S&M)

The Survey of Egypt was established in 1894 to carry out a program of survey and mapping. Geodetic control networks were established though the Nile Basin. Most of the cad astral and topographic maps currently in use for planning and designing irrigation projects were prepared between 1900 and 1945. Nearly all these maps are inadequate for preparing feasibility studies or detailed project plans. In addition, accurately scaled aerial photography is not available for the irrigated areas of Egypt.

The Egyptian Survey Authority (ESA) was established in 1971. The major task of ESA is to prepare high quality maps needed for planning irrigation improvements and maps for detailed design of irrigation projects and for maintaining cad astral records. ESA is also responsible for all cad astral surveying in Egypt. In addition, accurate measurement of the nation's crop areas is needed for the development and calibration of complex models of irrigation system. The serial photographing techniques provide such accuracy.

The objective of the S&M component of the EWS project is to make maps and aerial photographs of high quality available for use in irrigation improvement purposes.

Conservation of Freshwater Released to the Sea

Water used to be released to the AHD during the low requirement season (winter) for purposes of navigation and hydropower generation. Large volumes of water used to flow directly through Rosetta branch into the Mediterranean as agriculture requirements are low in this season. NTWVYRR was aware of the quantities of water lost to the sea; therefore it has taken many steps towards minimizing fresh water spills into the Mediterranean. Through the construction of the new Esna barrage, new Nag Hammadi navigation lock, and the improvement of the river channel, releases from AHD will be stored in the river channel.

Also, MPWWR reduced the releases from AHD and they were restricted to only 60 million cubic meters (mcm) per day during the low requirement season of the year 1994-95, with a total volume of flow to the sea of 0.96 bcm. This minimum discharge is necessary to provide intake levels for municipal water supply pumps along the river course and to satisfy municipal and industrial water requirements.

The closure period is recently practiced for a period of 10-14 days for each of the five geographical regions of Egypt (Upper Egypt, Middle Egypt, East Delta, Middle Delta, and West Delta) with partial over laps between regions. The water released from the reservoir also serves for a general irrigation before and after the closure period for each region.

Figure 1 illustrates the relationship between the fresh water flow to the sea through the Efina barrage and the releases from AHD. In 1977-78 the released water to the sea was determined by 11.6 bcm compared with AHD release of 61.8 bcm. It is clear from the figure that fresh water releases to sea have been decreasing since then, especially after the drought period that have been experienced by the Nile Basin. The minimum outflow to sea was achieved in 1995-96 and it is the Ministry's plan to continue the reduction of this water.

Water Recycling and Reuse

Abstractions of groundwater and agriculture drainwater are currently the main two forms of water recycling in Egypt. In the Nile Valley and Delta they both originate mainly from the Nile water used in irrigation. The exploitation of these waters on sustainable basis requires careful investigations and planning. The crucial issue in meeting future demands through water reuse is to teach the maximum exploitable quantities of the available groundwater and drainwater without upsetting the physical system or causing environmental damage.

Reuse of Agriculture Drainage Water

Agricultural drainage water in Upper Egypt is discharged back into the Nile River. This slightly affects the quality of the Nile water as its salinity increases from about 250 ppm at Aswan to 350 ppm at Cairo. The drainage water in the Nile Delta is of lower quality, and accordingly it is collected through an intensive drainage network, then pumped into the Mediterranean and the northern lakes.

The total amount of drainage water discharges to the sea depends mainly on the amount of water released from AHD, cropping pattern, and irrigation efficiency. Figure 2 shows that amount of drainage water pumped into the sea and the total amount of drainwater officially reused for agriculture during the period 1984-1992. The figure shows a significant decrease in the amount of drainage water discharged annually to the sea and that it has varied from about 14 bcm in 1984 to 12 bcm in 1992. An increase is also noticed in the amount of drain water reused in irrigation. The effect of reducing releases from AHD and from applying RIIP will lead to a decrease in drainage quantity and an increase in its salinity.

Surveys and monitoring quality and quantity of drainwater in the Nile Delta has shown that it is possible to reuse part of it in irrigation. When the salinity is low (below 1000 ppm), water can be used directly, while when the salinity is slightly higher (between 1000 and 2000 ppm), it can be mixed with fresh canal water. If the water salinity is determined to be more than 2000 ppm or if it is contaminated with municipal and industrial wastes, it cannot be used in irrigation unless proper treatment is carried out. Under any circumstances a substantial portion of drainage water has to be discharged into the sea to maintain salt balance in the Nile Delta and prevent seawater intrusion. Studies are carried out now to precisely estimate the quantity needed for this purpose.

Reuse of Treated Municipal Waste Water

Between 65-80% of the total municipal and industrial water supply can be recycled and reused after proper treatment. The first use of treated waste water in Egypt was in 1915 in the eastern desert north east of Cairo. An area of 2500 feddans are still under irrigation with waste water which receives only primary treatment. With the scarcity of water resources, it is planned to irrigate 150,000 feddans with treated waste water up to the year 2000.

All urban waste water projects include facilities for treatment up to the tertiary level and allows reuse for irrigation. But still, many of the rural areas are lacking such facilities. The amount of waste water produced from Cairo and Alexandria in 1992 was estimated by 1.'J6 and 0.53 bcm, respectively. It is expected that these amounts will reach 1.70 and 0.65 by the year 2000.

WATER QUALITY CONSERVATION MEASURES

Currently, water quality in the Nile upstream of Cairo is good due to the river dilution capacity. The situation in the Delta and northern lakes is deteriorating. The Greater Cairo area can be described as the black spot of the entire system where more than 25% of the population live and 75% of the public industry and 25% of the private industry.

MPWWR's policy is to prevent using the Nile and the irrigation canals as a disposal system for the untreated sewage and industrial effluent. Although practicality of this policy is doubtful, the option is impossible. Dilution of the pollutants by good quality water is not a feasible option in a country with very limited water resources.

In 1983, the General Organization for Industrialization (GOFI) put a pollution control plan for the Nile. The plan addressed 25 public sector plants with priority given to plants that discharge its effluent directly to the Nile. The plan was modified in 1985, but its implementation has been very slow. A special fund is created and administered by the government to accelerate the implementation flow.

Greater Cairo being a major source of pollution received greater attention. An extensive sewage system and six large treatment plants are currently under construction. The reduction in the pollution due to these plants will allow for reuse of treated water in agriculture.

In the industrial cities growing around Cairo water is either provided from the Nile, groundwater sources, or both. In the 6 of October City, a model system is followed to get rid of pollutants before water goes back to the groundwater or the Nile system. Effluent from industry and domestic system is collected, treated, and recycled for non-food agriculture internally within the city borders. Similar process should be followed in sister cities.

Presently, a fairly adequate water quality monitoring system is available in water bodies such as the Nile, drains, and groundwater wells, while no water quality monitoring is available in irrigation canals. The monitoring of water quality in irrigation canals is of paramount importance especially for those providing drinking water to cities. Recently, a new project "Design of an Integrated National Water Quality Monitoring System" has been launched to complement the ongoing monitoring activities.

On the legislative side several laws and decrees have been issued to protect waterways from industrial and sewage pollution. The most important laws are Law 48/1982, Law 12/1984, and Law 4/1994. Law 48/1992 mainly regulates the discharge of liquid waste into waterways and NTWVYR is in charge of licensing the water disposal and Ministry of Health is in charge of monitoring. The standards for disposal of waste water are determined by Decree 8/1983. Law 12/1984 on irrigation and drainage defines the jurisdiction of MPWWR. The most recent Law 4/1994 outlines the tasks of EEAA and provided general environment protection rules. Regardless of the criticism and lack of enforcement directed to this set of legislative measures and other provides the base legal work for protecting the Egyptian waterways.

Realizing that important role of public awareness in water conservation (quantity and quality), EEAA, with the help of NGOs, are leading a national campaign for water saving. The goal is to encourage people to save water and maintain its quality. It increases the public awareness by providing the people with the simple facts that address the water shortage problem and the water quality issues. These facts are addressed in an attractive format to gain public acceptance. The campaign is gaining momentum and is expected to achieve its ultimate goal in the long term since it is mainly concentrating on children in schools and educational institutes.

The Need for Exchange of Experiences

Unless learned lessons and results of research relative to water savings are documented and to be disseminated to the public, their value will be of no use or limited use to the users then, the role of extension service people is to have accessibility to get the right information from the available sources, adopt it to the local conditions of the users through pilot testing and finally the appropriate mechanisms for the dissemination of the gained knowledge on a large scale.

The feedback from the users of the new technology is very important in enhancing the technology and making it more easy for the operators to adapt it.

There is no end for the creative thinking of humans as long as new challenges are to be faced. The new concepts of water savings nowadays concentrate more on the software changes of the systems more than the hardware changes of the systems, hardware changes are easy to be seen but software changes are seriously needed to be documented.

CONCLUSION

Egypt's water resources are getting exhausted because of the rapidly increasing population and the increasing water demands of the different economic sectors. Plans considered in the past to increase Egypt's water share from the Nile, through the implementation of the Upper Nile Conservation projects. The first of these projects, Jonglie Canal, has been abandoned since November 1983, on account of security problems in southern Sudan. It is uncertain when work will be resumed in this specific project or in any of the other three projects in the area.

Re-planning to satisfy the increasing demands without increasing the Nile supply, dictated the start of a comprehensive irrigation water management program to raise the water use efficiency and allow for sustainable recycling and reuse. The irrigation management program includes improvement and modernization of the irrigation system both at the macro level (irrigation network) and the micro level (on-farm). It also comprises rehabilitation of water control structures and pump stations, improvements in irrigation techniques, timely maintenance and other works aiming at increasing the irrigation efficiency to the maximum economically possible value. To carry on this program, many research work has been accomplished and is continuing to answer the questions arising and to prove through applied research, the viability of each of the different activities incorporated in this program. Training is also becoming more and more active to enable build up of human resources capabilities of the individuals involved in those programs both in public and private sectors.

The recycling of drainage water and municipal and industrial effluents to satisfy the pressured demands in irrigated agriculture as well as other demands indicated the importance of addressing the related environmental issues. An environmental action plan has to be drafted to provide a framework for dealing with many of the related problems, including law enforcement, institutional strengthening, raising public awareness and economic impacts of environmental preservations.

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Water Quality Monitoring of Lakes, Rivers and Coastal Waters, and the Framework of Environmental Conservation Policy in Japan

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1. Ambient Water Quality Standards and Effluent Control Regulations

The ambient water quality standards have been developed within the framework of the Basic Law on Environment, with the aim to protect human health and to maintain the basic living environment. The ambient water quality standards collectively represent the goal of the water quality conservation polity, and to maintain these standards, such policies and programs as the effluent control regulatory provisions stipulated in the Water Pollution Control Act are implemented.

2. Water Quality Monitoring

Monitoring of water quality items is pursued with respect to public water bodies, industrial effluents, groundwaters, and bottom sediments.

3. Support for Water Quality Monitoring

For pursuing efficient implementation of water quality control policy of the government, financial and technical support is provided to prefectural and other local government programs.

4. Remaining Issues

The measures to improve water quality, including the measure to step up water quality monitoring activities, will have to be further strengthened in the course of administering the future water quality programs. In addition, the collection of information on chemicals yet to be regulated but their presence detected in public water bodies will have to be continued, in view of the fact that a greater number and amount of chemicals are being and will continue to be produced and used in future.

(In order to get detail paper please contact Mr.Yoshio Yagi, Water Quality Bureau, Environment Agency, 1-2-2 Kasumigaseki, Chiyoda-ku, Tokyo 100-0013 Japan, original in Japanese)

Our Expectations of the Lake Biwa Museum

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Abstract

With its focus on "humans and lakes" the Lake Biwa Museum, which has been open to the public since October 1996, is attracting a great deal of attention from both home and abroad. The focus on "humans and lakes" is not just a simple look at human activities and Lake Biwa in parallel, but is a far more ambitious effort to cover the relationship between lakes and those who live around lakes and its history. In other words, a comprehensive and total look at the relationship between the two.

The entrance to the field: museum is not a closed exhibit space. It could be said that the land, lakes, rivers, the sky, and above all people's lives in terms of relations with them are in the museum. A building is just an entrance to this real museum and this should be open to all the people concerned. Not interpretation, but explanation. There are so many ways of how to understand what happens on the earth. Though the visitor will receive some minimum explanations on the exhibit, people will not be forced to interpret them in a censored way.

Lake Biwa Museum is a pilot to guide people to a more comprehensive understanding of Lake Biwa, its surroundings, people's lives up and down stream, nature and culture.

(In order to get detail paper please contact Professor Hiroya Kawanabe, Lake Biwa Museum, 1091 Oroshimo-cho, Kusatsu-shi, Shiga 525-0001 Japan, original in Japanese)

Dissolved Matter Transport to the Sea
- Limiting Ecological Sustainability -

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ABSTRACT:
Landscape dynamics can be seen as an interaction of the dynamic medium water with the landscape's surface, the amount of irreversible material losses from surface soil as a matter of the energy processing capabilities of the vegetation cover. Energy processing means the local partition of the precipitation in an evaporating part and in percolating water, dissolving and transporting plant usable material. The irreversible flow of matter (as essential nutrinets and the buffering bases) to the sea determines the sustainability of the vegetation cover in a given are of landscape.

This ageing process explaines selforganization according to sustainability criteria. The lest ageing system - with the best cycling capabilities and least irreversible material flow to the sea - is the most sustainable system.

Disturbance of optimized coenotic structures results in reduced cooling properties (temperature distribution in the landscape with high spatial variance) and increased matter (charge) flow rates from the landscape to rivers and streams, resulting finally in irreversible losses from the landscape to the sea. Investigations in the catchment of the river Stor (appr. 100km2) in northern Germany show these relation and reveals the mechanisms of this landscape degradation.

A redevelopment of the landscape together with the water transport system minimizing irreversible charge losses (amounting now up to 20 kmol/ha/yr _ irreversible loss therm of the landscape) is urgent and necessary. Water protection requires the control of water and matter flow processes in the landscape rather than management of aquatic ecosystems. Lowered cooling capability by vegetation in interference with industrial and urban heating structures, as recognized from the satellites, together with the irreversible charge losses from the landscape seem to be quantitative
measures of deterioration of the system&s energy dissipative structure.

The eutrophication process - enhanced irreversible matter losses -* is the result of large scale interference (opening closed metabolic matter cycles in the coenotic structures and manipulation of the water regime by successively lowering the water table ib catchments. The order created by the selective (water-flow, moisture, temperature and chemical) gradients, is established by the water cycle in interaction with the solid surface in space and time.

The long-term influence of man on the landscape has affected the energy flow and its coupling to the water cycle and thereby the transport of matter optimized by nature was disrupted.

Some solution are briefly described for improvements in catchments and water bodies for short-term, and more radical

solutions to re-establish urban-rural integration, short circuited water cycles, food production and the balance of terrestrial and aquatic ecosystems, for a sustainable future.

INTRODUCTION:

Landscapes as catchment, lakes and rivers were mainly created and developed to the present conditions by more or less violent water processes in interaction with the geogenic substratum, the vegetation cover and men. Lakes and rivers are thus indicators for past and present processes and their distribution in the catchments (1). Their degradation can be seen as the degradation of landscape efficiency with respect to retention of matter in the place by closed matter cycles and inherent irreversible matter losses (2).

Landscape has always changed, so have lakes and rivers, however the ageing process has been severely increased, when the natural dissipation of the daily energy pulse was augmented by use of fossile energy sources since roughly two centuries of industrialization in cities and the landscape. This increased energy input into society, random in its time- and spatial pattern changed the distribution of men, of the vegetation cover and livestock. This was caused by a new transport- and management structure. Increased irreversible matter transport from the landscape to the sea was the result of opened local matter cycles. The consequence was a decreased efficiency of the landscape.

The primary selforganizing landscape processes were disturbed and replaced by agricultural practices gaining net production. The water tables in soil were lowered and organic soil layers were mineralized. The feedback control of the water table by evapotranspiration of the original vegetation cover was removed, thus temporally increasing soil fertility and net productivity at the expense of highly increased ageing of the landscape.

Almost closed matter cycles optimized during long lasting interstadial periods were terminated and turned into vast outflow of base cations and pollution of rivers and lake with nutrients. So did the waste effluents of steadily growing urbanized areas. This process is still prevailing and considered as eutrophication. The lacking nutrients and minerals in agriculture have, however, be replaced by increased use of fertilizing agents as nitrogen, phosphorus and base cations as calcium, magnesium and potassium. At the moment the base cation flow in many continental areas exceeds 500 kg of $CaCO_3$ equivalents per ha and year [3].

While landscape was dried out and lost its natural fertility, people moved to cities, where the recycling of nutrients and minerals to the landscape was replaced by an increased transport of base cations to the sea. The removal of phosphorus and nitrogen Takes place in energy demanding sewage treatment plants. Sewage is polished by precipitation of phosphorus with metal ions, recycling of nitrogen to the atmosphere by denitrification while minerals are discarded at highly increased rates to the sea.

Lakes in areas of former glaciation developed under natural conditions from at least a mestrophic state as long as a rich material flow from the catchment was maintained [4]. During the establishment of the primary vegetation cover when were more pronounced. After the development of terrestrial biodiversity had taken place, an increasing efficiency and a decreasing ageing rate of landscape appeared. In the littoral zones of lakes and rivers a short circuited matter flow was then organized in interlinked coenotic structures like periphyton, extremely poor in losses to sediments and outflowing water.

Men's interference ceased these limitations by agricultural management. This was done in a random manner with respect to the natural water cycle in the catchment by implementation of an agriculture using fertilizers, pesticides and irrigation, by forestry based on quick growing monocultures and by an unlimited growth of cities. In the lakes the littoral zones with short circuited matter flow were succeeded by almost unlimited planktonic growth and increased sedimentation rates indicating loss in system efficiency. Interlinked, short circuited production and respiration processes were separated in time and space with result of increased ageing.

Inevitably the material stock of nutrients and minerals in the topsoil of the catchments were lost and in sensitive areas, especially in geologically old areas, depleted. The immediate result was a change from increased nutrient and mineral flow to lakes and rivers to an increased proton flow in the root zones. This causes a drop in pH in the soil and leaching of abundant metals such as iron and aluminum resulting in water acidification [5].

It can be shown that at least two processes are involved in acidification of landscape and water bodies.

1. An increased net productivities in forestry and agricultural sites implies an increased proton flow in the root zones and irreversible losses of buffer substances and nutrients with the runoff water. In impoverished soils net productivity decreases by higher energetic expenses of the plants as e.g. trees, which results in a quicker turnover of root biomass, increased losses of organic matter and acidification of soil and water bodies. The intensified turnover and mineralization of the root biomass enriched in sulfer and nitrogen compounds has a strong acidifying effect. This acidification of soil leads to the dissolution of metal ions and their transport to the lakes.

2. Increased immissions of acid forming nitrogen- and sulfuroxides act on exposed sites, depleted in buffer capacity and case cations as e.g. hilltops and slopes.

Especially in the littoral zones the protolysis of water caused by the metal ions decreases the buffering capacity of the lakes, resulting in acidification and successively changed coenotic structures. Reproduction cycles of fish and fry depending on littoral food chains are thereby endangered or damaged.

There statements are results of deductive normative ecosystem model, which shows eutrophication and acidification as consecutive problems inherent to the energetics of the system. The formulated hypotheses can be corroborated or falsified by observations of time and space distributed data. The heuristic method seems, therefore, more promising for understanding and managing lakes in their catchments than models statistically delivered from ecosystem data. The spatial and temporal dissipation of the solar energy pulse or of external energy in physical, chemical and biological processes. Without knowing the time and space distribution of the energy-dissipative processes in landscapes, the reprsentativity of measurements cannot be determined. Up to now the scientific method extremely useful for laboratory work has rather led to fragmentation of knowledge than to understanding systems. It has made us forget for an almost too long time, that matter cycles in the landscape have to be reimplemented. The best protection of waters can only be achieved by a fundamental, conscious and intelligent regulation and management of the processes and the matter cycles in the individual catchment with regard to the various phases of individual development [6].

A reduction of the problem to one and only important limiting factor in waters (e.g. phosphorus) leads to linear models with little improvements of water bodies. At the same time the continued leaching of matter (nutrinets and minerals and organic matter) essential for vegetation and cooling structures (evapotranspiration) is not recognized.

Energy and resource intensive sewage treatment plants with several treatment steps have contributed to a short term and pretend solution of eutrophication problems. However, these treatment plants were not able to stop the ageing processes of the landscape from which we have to live on. At the moment the landscape is ageing by a factor of up to 100 compared to the losses of naturally optimized coenotic structures. Today waters can only be managed and protected by a better management of the landscape. The present aftercare protection of waters leads to ever increasing costs, a final large scale acidification of landscape and lakes, and the loss of the water cycle and the most important cooling system based on the vegetation cover.

The functionally of physical nature, which means sustainable carrying capacity of the landscape for society, seems therefore at the moment more endangered than lakes, rivers and the coastal waters.

The areal functionality of physical nature (hardware) necessary for sustainability of society (software) means:

* the integrity of the water cycle and its distribution
* the integrity of atmospheric composition and its vertical distribution
* the integrity of soil and its biological detoxification by selective, dynamic exclusion of toxics by the living membrane while organic substrate is accumulated.
* the integrity of process and reaction patterns and distribution in time and space.

NATURE AND ITS PROCESSES

To understand the causes and consequences of landscape degradation it is necessary to see wetlands, lakes and rivers as integrated parts of the whole catchment area. Rainwater, theoretically consisting of distilled water, is the dynamic transport and reaction medium which is collected in the lowest parts of the landscape. Water in lakes and rivers reflects reactions and processes in the landscape. Many processes have to be considered to understand how impacts in the catchment directly result in a non sustainable nature.

Due to the deterioration of local short water cycles, climate changes become more sudden and severe, as less water is involved in evapotranspiration (cooling processes). Temperature gradients become steeper and are randomly distributed thought the catchment.

The long-term influence by man on the landscape has thus affected the water cycle and its coupling with energy flow and the transport of matter. The redevelopment of vegetation and a more water-saturated soil is a prerequisite for minimizing matter losses by runoff. In other words, the restoration of short circulated water cycles in the landscape is essential for a sustainable development.

A holistic approach attempts to consider all the processes occurring in the landscape and their coupling in both space and time.

THE E(NERGY), T(RANSPORT), R(EACTION) MODEL

The interrelation of energy, water transport, physical, chemical and biological processes are described in a new ecological mode, called the Energy-Transport-Reaction (ETR) Model [7,8]. Ecosystems are optimized in their structure as dissipative energy processors, through the actions of the water cycle, driven by the precise structured, cyclical additions of energy. Man interferes with the regular, phased, energy input and its regular dissipation in an optimized biocoenosis selected by nature, through the introduction of random elements into the system. man's input of fossil energy coupled with the transport of material - especially in agricultural managed areas - has resulted in excessive energy - and matter flow densities. The degradation of biocoenotic structures and the distortion of the water cycle has resulted in an increased lack of cooling properties and their distribution. The out-of-phase oscillations thus created, result in highly irregular perturbations in natural systems, which can be manifested as the increased probabilities of floods and droughts, extremes of temperature, abnormal tropospheric reactions, mass die-off of plant and animal communities, etc., i.e. randomly distributed processes in both space and time.

The water cycle is the basis for all metabolic processes in nature. Water is the connecting, transport - and reaction - medium of the biosphere and its structure in space and time. The dissipation of energy by the water cycle is an energy-driven process where water and/or organisms are seen as processors which channel the energy partition and dissipation in the system, while the energy (solar radiation) is offered on a precise daily and yearly frequency. Water, as such an energy processor, shows three dissipative processor properties acting in a recursive way, all three which involve both cooling and heating respectively: the physical process of evaporation and condensation, the chemical process of dissolution and precipitation, and the biological process of production and respiration (water cleavage and reassembling).

THE PHYSICAL PROCESSOR PROPERTY OF WATER (EVAPORATION-CONDENSATION)

The daily solar energy pulse results in dynamics of the most important dissipative medium, water, which dissipates the pulse in space and time. Potentials are mainly distributed by evaporation and condensation of water using the enthalpy leap between liquid water and water vapor or ice respectively.

THE CHEMICAL PROCESSOR PROPERTY WATER (DISSOLUTION-CRISTALLISATION)

The chemical processor property of water is based on the polar property of the water dipole which leads to the dissociation of water. This dissociation lets water act as a week acid with a proton density of 10-7 mol / l at 20 degree. Thereby chemical reactions at an interface with solid matter are enabled, leading to dissolution of various ionic lattices into dissolved ionic charges. At thermodynamic equilibrium conditions any process ceases. This processor property causes, due to solution of matter in the soils and transport of this water to the sea an irreversible charge flow.

THE BIOLOGICAL PROCESSOR PROPERTY OF WATER (PHOYOSUNTHESIS-RESPIRATION)

There are optimized "dissipative water-structure" containing highly organic molecules which can absorb and channel light as additional energy in such a way that the water dipole is disintegrated (condition at pH = 0) and the liberated hyfrogen can reduce carbondioxide, forming carbohydrate radicals and finally sugars or cellulose while oxygen is liberated to the environment. These energy dissipative structure are found in primary producers. The opposite reaction is known as respiration where water is reassembled thus producing energy for coupled "biocatalized" processes. Since these processes keep the matter cycle in place, areal losses in dissolved matter are rare. Organisms arrange in communities, forming coentic structures decisive for the short-circuited evaporative water cycle. Under this circumstances an adequate stock of energy is stored in the form of organic degradable matter and nutrients and minerals Soil) are stable in their spatial domain. Such optimized structures with respect to sustainability, dissipate the energy pulse in time and counteract matter losses which would occur with the hydrological process combined chemical reactivity.

The irreversible matter losses from a considered system (e.g. catchment) determine the stability f the assemblage of organisms (energy processor structure). The efficiency of such a structure (coenosis), coupled with the dissipative water cycle, is given by the amount of matter cycled in relation to matter losses (charge losses) for a given amount of energy delivered.

The theory of energy-dissipative structures was developed by I. Prigogine [9]. This theory refers to nature as an energy dissipative process and the structure of organisms and ecosystems as the result of this process. Temporally stable structures evolve far away from thermodynamic equilibrium as a necessity and not by chance. This theory closes the former gap between physics chemistry and biology. Together with the ETR model it can explain selforganization in a delimited area under precise alternating energetic conditions according to sustainability criteria. The least ageing (composed)structure with highest thermodynamic efficiency (least irreversible losses) will prevail. This suggests the selection of new species is according to the improvement of efficiency (minimizing ageing). A mature system is characterized by more species than a new system. However, a high species diversity does not necessarily indicate a sustainable system.

The diversity concept is therefore implied in the sustainability concept. As a stand alone concept it is redundant and contradictory to the sustainability concept.

THE BASIC DISSIPATIVE COENOTIC STRUCTURE CONCEPT

Let us consider organisms as energy processors which dissipate an energy pulse by converting it into an even matter flow by reducing energy flow density. The usable energy is converted to mean temperature in time and space lacking future potentials for reacted (non random) processes. The above named processor properties of water allow five necessary, functionally defined components to assemble a simple ecosystem which can be delimited in time and space. We could see these structures in an analogous way certain coefficient of efficiency in a given environment [10].

The five components are:

1. The primary procedures are process carriers and process controllers. The primary procedure have a double function a.) As process carries by storing energy, producing carbohydrates and biomass and thus providing and energy source independent of the solar pulse, and b.) As process controllers by pumping water through the organism (evapotranspiration). Thereby the water content in the soil is controlled, and so are redox conditions and mineralization processes.

2. The detritus, forming a raw humus layer and soil containing the nutrient-, mineral- and energetic stock.

3. The destructors, bacteria and fungi as process carriers responsible for the mineralization of detritus. These components can be activated by water flow and topped when waterflow is ceased by negative feedback due to product inhibition. These components would clog the interstitium in the humic layer due to rapid reproduction thus increasing resistance again pumping.

4. The whole food chain as process controllers reduces space limitation by removing and using both autotrophic and heterotrophic process carries for food, keeping the energy dissipative cooling, transport and reaction medium.

Such a structure shows a minimum openness with respect to matter flow at a given energetic environment and can therefore be delimited in space and time. The efficiency concept can be applied to such a composed structure.

THERMODYNAMIC EFFICIENCY AS A MEASURE OF SUSTAINABILITY

Efficiency relates to two kinds of processes:

1. Cyclic processes (parallel structure which are short circuited and of relatively high frequency) and

2. irreversible processes (sequential processes which occur at much lower frequencies with high spatial impact showing "irreversible losses of bases and nutrients" to the sea) expressed in proton flow equivalents (one mol of carbon is equivalent to 2 protons or 2 equivalents of

ionic charges). They become cyclic outside of a relevant spatial or temporal observation span (e.g. glaciation phases to tectonic processes).

Efficiency which is closely related to stability and sustainability can be calculated when cyclic processes are put in relation to random processes, causing irreversible losses (= charges losses to the oceans = reduction of sustainable development). Efficiency is considered as:

(P-L)/P

Where P = gross production, L=irreversible losses all given hectare and year. For calculation purposes the flow is expressed in proton equivalents as energetic units according to the pH-concept. When absolute sustainability is to be calculated, the stock function of the mass of base cations and other nutrients has to be known down to a depth of 1 metre (which is approximately the depth of the active root zone) (11).

This ageing process explains selforganization according to sustainability criteria. The least ageing system (with the best cycling capabilities and least irreversible material flow in the most sustainable system.

Natural gross productivity per ha and year amounts in European wetlands at a maximum to about 12 tonnes carbon or 2000 kmoles of protons while the irreversible losses with water courses in large European catchments at average up to about 20 kmole per ha and year. Losses of this order of magnitude would need to be compensated by about 600-800 kg of limestone/ha and year at average in most of the areas used for agriculture and forestry. The total salt loss averages to about 1000 kg/ha and year (12).

Dynamic model for the distribution and accumulation of toxic substances in top-soil, wetland soils and lake sediments Decreasing plant-usable soluble mineral and nutrient stock from the top soil, however, leads to the accumulation of less soluble material, as e.g. heavy metals, and surface active immobile organic matter, such as chlorinated hydrocarbons. As long as the watercycle is acting upon an area, the selection process for material is proceeding according to solubility criteria.

It has been shown that fine dust particles contain more toxic substances than coarse particles. Emissions to the atmosphere occur almost exclusively from uncooled, overheated areas, while cooled wetlands, lakes and rivers are the places for immissions. The relations are highly nonlinear but were corroborated by sediment analysis which contain large accumulations of toxic metals and residues, especially in the upper strata (13).

The River Stor Project

The conceptual holistic framework presented above was the basis for investigations in the river Stor catchment carried our between 1990 and 1995.

The Sot Project is a study of a 1155km2 catchment in Schleswig Holstein, NW Germany. The catchment is predominantly arable (72%) with forestry (15%), and lies between 6 and 90m asl, with a river of mean slope 0.8 m/km.

The aims of the Stor project have been to gain a detailed understanding of systems and processes throughout the catchment. By understanding the processes, it is possible to derive realistic spatiotemporally-related landscape planning and management measures for sustainability. From the outset, a deductive procedure has been preferred enabling the rapid realization and interpretation of results.

The parameters measured included: total catchment runoff, dissolved chemical load (using both chemical analysis monthly at 128 measuring sites and conductivity measurements in 10 sites and 20 minute intervals), temperature measurements (both on a micro-habitat level and from satellite information) and aspects of river morphology, as well as incorporating land use and geophysical map data. Results from highly-resolved temporal information from measurements on the ground have been coupled with the relatively finely-scaled spatial information from satellite imagery. The investigations of the river Stor catchment were supported by the Ministry of Education and Research of Federal Republic of Germany and the Federal County of Schleswig Holstein.

Summarized results of water and matter losses

The analysis of chemical data (by means of mean and variance patterns of the different parameters) allows three classes of matter loss categories to be distinguished:

1. Acid creators, such as sulphur and nitrogen, can indicate the break-down process of organic substances. Where a water table is dropping (i.e. decreasing water flow), break-down processes occur in the upper soil layers while matter transport is relatively reduced. With s rising water table (i.e. increasing water flow), the released matter (mineral salts and nutrients) is dissolved and easily transported. Their contribution to the dissolved load therefore often peaks in autumn/early winter when the water tables rise.
2. Soluble elements such as calcium, potassium and magnesium (summarized by the parameter alkalinity). Their concentration is directly dependent on their solubility and water flow. At very high rate of runoff a "fall-off" of concentrations will be measured. Fluctuations will generally be considerably less than that of the first group.
3. Elements that are coupled to the erosion process at the soil surface layer, such as heavy metals and particulate phosphorus.

MECHANISMS OF MATTER LOSSES

1. The process of matter loss is an aerial function and therefore primarily dependent on available water and its distribution. Secondly, the matter-loss flow is determined by the energetic and solubility criteria in their spatiotemporal distribution.
2. Energetic boundary conditions of the mineralization process or organic soil particles (control of pH and redox-potential) are determined by the alternation between dry and wet phases in their spatiotemporal distribution.
3. Through human actions with respect to the water supply, the degree of coupling between production and break-down processes is considerably lowered and the overall system efficiency reduced. This is demonstrated by the tremendous matter losses from soil surface layers. Through such matter losses the ratio between available, soluble material and less-mobile toxic substances (e.g. heavy metals) is also

changed. The habitat is degraded in a non-linear way.

4. The salt concentrations of the dissolved load changes in direct proportion to its conductivity. Thus a time-series of runoff salt concentrations can be derived from a monthly measurement of chemical concentration together with data obtained from a conductivity probe (automatic recording device) having a very high temporal-resolution.
5. There exists a close, site-specific, link between discharge (total runoff) and conductivity. The conductivity rises in response to an increasing discharge but falls with a slower rate of decline when the discharge rate falls.

MONITORING ECOSYSTEM EFFICIENCY

1. The primary measure for the sustainability of a system is its efficiency. If the efficiency is very high, only little energy is necessary to compensate for any matter loss.
2. An efficiency term for ecosystems can be defined by the ration between gross production and turnover of matter to matter losses, or alternatively, through the quality of thermal damping.
3. Society has to define a framework of self-optimization that leads "automatically" to increases in the sustainability of the landscape and hence the stabilization of society.
4. The heuristic process of improving methods of efficiency evaluation has to taken further so as to better judge the differences between different regions (e.g. subcatchments) (14).

THE MANAGEMENT OF WATER CYCLE AND MATTER LOSSES

Water management and protection requires, therefore, the control of water- and matter-flow processes in the landscape rather than management of aquatic ecosystems.

A redevelopment of the landscape together with the transport system water course minimizing irreversible charge losses (amounting up to 20 kmol/ha/yr which could be considered as an entropy term of the landscape) is necessary and urgent. Lowered cooling capability by vegetation in interference with industrial and urban heating structures as recognized from the satellites, together with the irreversible charge losses from the landscape seem to be quantitative measures of deterioration of the system's energy dissipative structure.

This dynamic structure interacts (controls and ins controlled) with the dynamic distribution of energy, potentials and processes in the landscape, including atmosphere and clime. Evolution an ecological succession, also energy-driven processes are in confined areas (as e.g. a catchment with a coherent water transport system) strongly dependent on system efficiency.

Cyclic matter flow is improved and matter losses are lowered thus structuring process distribution and coupling. The structures are coupled in such a way that relatively high entropy (measured e.g. in irreversible charge losses) of the single process is lowered by coupling with another process in a different time phase thereby increasing sustainability. A confined area is necessary to put a negative feedback by space limitation on maximum growth rate, thus turning reproduction (r)-strategy into survival (K)-strategy, allocating process of selfoptimization relies on highly structured energetic pulses stable in frequency, phase-modulation and amplitude.

Suggestions for improvement of the landscape degradation problem are briefly described for catchment and water bodies. More radical solutions are demanded to restabilize urban-rural integration, local water cycles, food production and the balance of natural, terrestrial and aquatic ecosystems (15).

Stagnant waters hardly show losses concerning organic matter, nutrients, and mineral substances and are conservative, whereas running waters and especially water percolating through the soil are far more erosive. Only the biological process, represented by a vegetation cover, can control the ratio between evaporating and running-off water. With the increasing spatial and temporal interlacing of organisms net production will decrease approaching zero while the carrying capacity for (living) biomass will rise. The thermodynamic efficiency and the life span of the system are increased.

The problems concerning nutrient content in our waters represent but "the tip of the iceberg" and can at reasonable costs only be solved within the catchment. A minimization of all matter losses from the land represents the best and most lasting protection of waters.

REDEVELOPMENT OF THE CATCHMENTS IN A LANDSCAPE

A redevelopment of the landscape, confined in catchments and including sustainable water cycle seems unavoidable.

1. The upper parts of the catchment are most sensitive to the leaching of soils by runoff. Priority in redevelopment will be given to cover the upper catchment areas with almost unmanaged mixed forest. This forest should prevent erosion and provide local cycling of matter.
2. More wetlands are needed in headwater areas to act as hydrological buffers and to equalize uneven flow rates (hydrograph control). This can be achieved by building up water retaining organic soil structures saving water even from minor precipitation events.
3. Areas where matter losses are retained are riparian zones. Here stored humidity reduces mineralization processes and matter efflux (especially of organic substances) can be prevented. These wetlands should increase evapotranspiration and accumulate organic soil. In a long term management program these soils could be used in areas where soils are degraded.
4. Human faeces and urine separated by vacuum toilet systems will after digestion and addition of lime constitute a high grade fertilizer for agricultural purposes. Biologically treated waste water or untreated "gray water" can be used in managed wetlands. In most cases this is probably in advantage of energy-demanding "hightech" treatment plants producing unusable sludge and water low in nutrients but rich in bases and buffer substances. Wetlands have been identified as efficient nitrogen sinks in the landscape. Water from hightech treatment plants is up to now discarded into receivers and irreversibly transported to lakes and coastal waters. Manure from industrial animal production is however, still

considered as fertilizer and often spread on the fields to the edges of water bodies. The biomass produced in managed wetlands can be transformed to food for animals or used for other purposes.

5. Improving the cooling structures wherever possible. Especially in cities storm- and graywater should be used for creation of local evaporating wetland vegetation or other cooling structures. Greening overheated surfaces in urbanized areas should reduce emissions and inhibit the transport of radicals and noxious gases to the atmosphere.

To make the redevelopment of a landscape even politically feasible, the income of land managers has to be increased by making them responsible for the production of clean water to rivers, for a better distributed hydrograph, for improving the cooling system by adopting a better distribution of vegetation, for production of drinking water and for taking care of biologically treated waste water and sludge. Aerial managers as farmers and foresters have thus to be made responsible for environmental quality in general and nature conservation, integrated in landscape planning and water management. They should be paid according to their success in their own land and collectively in the catchment. The use of groundwater for water supply should be successively avoided.

The intelligent management of catchments by use of vegetation in wetlands and food production on minimized and carefully chosen areas seem the only way to gain sustainable development and to counteract global change with respect to desertification and degrading climate.

The funds necessary for aerial managers could be money at present spent on production of water, on environmental planning and, e.g. the subsidies given from European Union and local governments to farmers and forest owners.

A permanent improvement of the environment can only be achieved by turning wastes into assets. Society has to turn from the r-strategy of ever increasing markets and economical expansion to the k-straggly of better social coupling resulting in more short circuited matter cycles and regional markets for goods with a high turnover and short life cycles.

In a longer perspective the restructuring of society is a necessary prerequisite for an efficient recycling. Regionalized markets for goods with short turnover time as e.g. food can be formed only if energy and transportation costs are increased. Resource taxes instead of labour taxes seem to be the only alternative. Resources considered are reciprocal time (=energy) and space in the form of a property value (related to sustainable use), given by the market. These resources should be limiting and taxed only for a restructuring of society. This would result in more slowly growing energy prices (the increase in oil price was 1995 about 30%) and give developing countries the possibility of improving their structure. In the industrialized countries the structures with extremely low energetic efficiency would disappear.

The excessive growth of cities would probably stop. New working places dealing with a more intelligent management of landscape would be created. All processes could then be improved with respect to energetic efficiency and more stable social patterns formed in connection with low material losses under dynamic conditions. The object oriented society would then turn into a more communication oriented global structure thus increasing life quality with less risk for conflicts, cutting production processes back to human demands and thus enabling sustainable development.

Environment and Development of the Mekong River Basin and Multinational Coordination

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October 1996

ABSTRACT

The development in the Mekong River Basin is moving fast. Economic growth rates of the riparian countries are expected to continue to be in the order of 6-9% per year for the foreseeable future, and simultaneously, investments in industrial and power generating plants can be expected to nearly double over the next decade. It is time now for taking the opportunity to prevent irreversible impacts on the environment, and prepare the basis for a sustainable development in the Mekong River Basin into the next century. The Mekong River Commission (MRC) will be prepared to assist the riparian governments to meet these crucial challenges. On April 5 1995, the governments of four riparian countries in the Lower Mekong River Basin signed the "Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin" and established the Mekong River Commission (MRC). The Agreement stipulates the framework for cooperation within the fields of sustainable development, utilization, management and conservation of the water and related resources of the Mekong River Basin.

A large scale Environment Programme has been started in 1996 providing support for establishing the required institutional capacity for managing the environment, and for developing in depth knowledge about the environment and its response to human activities. This programme receives support from several donors and will initially run over three years.

The MRC intends to start preparation of the Basin Development Plan (BDP) in early 1997. The BDP will provide a framework agreeable by all countries for sustainable use of water and related resources in the Mekong River Basin. The Environment Programme will support the BDP preparation, and environmental aspects will be considered for all basinwide focusing on transboundary impacts. The BDP is intended to be a key tool and process for future planning in the Mekong Basin, and it will be maintained and updated/improved at regular intervals.

Coordination of donor assistance to the Environment Program and the BDP is expected to be ensured by establishing procedures for regular consultations among the supporting donors. Dander, SDI and SDC, for example, have already coordinated

their interest in the Environment Programme. Together, they emphasize on strengthening certain core functions of the MRC Secretariat related to environmental policy, assessment and training, and in specific areas related to management of watershed, wetland, natural resources data management, integration of environmental aspect in projects.

In addition there are several other related regional initiatives and relevant programmes and activities in the region from which the MRC Environment Programme and BDP may benefit :

- The Greater Mekong Subregional Cooperation Programme, (GMS), initiated by ADB
- The Forum for Comprehensive Development of Indochina, initiated by Japan
- The ASEAN - Mekong Basin Development Cooperation
- The Mekong Development Research Network
- Various UNEP programmes
- The Economic and Social Commission for Asia and Pacific (ESCAP)

The MRC Secretariat has taken initiatives in relation to several of the above initiatives and activities to avoid overlap and duplication of efforts and thereby contribute to a more efficient utilization of funds made available by the donor community for support of environment and development in the Mekong River Basin.

1. INTRODUCTION

The development in the Mekong River Basin is vibrant. With economic growth rates expected to be in the order of 6-9% per year for the foreseeable future, the countries in the region may well double their CDP within ten years. Such high growth rates pose a threat to sustainable development and environmental quality. The countries are mainly rural and by year 2010, 60 to 70 percent of the population will still be living in rural areas. Intensification of agriculture, expansion of agricultural land and rural industrialization will therefore be key areas of development affecting a high number of people. The environmental issues related to rural areas can therefore be expected to increase and change in character during the next decade.

Simultaneously, investments in industrial and power generating plants can be expected to nearly double over the next decade. It is time now for taking the opportunity to prevent irreversible impacts on the environment, and prepare the basis for a sustainable and environmentally sound development in the Mekong River Basin into the next century. The Mekong River Commission (MRC) will be prepared for assisting the riparian countries in the meeting this crucial challenge.

A large scale Environment Programme has been started in 1996 providing support for establishing the required institutional capacity for managing the environment, and for developing in depth knowledge about the environment and its response to human activities. This programme receives support from several donors and will initially run over three years.

The MRC intends to start formulating a Basin Development Plan (BDP) in early 1997. The BDP will provide a framework agreeable by all countries for sustainable use of water and related resources in the river basin. The Environment Programme will support the BDP preparation and environmental aspects will be considered for all basinwide development plans and projects, and integrated in the process of developing the BDP. The BDP will focus on activities that involve implementation by more than one of the member countries or would have transboundary impacts. The BDP is intended to be a key tool for future planning in the Mekong Basin, which will be maintained and updated / improved at regular intervals.

2.THE NEW MEKONG AGREEMENT

On April 5 1995, the governments of four riparian countries in the Lower Mekong River Basin i.e., Cambodia, Lao PDR, Thailand and Vietnam signed the " Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin " and established the MRC.

The Agreement stipulates the framework for cooperation within the fields of sustainable development, utilization, management and conservation of the water and related resources of the Mekong River Basin (MTB) for the multiple use and mutual benefits of all riparians.

Emphasis is further put on conservation of the environment and ecological balance from pollution and other harmful effects resulting from any development plans and uses of water and related resources.

3. ENVIRONMENT

3.1 The State of the Environment

Problems and environmental issues in the development and in the utilization of the Mekong River and related resources are being acknowledged and addressed. However, the Agreement dose not in all areas safeguard the minimization of the harmful effects that might result from natural occurrences and man-made activities. In this respect, it is also and opinion of the public that the riparian countries should commit themselves to observe certain international conventions commit themselves to observe certain international standards regarding the conservation of the environment.

To identify all subject specific problems related to the development and management of water and related resources in the watershed of the lower Mekong basin with a size of more than 600,000 km^2 will be a major challenge. Specific impacts will depend on many factors including natural conditions, the size and type of development project, the time-frame involved, the technologies used and potential mitigation measures. There are, however, a number of sensitive geographical areas in the basin which have proved to have "specific" problems related to water development projects including changes in water regimes. These include :

- The Korat Plateau (north-east Thailand and Vientiane plain in the Lao PDR) ;
- The Mekong Delta in Vietnam ;
- The Central Highlands in Vietnam ;
- Floodplains and wetlands along the mainstream and in the hinterland of Cambodia ;
- Mountainous areas in the Lao PDR.

Theoretically, environmental impacts are :

- A general deterioration of the quality of the surface water due to various human activities in the watersheds ;
- A general deterioration of the quality of the groundwater ;
- Negative impacts on aquatic ecosystems, in the floodplains , and in the river itself, due to changed water regimes by uses of the river water ;
- Public health hazards by water related diseases, which might increase and spread due to increase use of chemicals in agricultural production and the disposal of hazardous wastes;
- Deterioration of wetlands resources due to changing water regimes ;
- Changes on flood patterns ; and
- Reduction and degradation of natural resources and biological diversity due to over exploitation.

Karat Plateau
The environmental parameters of greatest concern in the Korat Plateau and the Vientiane Plain is the risk of salinization due to rock salt in the bedrock and / or salt accumulations in the sub-soil. This affects the potential to land use for irrigated agriculture, and it will increase the salt content in surface water and will, under certain conditions, probably destroy the soil conditions due to salt accumulation in the topsoil.

The lower parts of many tributaries of the Mekong River in north-eastern Thailand are known as important breeding and nursery grounds for many economically important fish species captured in the main river. An increase in the salt content as well as the construction of river structures may affect the fish production, if no countermeasures are taken.

Mountainous Areas in the Lao PDR
In the northern part of the Lao PDR the ongoing slash-and-burn farming is causing a serious threat to the run off from the watershed. Increased runoff and flooding due to the decreased infiltration and water storage capacity by the degraded vegetative cover have been noticed in some watersheds. This is to some extent also valid for other parts of the basin, but the topographical conditions in the Lao PDR, with steep slopes dominating the landscape, make the impacts

of slash-and-burn farming more severe.

Mekong Delta

In the Mekong Delta great efforts are being made by the Vietnamese authorities to increase agricultural production, mainly for rice, by draining acid sulphate soils covering large areas in the Delta and through reduction of salt intrusion along the coast. Acid-sulphate soils in the Mekong Delta are characterized by high acidity, high levels of potentially toxic aluminum and poor phosphorus availability. These soils cover 1.6 million ha., divided into 0.55 million ha of severe acid-sulphate soils (usable for agriculture, with proper water management and fertilizer application).

Flood Plains and Wetlands

Flood plains and wetland along or close to the mainstream and in the hinterlands of Cambodia are ecologically important for the overall biological life and balance in the mainstream, as well as a moderator for the water regimes over time. Most wetlands serve a wide variety of functions, including flood control, nutrient retention, sediment and toxicant retention and groundwater recharge. They serve as both nursery and spawning ground for many fish species in the entire river system and are an important natural habitat fort wildlife resources in a landscape. Major changes in the water regimes of the river may have negative impacts on the above-mentioned natural functions of the wetland ecosystems. The importance of the wetlands for the productivity and overall ecological functions of the Mekong River system should be estimated as early as possible. For the management of the environment and the natural resources based on the principle of sustainable development, adequate personnels, comprehensive data bases, appropriate legislation and regulations, and great enforcement capability will be required.

3.2. Impacts of Development Activities

The current level of major impacts of development activities on surface water hydrology (SWH) and surface water quality (SWQ) are as follows:

	SWH	SWQ
Population growth	slight	moderate
Urban development	slight	moderate
Roads and bridges	slight	slight
Lowland agriculture	moderate	moderate
Upland agriculture	slight	moderate
Aquaculture	slight	slight

3.3 The Environment Programme of MRC

The overall strategy of the MRC Environment Programme is based upon the wish of offering a programme which address the core environmental problems and issues in the Mekong basin.

Long-term economic development and satisfaction of basic human needs in the lower Mekong basin depend on sustainable use of the natural resources. It is not only the poor and marginal people but also the public in general whose life, habitats and customs are likely to be affected to a great degree, when the basin's natural resources are overexploited or degraded. The Environment Programme will assists the MRC and the riparian countries in enhancing the integration of environmental protection and conservation into their development activities in a coordinated and internally cohesive manner.

Capacity Building

In view of the present situation in the riparian countries with a general shortage of experienced professionals with appropriate skills, development of human resources in the responsible institutions is the first and most urgent priority.

Coordination and Collaboration

The programme has been designed so as to be coherent with the plans and priorities of the riparian governments. It will be implemented through the national institutions in order to ensure sustainability of the results, and in close coordination and cooperation with permanent regional institutions in the sector in order to ensure efficiency and avoid unnecessary duplication of efforts.

Participatory Approach

Experience from other natural resource management projects has shown that commitment and responsibility for proper natural resource management can be generated if a participatory approach is followed. This means that target groups participate in identification of problems and solutions, and in planning of interventions and implementation, monitoring and evaluation of activities.

Programme Implementation

The responsible executing agency of the Environment Programme will be the MRC Secretariat. The assistance from Danida, Sida, SDC, and other donors will basically be provided and implemented on basis of two complementary inputs :

1) The provision of long term assistance for supporting environment policy planning, institutional strengthening , and integration of environmental aspects in projects ;
2) The provision of support for programme components / activities aiming at developing means and tools for solving and managing environmental problems e.g. monitoring, information management, capacity building, training, and studies of measures for management and conservation of natural resources.

Programme Priority Areas

In order to address the environmental problems of the MRB, to strengthen the core environmental functions of the MRC Secretariat, to support the National Mekong Committees, and to ensure the integration of environmental aspects in the projects and programmes of the MRC and its national agencies concerned, Danida, Sida and SDC will support the Environment Programme through a number of programmes, activities and projects. The assistance will take the form of both technical assistance and financial support to core functions of the

MRC Secretariat. The Environment Programme includes the following components :

- Environment Policy Planning
- Institutional Strengthening and Capacity Building, including financial support for long term staff (regional / riparian)
- Integration of Environmental Aspects in Projects
- Environmental Planning and Impact Assessment
- Integrated Database and GIS for Natural Resource Management (Basinwide)
- GIS / Watershed Classification Project
- Integrating Catchment Conservation with Local Development (Basinwide)
- Inventory and Management of Wetlands in the lower Mekong Basin (Basinwide),Phase II
- Inventory and Management of Cambodian Wetlands
- Water Quality Monitoring and Pollution Control in the Lower Mekong Basin, Phase III
- Groundwater Investigation Programme (Basinwide), Phase II
- Soil Erosion and Sedimentation Studies, Phase II
- Environmental Management of the Plain of Reeds and Acid Sulphate Soils in the Mekong Delta, Vietnam.
- Environmental Training, (Basinwide)

4. MEKONG BASIN DEVELOPMENT PLAN (BDP)

The Agreement defines the BDP as a general planning tool and process that the Joint Committee of the MRC would use as a blueprint to identify, categorize and prioritize the projects and programmee to seek assistance for and implement the plan at the basin level to promote, support, cooperate and coordinate in the development of the full potential of sustainable benefits to all riparian states and prevention of wasteful use of the Mekong River Basin, consist with the needs to protect, preserve, enhance and manage the environmental and aquatic conditions and maintenance of the ecological balance exceptional to the MRB.

The preparation of the BDP has started and is being carried out in two phases. The objective of phase 1 is to identify an appropriate basin development planning methodology and scope of priority areas of basin planning, and to prepare draft Terms of Reference for phase 2, the detailed BDP formulation study. Phase 1 will include information on present status of basin and related sectoral development, detailed planning modalities, work plan, detailed budget and necessary national contributions. The approach proposed for phase 1 is different from resource-oriented approaches adopted in the previous basin planning efforts for the Mekong. The new approach is aiming at supporting national efforts in achieving national development goals based on priority areas and linking these growth areas into a Mekong network of growth areas and thereby ensure "*interdependent sub-regional growth*". The new approach is also aiming at supporting continuity and consistency of efforts made by the riparian countries and donor community for sustainable development and management of the Mekong water and related resources.

BDP is envisaged to be the key tool to enable the MRC to establish itself as the leading sub-regional organization that ensures sustainable development of the Mekong River Basin and initiates core activities required for an interdependent sub-regional growth.

In this context, the BDP will be based on a shared vision, and for realizing this, a mission statement has been formulated setting the guidelines for the planning process leading to the BDP.

The preparations for the Basin Development Plan are moving swiftly. The first phase supported financially by Sida and with advisory services from Danida is expected to be finalized by the end of 1996.

4.1 Vision and Mission of the BDP

Emphasis is put on a shared vision as basis for the overall basin planning programme. The Shared Vision is described by the following statements :

1) "Development of the full potential of sustainable benefits of the basin's water and related resources to all riparian states for the economic and social well-being and living standards of their peoples ;
2) Maintenance of the ecological balance exceptional to this river basin;
3) Encouragement of and support to interdependent subregional growth; and
4) Development of an adequate, efficient and functional joint organizational structure."

Statement 2 including :

- Maintenance and development of Mekong protected areas ;
- Maintenance of the ecological balance of all the Mekong basinwide important ecosystem such as the Great Lakes and the Mekong estuarine ecosystem : and
- Protection of the Mekong Biodiversity

It is recognized that environmental aspects and maintenance of ecological balance of the Mekong River Basin will be integrated into the interactive planning process leading to the BDP.

The Mission Statement is started as follows :
" The Basin Development Planning Process is a continuing process ton contribute to improvement of standards of living, and support environmental sustainability in the MRB. A BDP (to be periodically updated) will be produced to serve as a framework for cooperation among the riparian countries to utilize the full potential of sustainable benefits of the water and related resources of the MRB. Initiatives, based on the most effective management of water , and related natural and human resources, will be identified, developed and implemented as part of the BDP process. Interdependent subregional development will be encouraged

through cooperative actions initiated by the MRC and other concerned agencies".

4.2 Term of Reference for the BDP

The Terms of Reference for the BDP has already been prepared and endorsed by the Joint Committee. The TOR specifies the approach and methodology for development the planning process leading to :

1) An overall development framework for the MRB based on a year 2010 planning horizon in the context of a year 2020 development perspective ;
2) A Water Systems Development and Management Strategy which would include : a) priority development strategies for seven water related sectors, including cross-sectoral human resource and environmental themes and issues, which will be integrated in all analysis and outputs ; b) programmes and projects associated with strategies. The seven water related sectors are :

- agriculture / irrigation
- fisheries
- forestry / watersheds-
- navigation and transport
- hydro power / energy
- tourism and recreation
- urban and industrial uses

3) An established tool and process for planning which would include :

- A planning information / monitoring system, and a data base ;
- A process and mechanism to facilitate the updating of the BDP at regular intervals ; and
- A human resources development programme and process.

The methodology is composed / described through a set of activities briefly outlined in the following.

- The first activity is initial situation assessment, followed by identification of priority issues associated with water related activities and ecological systems in the MRB.
- Development driving forces will be identified for water related sectors and systems. Strategy identification will be based on analysis of the driving forces, opportunities and threats for the water related systems, and assessment of institutional capabilities.
- In parallel, our analysis of the status and dynamics of water related sectors and systems will be carried out, focusing on the relationship between water demand and water availability. Water quality will be one of the key issues the analysis. This work will initially be based on existing data compiled by MRC Secretariat through many years. Data and information gaps crucial for proper analysis will be identified and data collection activities be initiated.
- A development framework (year 2010) will be derived from consideration, in an iterative manner, of national plans, driving forces, and public input. On

this basis, a strategy for water systems development will be developed . This will describe the role that water related sectors and systems should play within the year 2010 development framework for the region, and within the limits of key parameters such as environmental conservation, water availability, available technology, etc.

- The output will be a set of high priority strategies for water related systems within the Mekong River Basin. These strategies will be broken down into programmes and projects for implementation.

For supporting and facilitating a progressive interactive planning process, existing tools and mechanisms will be utilized if required. This may include : a) tools for dynamic water resources availability analysis and sector-wise water demand analysis ; b) a mathematical simulation modeling capability of the Mekong River System for providing proper simulation of consequences of impacts from development projects (development scenarios), and as a high-level decision-making in the riparian countries stakeholders, and public participation encompassing integrated multi-objective and systematic analysis of the constraints, opportunities, benefits, impacts and uncertainties involved with proposed projects, with the aim of reaching consensus on a sustainable development framework, in terms of a set of agreed development scenarios.

4.3 Implementation of BDP Formulation

Financing the implementation of the BDP formulation will require about US $ 5 million and the MRC will be seeking support from donors. Some donors have already shown interest but no commitment as yet.

The MRC Secretariat is completing the needed documentation including a project proposal which describes the objectives, expected outputs, required resources including external funding, the implementation plan and time frame that will lead to the establishment of the BDP incorporating the interactive planning process and a basin development framework which will balance socio-economic and environmental considerations. On the other hand, there is a strong pressure from the riparian countries to have the project started as soon as possible, and to complete the first version of the BDP within 2 years. It is the hope of the MRC that donor support may be available from early 1997.

5. MULTINATIONAL COORDINATION

Coordination of donor assistance to the Environment Programme should be ensured through establishing procedures for regular consultations among the supporting donors. Danida and Sida have already coordinated their interest in the programme through the conduction of joint appraisal in August / September 1995 of the Environment Programme.

The Swiss Development Cooperation (SDC) is also interested in supporting the

Environment Programme and fielded two missions between November 1995 and February 1996. SDC also emphasized on strengthening certain core functions of the NRC Secretariat related to environmental policy, assessment and training. The priorities of Danida, Sida and SDC on policy and organization level are very much in line. Sida Danida, and SDC will closely coordinate with the MRC Secretariat, in particular in areas related to management of wetlands, natural resources data management, integration of environmental aspect in projects, and environmental training.

In addition to the various types of projects within the MRC Work Programme, there are several other related regional initiatives and relevant programmes and activities from which the MRC Environment Programme may benefit :

- The Greater Mekong Subregional Cooperation Programme, known as ADB-GMS
- The Forum for Comprehensive Development of Indochina, initiated by Japan.
- The ASEAN-Mekong Basin Development Cooperation
- The Mekong Development Research Network
- UNEP's Environment Assessment Programme and GEMS
- UNEP-GLOBAL Resource Information Database (GRID)
- UNEP Regional Office for Asia and Pacific
- Geographic Information Systems and Remote Sensing for Sustainable Development (UNDP)
- Programme for Asian Cooperation on Energy and the Environment (UNEP)
- Economic and Social Commission for Asia and Pacific (ESCAP), Environment and Natural Resources Management Division, Environment and Water Resources Section
- ADB - Regional Technical Assistance on Coastal and Marine Environmental Management in the South China Sea.

Bi-laterally there are also a large number of planned and ongoing programmes and activities that needs to be considered and coordination should, where appropriate, be sought in order to ensure efficiency and effectiveness. The MRC Secretariat has taken initiatives in relation to several of the above programmes and activities in which some overlap and duplication of efforts could be identified when compared to ongoing or planned programmes and projects of the MRC. It is the intention to establish a mechanism for regular coordination and review of planned activities together with other actors, and thereby ensure a more efficient utilization of funds made available by the donor community for support of the environment in the Mekong River Basin.

River Basins as Ecological Management Units

-International co-operation and efforts for water management around the Baltic Sea-

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THE BALTIC SEA AND ITS CHATCHMENT AREA

With an area of ca 400 000 km^2 the Baltic Sea is at present the largest brackish water body in the world (Fig 1). It is the collecting basin of freshwater from a catchment area of 1 600 000 km2 and it receives saline water from the North Sea. Its average depth is 55 metres. However, the bottom topography is very uneven, with depressions down to 459 metres, separated by sills only 18-25 m below the surface.

The volume of the Baltic Sea amounts to ca 20 000 km^3. It receives about 470 km^3 freshwater per year from more than 200 rivers. Physiographic conditions such as morphology, topography, location of freshwater inflows and influx of saline water creates a Baltic Sea with great variations in salinity, from freshwater in the Bothnian Bay to pronounced salinity stratification in the Baltic Proper. The long retention time, theoretically 25-35 years, and the stratification conditions in connection with the irregular inflow of saline water make it very sensitive to pollution.

The inflow of saline water through the Danish Straits takes place partly as a constant, usually small influx, partly as rare, major inflows, caused by westerly storm winds. "Until 1976, major inflows were observed more or less regularly, with about 13 events every decade; but since then the frequency and intensity have changed. Only a few major events have occurred and no inflow events at all were recorded between the beginning of 1983 and the end of 1992. Conditions in the deep water of the Baltic Proper changed drastically and led to the most significant and serious stagnation period ever observed in the Baltic Sea. In January 1993, a much longed-for, major deepwater inflow occurred after 16 years of stagnation in the Eastern Gotland Basin. During a three-week period of strong westerly winds, a total of 300 km3 of water, about 150 km^3 of it highly saline and oxygenated, entered the Baltic Sea" (HELCOM 1996 b). No major inflows have occurred since then.

The Baltic Sea catchment is inhabited by ca 140 million people, of which ca 80 million live in the coastal zone. Discharge of sewage and industrial waste water as well as pollution from road traffic and shipping, not the least oil, has continuously increased. Eutrophication, oxygen deficiency and accumulation in the food web of poisonous substances have, therefore, caused severe environmental problems. The environmental degradation has had an impact on bird and seal populations, it is threatening valuable fish species and recreational possibilities have deteriorated. Even if the basin had become negatively influenced throughout the industrial period, political awareness of the problems has only recently been recorded.

INTERNATIONAL CO-OPERATION FOR ENVIRONMENTAL REDEVELOPMENT

The Helsinki Convention, HELCOM

In 1974 an international agreement was drawn up in Helsinki, on the protection of the marine environment in the Baltic area. The Helsinki Convention, which concerns dumping and pollution from shipping and sources on land, established the Baltic Marine Environment Protection Commission, The Helsinki Commission - HELCOM - as an intergovernmental organization. However, efforts to stop further degradation of the Baltic Sea were hampered by the iron curtain, which effectively divided the Baltic region into a Western and an Eastern section.

After the opening of the Berlin Wall, a revised convention was agreed upon in 1992. This new convention is adjusted to international environmental law and concepts such as the Precautionary Principle, and the use of Best Environmental Practice and Best Available Technology are now also included. Procedures for Environmental Impact Assessment (EIA) and a specific article on nature conservation and protection of biodiversity in the Baltic Sea drainage area are new, important components of the 1992 Convention. All the Baltic Sea States, and the European Community, are Contracting Parties to the Helsinki Convention and participate in the work of the Commission.

"The main duty of HELCOM is to keep the implementation of the Convention under continuous observation and to take decisions relevant to fulfil the objectives and goals of the Convention, i.e., the reduction and elimination of pollution of the marine environment of the Baltic Sea Area from all possible sources" (HELCOM 1996 a).

HELCOM has established the following four expert committees:

1) The Environment Committee for monitoring and assessment of the state of the marine environment,
2) The Technical Committee for handling issues related to pollution from land-based sources,
3) The Maritime Committee dealing with pollution from shipping, and
4) The Combatting Committee, dealing with responses to pollution incidents at sea.

International Financial Institutions such as the European Bank for Reconstruction and Development (EBRD), the European Investment Bank (EIB), the Nordic Environment Finance Corporation (NEFCO), the Nordic Investment Bank (NIB) and the World Bank are also members of the Programme Implementation Task Force, which is coordinated by HELCOM, as the administrative framework for the implementation of the Baltic Sea Joint Comprehensive Environmental Action Programme (JCP) of 1992 (Fig 2).

Some of the Commission's meetings are at the level of Ministers of Environment to strengthen and facilitate the implementation of the Convention and the Joint Comprehensive Environmental Action Programme (JCP). Such meetings were held in 1984, 1988, 1992 and 1994.

The 1992 HELCOM joint action programme (JCP) for the Baltic

1) has a regional approach, setting priorities for the Baltic drainage area as a whole;
2) is based on an attempt to identify all major point sources of pollution (referred

to as hot spots);

3) contains concrete proposals for remedial (preventive and curative) action at hot spots, based on prefeasibility studies, carried out for each of the major subbasins of the Baltic drainage area and for coastal areas;
4) identifies major non-point sources of pollution and outlines principles for appropriate action to address these sources;
5) contains rough estimates of investment costs, as well as of the anticipated reduction of the pollution load;
6) calls for a series of complementary and supportive activities which are intended, among other things, to help mobilize the necessary political commitment and public acceptance, and
7) initiates programme activities designed in such a way as to facilitate international financial institutions, donor organizations and domestic funding authorities to take necessary decisions without undue delay.

Thereby the key principles are to:

1) recognize the importance of a long-term perspective for ecologcial restoration;
2) take account of the important role of natural factors;
3) harmonize economic and environmental objectives;
4) undertake preventive and curative actions;
5) control pollution at source;
6) establish conditions for private sector participation;
7) take action to overcome constraints and build local capabilities.

The JCP Programme (Fig 2), which is expected to be implemented during the period 1993-2012, is focused on broad areas of action. One of these deals with the revision and general harmonization of environmental policies, laws and regulations between the Eastern, former centrally-planned countries and those in Western Europe.

In a variety of ways a second area of action supports the strengthening of institutional and the development of human resources. Scientific exchange programmes, networks between organizations, "twin city" and "twin county" arrangements and contacts between schools are considered to be as important in the long term as the intergovernmental co-operation in various fora.

The central objective of the Environmental Action Programme is the reduction of the pollution load from point sources of pollution, first of all municipal and combined municipal and industrial hot spots (Fig 3), calling for the largest share of the total estimated costs for the Programme. Various kinds of loans from international financial institutions are combined with grants from Baltic donor countries and from the EU for investments in countries East of the former iron curtain. St. Petersburg and Kaliningrad (Königsberg) are examples where planning and financing are not working well.

Of the original 132 hot or most stinking spots identified in the JCP, 50 are industrial, and 38 of them are located in the Eastern countries where investments have been initiated at only 11 sites (1996). In addition to the distinct hot spots there are many polluting industries also in need of urgent attention. In several cases social and economic considerations have prevented necessary action, such as the closing down of totally outdated and very polluting plants. In countries in transition there is often a weak commitment to environmental questions at all levels of society, and particularly at the local and regional levels.

Among the non-point or diffuse pollution sources agriculture and transport (Fig 4) contribute significantly to the pollution of the Baltic Sea Area, but action is as yet far from the level that would correspond to the seriousness of the problems. Of the total annual load of nitrogen on the sea, 30-40 % is estimated to originate from agriculture. The corresponding figure for phosphorus is 10 %. Certain river basins have been identified as high-priority hot areas for agricultural runoff. In the 1988 HELCOM Ministerial Declaration, a reduction by 50 % of the total nutrient load to the Baltic Sea was called for. However, progress in reducing nutrient input into the sea has been slow. In the countries in transition, several problems are connected with the restructuring of the agricultural sector.

With regard to effects on the Baltic Sea marine environment, nitrogen oxides and possibly metals are causing most concern. Emissions from transport on land and at sea constitute a substantial part of the total emissions of nitrogen oxides, sulphur dioxide, metals and carbon dioxide. In the countries surrounding the Baltic Sea, the transport sector contributes from less than 40 per cent to more than 80 per cent of the total emission of nitrogen oxides. Road traffic is the dominating source. Emissions of nitrogen oxides from the transport sector have not decreased markedly in any of the Baltic countries. On the contrary, in the Eastern countries, there has been an increase in emissions as a result of increasing transportation by motor vehicles. In the Western countries, the introduction of catalytic converters on motor vehicles has been counteracted by the overall expansion of the transport sector. HELCOM's recommendations in March 1996 on Reduction of Emissions from the Transport Sector Affecting the Baltic Sea is focused on the reduction of pollution from land-based transports and includes an integration of environmental considerations in all transport activities. HELCOM concludes that the transport sector is a major contributor to the pollution load on the Baltic Sea Area. The overall objective should, therefore, be to develop sustainable transport systems throughout the Baltic Region, preferably railways, to minimize environmental disruption and energy consumption.

The existence of natural estuaries, lagoons and inland and coastal wetlands used to function as biologically highly diverse, efficient filters and buffering ecosystems of great importance for the ecological protection and stability of the Baltic Sea. However, their function have largely been eliminated through economically short-sighted drainage projects, more drastically in the Western than in the Eastern countries. Another of HELCOM's areas of action is, therefore, to initiate the development and implementation of integrated management plans for the coastal zone. This truly ecological approach for the creation of a sustainable environment has been included as the result of the efforts made by the WWF Baltic Programme to convince the policy-makers of its feasibility.

Ever since the 1970's, HELCOM has initiated international Baltic co-operation by means of exchange of information and practical experience and joint activities such as seminars, symposia and workshops. Intensified, applied research is promoted and it is stressed that more precisely identified problems should be listed as a guide to scientists who might be willing to devote their research activities of vital importance to the restoration of the ecological balance of the Baltic Sea Region. Examples of issues which should be addressed through applied research within the JCP concern future transportation systems and management of critical ecosystems.

HELCOM stresses that in order to attain an ecologically sustainable development in the Baltic Sea Region, public awareness must be raised, attitudes changed and people made to understand the impact of human behaviour on the environment and as a result commit themselves to the restoration of the environment, including their own local environment. A special working group on Public Awareness and Environmental Education has, therefore, been set up and it has been agreed that public awareness and environmental education should be integrated in all projects implemented within the JCP. The 1992 Helsinki Convention contains provisions specifically concerning information to the public. Accordingly, countries shall ensure that information on the condition of the Baltic Sea and the waters in its drainage area, on measures taken or planned to be taken to prevent and eliminate pollution is made available to the public. Unfortunately, however, it is stated, that progress concerning activities to foster public awareness and promote environmental education has been and is still slow. Mechanisms to secure public access to open and objective environmental information is still largely missing. We have a clear example in Sweden, where the Road Administration and the civil servants on the staff of the County Office of the District of Blekinge are at the present time (1996) attempting to force through the administration a decision on a road construction which will degrade a well-preserved wetland. The arguments put forward for this construction are misleading and based on an unacceptably poor Environmental Impact Assessment (Lund University 1996).

It is estimated that around 2,000 ships are at sea at any one time in the Baltic Sea, passenger ferries carry about 70 million passengers per year, oil tankers carry over 100 million tonnes of oil and oil products per year and about 12 loaded chemical tankers with hazardous cargoes are always en route. During the years 1988-1993, the number of observed oil spills was 600-700 per year, most of them illegal. Since then oil spills have increased by 30 per cent and tens of thousands of sea birds were killed by oil during the winter 1994/95. HELCOM has taken several decisions, assembled in the HELCOM Combatting Manual, concerning arrangements for co-operation in combatting oil pollution.

Founded on the Helsinki Conventions of 1974 and 1992, HELCOM functions as an umbrella organization for governmental efforts to protect the environment of the Baltic Sea. A realization of the agreed Joint Comprehensive Environmental Action Programme (JCP) demands the allocation of sufficient resources. Available economic resources have, so far, been insufficient.

The Gdansk Convention

The objectives of the Convention on Fishing and Conservation of the Living Resources of the Baltic Sea and the Belts, called the Gdansk Convention, is to provide general guidelines for the co-operation of fisheries in the Baltic Sea area and to lay down the aims of that co-operation. The convention came into force in 1974. It was established with the objective "to achieve greater and closer co-operation between the (Contracting) Parties in order to maintain the maximum stable productivity of the living resources of the region". The Gdansk Convention is also to "keep under review the living resources and fisheries of the region by collecting, analyzing and dissiminating data; to draft proposals to co-ordinate scientific research; and to submit recommendations to the Parties based on scientific research".

WWF Baltic Programme

A large number of hard-working, non-profit NGOs, agencies and associations at scientific and local levels inform the public, are initiating projects and working for the environmental improvement of the Baltic Sea environment.

The WWF Baltic Programme was launched in 1990. Among its overall objectives are the development and implementation of a comprehensive work programme in nature conservation and biodiversity in the Baltic region and the establishment of co-operation with NGOs working on conservation issues in all countries and regions around the Baltic. The newsletter, The Baltic Bulletin, published 1992-1995 (ed. B. Hagerhall Aniansson) by the WWF Baltic Programme is a most informative journal describing environmental activities at governmental and non-governmental levels within the whole Baltic Region. Its value as a uniting and connecting measure can not be overestimated. WWF Baltic Bulletin no. 3-4 1994 is a special issue concerning international co-operation for the Baltic Sea.

Foundation for the Baltic Sea

The Foundation for the Baltic Sea (Mariehamn, Finland) supports, promotes and encourages scientific investigations and other activities in order to improve the environmental knowledge and general consciousness of the Baltic Sea environmental protection. The Foundation stimulates activities through awarding persons and organizations prizes, grants and economic support for successful work. The Foundation's publication, "World of the Baltic Sea", is an informative magazine describing environmental activities in the Baltic region. It is available as free copies on board passenger vessels in the Baltic Sea.

VASAB 2010

In 1992 representatives of the ministries responsible for spatial planning around the Baltic Sea agreed to jointly prepare a spatial development concept, Vision and Strategies around the Baltic Sea 2010, VASAB 2010. The report was presented and adopted by the Third Conference of Ministers responsible for Spatial Planning held in Tallin 1994.

The vision and strategies are based on four basic values referred to as the "Pearls" (= the urban network), the "Strings" (= the mobility network), the "Patches" (= specific types of areas), and the "System" (= the spatial planning processes and institutions). One major focus in the vision concerning physical planning and development is concentrated on trans-European transport networks.

It is stated that "the Baltic Sea Region shall become a masterpiece for sustainable, environmentally sound development". It also underlines that in planning procedures, environmental impacts have to be considered in time and that demonstration projects for the application of EIA (Environmental Impact Assessment) at an early stage should be encouraged.

The vision includes an environmentally friendly transportation system. This means that railway instead of road transports should be enhanced.

Agenda 21 for the Baltic Sea Region

At the request of the Swedish Ministry of the Environment the report "Baltic 21 - Creating an Agenda 21 for the Baltic Sea Region" has been prepared by the Stockholm Environment Institute and was presented in October 1996 (Fig 5). Sustainable development is the fundamental concept for the Baltic Agenda 21. In a recent (October 1996) meeting with the Baltic Ministers of the Environment dealing with the agenda, it was stressed that the regional Agenda 21 plan is aiming at prophylactic actions within the Baltic area as a complement to HELCOM's work to clean up the worst 132 sources of pollution (the hot spots).

It is concluded that agriculture and transport are the two dominating sources of diffuse pollution, but actions against their degradation of the environment are as "yet far from the level corresponding to the seriousness of the problems". The lack of funding for environmental upgrading calls for raising taxes on petrol and fertilizer.

Every sector of activity in society has to take responsibility for the environment. Especially within the transport sector the mistakes made in Western countries in conjunction with road construction and unlimited car traffic must not be repeated in the countries in transition. Railway transports must, therefore, replace road traffic, which, so far, has been allowed to develop into one of the biggest environmental problems, with cascading effects including pollution, landscape fragmentation and traffic congestion. Goals, time-table and financial plans for prophylactic actions for the creation of an ecologically sustainable development of the Baltic Sea region are to be presented in 1998.

The Baltic Agenda 21 report calls attention to the fact that the momentum of the 1992 Agenda 21 of Rio de Janeiro has shown signs of slowing down, as well as to the fact that "despite the future potential of the Baltic Sea Region, and despite some of its countries being some of the world's most advanced industrial nations, development in the region is", nevertheless, "nowhere on the path towards sustainable development". It is, however, also pointed out that "The political and economic reforms and the societal restructuring now taking place provide a unique opportunity for building environment considerations into economic growth and societal development in the region as a whole, and turning this process in the direction of joint and regional, sustainable development".

A Baltic Agenda 21 has simultaneously to cope with

1) environmental damages accumulated from the past, by restoring areas or by cleaning up dangerous substances accumulated in soils, landfills and other waste sites, watercourses and basins,
2) the monitoring and control of ongoing emissions and use of various hazardous substances and chemicals, decreasing

loads and harmful impacts, and

3) the introduction of preventive responses to emerging problems and the development of avoidance measures. practices and technologies to ensure a minimisation of waste and non-depletion of resources.

An underlying assertion acknowledges a complex inter-relation between economic development and care for the environment. Exploitative forms of economic development - not foreign in the Baltic Sea Region - could quickly erode the environmental resource-bases upon which they are based, while environmental degradation could undermine economic development and growth." This demands an integration of sector policies and reliable, long-term prognoses (EIA) based on ecological common sense.

Agenda 21 reports that "For all practical purposes, sustainable development is currently not in central focus in Russia. ... Environmental protection is a very weak interest when confronted with strong energy, agrarian and military lobbies in executive and legislative structures/institutions". This must not be considered anything unique for Russia, where "sustainable development still appears as exotic theory, poorly connected with economic practice".

Another example from a country in transition is given from Poland, where present, old-fashioned transport policies pave the way for large-scale environmental damage:

1) priority for the programme of mass building of higways,
2) promotion of road transport but not railway transport or water transport,
3) support for the development of individual means of transportation and not for public transport, and
4) negligence of local transport problems, poor awareness of environmental issues connected with a massive development of motor transport.

According to the Baltic Agenda 21 "sustainable development means improving and maintaining the well-being of people and ecosystems" and reminds of the common opinion "that it is economic growth itself and its accompanying demand for more input and output that is the root cause for environmental degradation". ... "Even if major industrial point-source pollution may soon be something of the past, this is not the same thing as industry being sustainable. For example, the environmental focus is increasingly shifted away from production to products and how they are used, i.e. towards 'sustainable consumption patterns'." This includes a programmed, restricted life-span of products.

Among strategic guidelines for environmental improvement the Baltic Agenda 21 includes the following elements:

1) A move forwards to tomorrow, while, where appropriate, aiming at restoring the marine environment of yesterday.
2) A change of paradigm. Environmental treatment should be addressed at the source rather than at the end, by prevention rather than by cure, by expanding the circle of environmental responsibility across the life cycle of products, from extraction to production and consumption and to disposal.
3) A change of focus from point to diffuse sources. Air emissions and point discharges into water and rivers are thought to be gradually being brought under control while the water situation might deserve more attention.

4) Preserving and restoring biodiversity by preserving the untouched parts of nature in the Eastern parts of the Region while creating a regime for halting further losses in the Western parts.

The Baltic Agenda 21 underlines that "Banks and other institutions in charge of financial mechanisms, have a formidable responsibility in allocating the financial resources of society. Only if this allocation process is based on values and principles which harmonize with and support a sustainable development, will the financial sector contribute to this end. ... Ways and means to environmental concerns into financial decision making should, therefore, form a part of a programme for sustainable development".

Other co-operation

Networks among university institutes and scientists, exchange among schools, counties, cities and municipalities are of great importence for the creation of a broad public interest in environmental improvement. The Union of Baltic Cities (UBC) is responsible for JCP implementation at the municipal level and the Coalition Clean Baltic is an umbrella organization co-ordinating 26 different national and international NGOs and is active within different fields of environmental education and public awareness. The Baltic Institute (Karlskrona, Sweden) organises and implements projects within the fields of Planning, Communications and Environmental Issues, the EU and the Baltic Region, the Culture of Democracy and Commerce and Industry.

Among research programmes, the International Research Programme for the Gulf of Riga should be mentioned. It includes scientific input from all the Nordic countries and from Estonia, Latvia and Lithuania and is financed by the Nordic Council of Ministers. The research progamme concentrates on the interaction between the drainage area, the Gulf of Riga and the open sea, and focuses on exchange mechanisms between land and sea for toxic substances and elements causing eutrophication.

CURRENT CHANGES IN THE BALTIC SEA

During the past five decades there has been a general trend to move polluting industries located at inland water bodies, which they used as a water supply and as receivers of waste water, to the Baltic coastal zone, preferably to river mouths. In this way the enlarged factories have been given access to both freshwater and a huge body of water as the waste water recipient, and thus the time-lag between start of waste water discharge and severe signs of pollution has become much longer in the Baltic Sea than in small inland water bodies.

In recent years it has been possible to reduce environmental threats such as the discharge of DDT, PCB, organic matter and nutrients from the Western sector of the Baltic Sea Region and they are currently under reduction in the Eastern one. However, new threats are appearing. Among these are the unlimited increase of car traffic and the intensive fragmentation, including drainage, of the catchment landscape with its river basins. Thus, efforts have hitherto been concentrated on the reduction of industrial and municipal point sources, first of all the hot spots, but at the same time the measures already in place are being counteracted by pollution and eutrophication from diffuse sources such as traffic - as the most obvious sign of disturbed local matter recycling - and from industrial agriculture and forestry, including long-term nutrient losses from the vast areas of drained wetlands. The intensified fragmentation of the landscape caused by more and more fine-meshed networks of roads has serious, negative, long-term, cascading effects on biological diversity and on the potential of the landscape to produce clean air, clean water and to consume carbon dioxide (Jansson 1996).

One of the man-made changes in the landscape of the Baltic Sea Region which will have a long-term negative influence on the sea is the large-scale drainiage of wetlands. For instance, in former East Germany, intensive drainage projects were carried out in the 1960's and l970's. Only in the North German land of Mecklenburg-Vorpommern more than 3,000 km2 (= 15 per cent of the total agricultural land area) are now on drained and degraded wetland (Wichtmann & Succow 1996). All around the Baltic Sea, mineralization of drained wetlands has caused a subsidence of 1-2 metres or more. The dissolved products from the mineralization are to a large extent drained towards the Baltic Sea, while the gases escape into the atmosphere. Great efforts are now being made to restore the degraded wetlands to function as sinks instead of sources of nutrients and carbon dioxide.

RIVER BASINS AS ECOLOGICAL MANAGEMENT UNITS

Restorative measures in lakes in which the ecosystems have collapsed because of eutrophication are not successful unless the external nutrient loading from the catchment area has been reduced to close to the original level of the former balance between catchment and the well-functioning lake ecosystem. After the external loading has been adjusted to the acceptable level, it is necessary, in irreversibly damaged lakes, characterized by persistent heavy internal nutrient loading, to perform "surgical" operations on the ecosystems or to treat them by "medical" methods (Bjök 1988, Eiseltová 1994). Such restorative measures are needed to eliminate the internal nutrient loading and to stop rapid aging of damaged lakes. Large lakes with powerful ecosystems recover after the external loading has been normalized and river systems recover rapidly after elimination of pollution sources.

A redevelopment programme for the Baltic Sea has, of course, to start on land, focusing on restoration of the recycling of matter within individual river basins, constituting the ecological management units (the separate 'oikos') of the Baltic Sea catchment area. Re-creation of local recycling ecosystems, characterized by least possible loss of matter, has to constitute the leading principle (Ripl et al. 1995). And, furthermore, each river basin has to be treated according to its individual, small-scale, natural properties. This needs a holistic ecological approach and a basic knowledge about the primary, sustainable relations between land and inland waters. It is obvious that standardized methods and measures have to be replaced by individual design and programmes, tailor-made for the area of action of the individual river basin. However, because of the very weak position of ecology in society, there are at present hardly any professional ecologists available for such a highly qualified job. This is a sector of society within which a great number of jobs must be created.

In our time, environmental degradation takes place at such a high speed and in constantly changing manners, that legal tools to counteract damage constantly become old-fashioned and inoperative. So far violations of existing environmental laws do not result in any severe penalty. Present laws applied within the environmental sector are mainly based on the political ideology of exploitation of natural resources, economic growth and people's continuously increasing spending power. As stressed in the Baltic Agenda 21, the ideology of environmental management needs to be fully integrated into sectorial policy development, which is also the most common decision-making level in government.

The basic organisational requirement for the management of a river basin is, of course, the existence of a River Board (Basin Management Agency), which has to possess the legal tools and provide economic resources to implement a realistic managment programme for both land and water. During a first phase of management activity the board has to restore the ecological balance between land and water and later on to check that this balance is preserved. However, because of the weak position of ecology in society, powerful incentives to make fundamental improvements in the environment are at present difficult or impossible to attain. Any serious political will and inter-sectorial courage to concentrate on sustainable ecological balance instead of on economic growth has, so far, not been noted. In the case of the Baltic Sea Region, the Eastern countries have the Western countries as a model. This includes, among other things, unlimited increase of car traffic (cf. Tengström 1994) leading to road construction and fragmentation of the landscape into non-functioning portions and large-scale losses of matter from land to water, most severe from industrialized agricultural and forestry areas. The landscape is bleeding.

The first legal framework for the establishment of River Boards for Swedish Streams and Rivers was elaborated in 1974 and connected with the Water Act. The coming into being of River Boards is still on a voluntary basis. At the beginning the main interest of the Water Boards was focused on exploitation of water bodies and pollution problems including simple technical activities such as straightening of watercourses, dredging etc. Today activities are more and more directed towards re-creation of the former meandering character of running waters, the restoration of lakes, the creation of wetlands etc. with the aim to redevelop a natural environment, to recreate an ecologically functioning landscape, including restoration of its capacity of self-purification; i.e. to re-transform rivers from man-made, simple transport systems to ecologically functioning systems. This might be considered a first step towards a more holistic approach to river basin management, taking all ecological land-water relations into account.

At the same time as our understanding of the fact that the environmental problems can not be solved only through end-of-pipe actions becomes more well-founded, our insight concerning the importance of water as the fundamental medium for the ecological function of the landscape as a whole is also improving. The general development process of water management strategy develops from the simple combatting of point pollution sources over diffuse pollution, to a holistic approach of the river basin landscape as the functional unit. This development is, however, slow and has in parts of the Baltic Sea Region not even reached the end-of-pipe stage.

The mismanagement of river systems has sometimes resulted in such a severe man-made degradation that water supplies deteriorate to a most deplorable quality. In such cases it seems to be a rule that much money is invested in technical/chemical treatment of the miserable rest-water instead of in programmes for correcting the basic mis-management of the degraded, matter-bleeding landscape in urgent need of ecological redevelopment.

Another aspect of water management in the Baltic Sea Region is that there are modern possibilities to save freshwater and decrease the transformation of big volumes of clean water to sewage (Fig 6) and industrial waste water. Vacuum toilets (Fig 7-8) and recycling of water in industries are among the measures now being applied.

When fully designed a river basin management programme has to deal with all aspects that influence the optimization of freshwater production, quantitatively as well as qualitatively, with respect to groundwater and surface water. This needs qualified managers and EIA-procedures (EIA = Environment Impact Assessment) that really define progonoses for suggested further disturbances through exploitation of the landscape. For instance, in Sweden the local authorities still allow the EIA-procedure, introduced in 1991, to be a weak and toothless instrument. A recent OECD report demands an upgrading of the ecological competence at the County Administration level, however. Unfortunately there is simultaneously a general reduction of personnel dealing with environmental issues at all administrative levels.

An ecologically balanced landscape is characterized by local recycling processes and thereby minimized losses of matter from land to water, in contrast to the fragmented traffic and transport landscape characterized by urbanization and industrialized agriculture and forestry. Due to large-scale urbanization citizens have lost their direct contact with the landscape on which they used to be dependent for production of healthy products and clean water in an ecologically balanced, small-scale cultural landscape. Urbanization, therefore, is leading to great losses of knowledge about elementary environmental management. These losses are replaced by standardized, large-scale management methods, far from being tailor-made, and fitted to the natural variation and variability in environmental conditions.

In the long term it will be unavoidable to reconstruct functional landscape units, characterized by local, recycling ecosystems. This also means creation of a geat number of jobs for environmental management of river basins to optimize freshwater production both quantitatively and qualitatively. In the case of the Baltic Sea region this will be necessary for the supply of freshwater to both people and the Baltic Sea.

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Fig 1. The Baltic Sea and its catchment area. - From HELCOM 1996 b.

BOX 6

The Baltic Sea joint comprehensive environmental action programme (JCP) consists of six components:

- policy, legal and regulatory reforms to establish a long-term environmental management framework in each country bordering the Baltic Sea
- institutional strengthening and human resources development to plan, design and implement environmental management systems
- infrastructure investment to control both point and non-point sources of pollution to the Baltic Sea
- management of coastal lagoons and wetlands, considered to be particularly sensitive
- applied research, required to develop the knowledge on which solutions to the existing pollution problems can be based
- public awareness and environmental education, needed to develop a base of support for the implementation of the programme

Fig 2. The Baltic Sea joint comprehensive environmental action programme (JCP). - From Stockholm Environment Institute 1996 a.

Fig 3. Location and type of the hot spots in the Baltic Sea catchment area. - From HELCOM 1996 a.

Location, type and status (March 1996) of the hot spots in the Baltic Sea drainage area.

Emissions of nitrogen oxides (NO_x), sulphur dioxide (SO_2) and volatile organic compounds (VOC) from the Baltic Sea States and from sea traffic (most data from 1990) in 1,000 tonnes per year.

Country/ Source	NO_x *total*	NO_x *traffic*	SO_2 *total*	SO_2 *traffic*	*VOC total*	*VOC traffic*
Denmark	284	140	181	12	201	98
Estonia	65		206			127
Finland	291	176	261	9	205	51
Germany (1993)	2,874	1,936	3,156	72	2,558	1,116
Latvia	35		70			
Lithuania	158	81	222	9	116	49
Norway	230	180	54	11	270	103
Poland	1,280	514	3,210	54		330
Russian Federation	4,248		8,416			
Sweden	404	332	126	37	456	153
Sea traffic	80	80	72	72		

Fig 4. Total emissions from the Baltic Sea States of nitrogen oxides etc compared to emissions from the transport sector. - From HELCOM 1996 a.

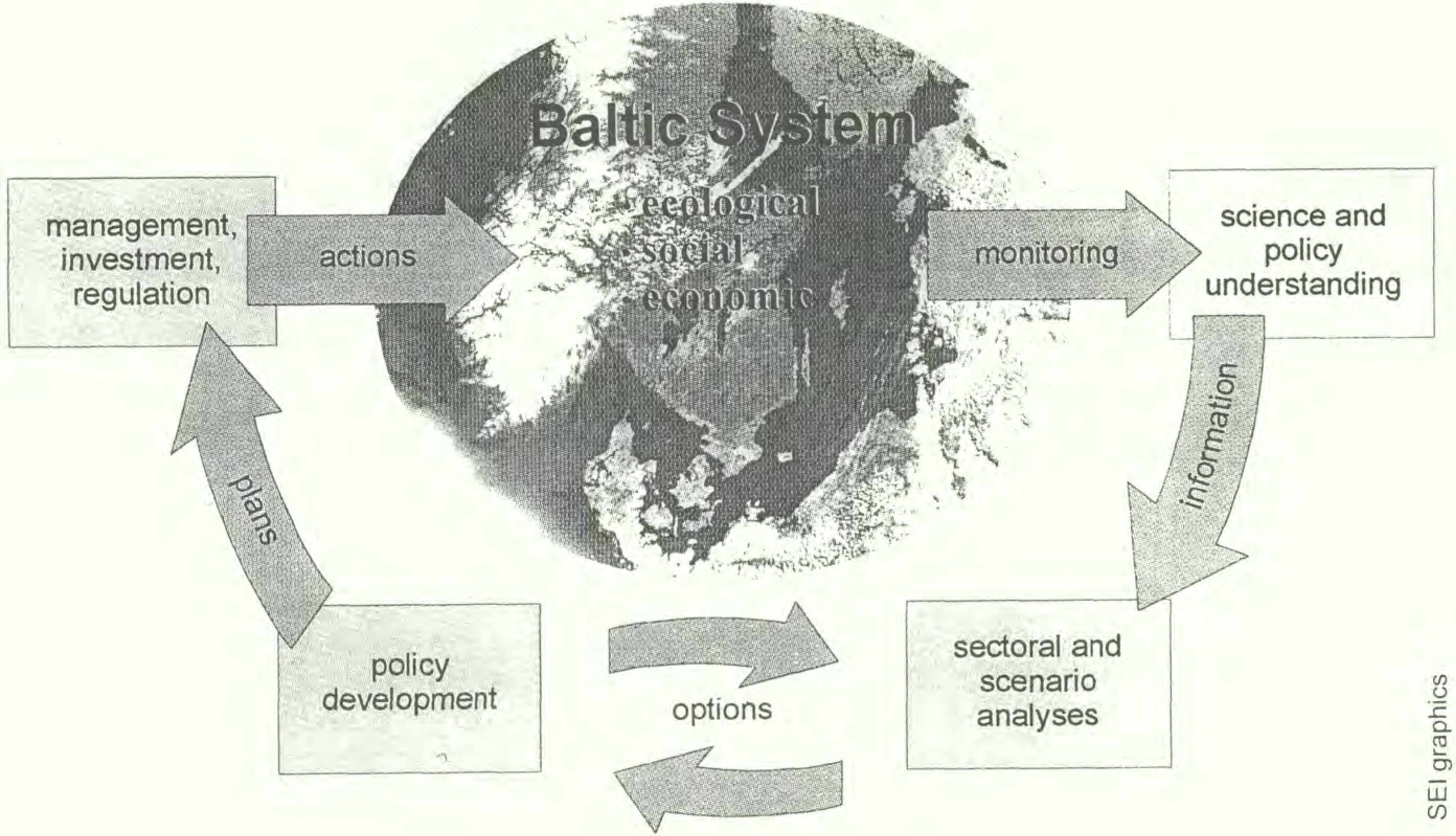


Fig 5. The Baltic 21 process must recognize the uncertainties inherent in the Baltic system and support a cyclical process of scientific discovery, policy analysis and formulation, investment and monitoring, through an underlying principle of adaptive management. - From Stockholm Environment Institute 1996 b.

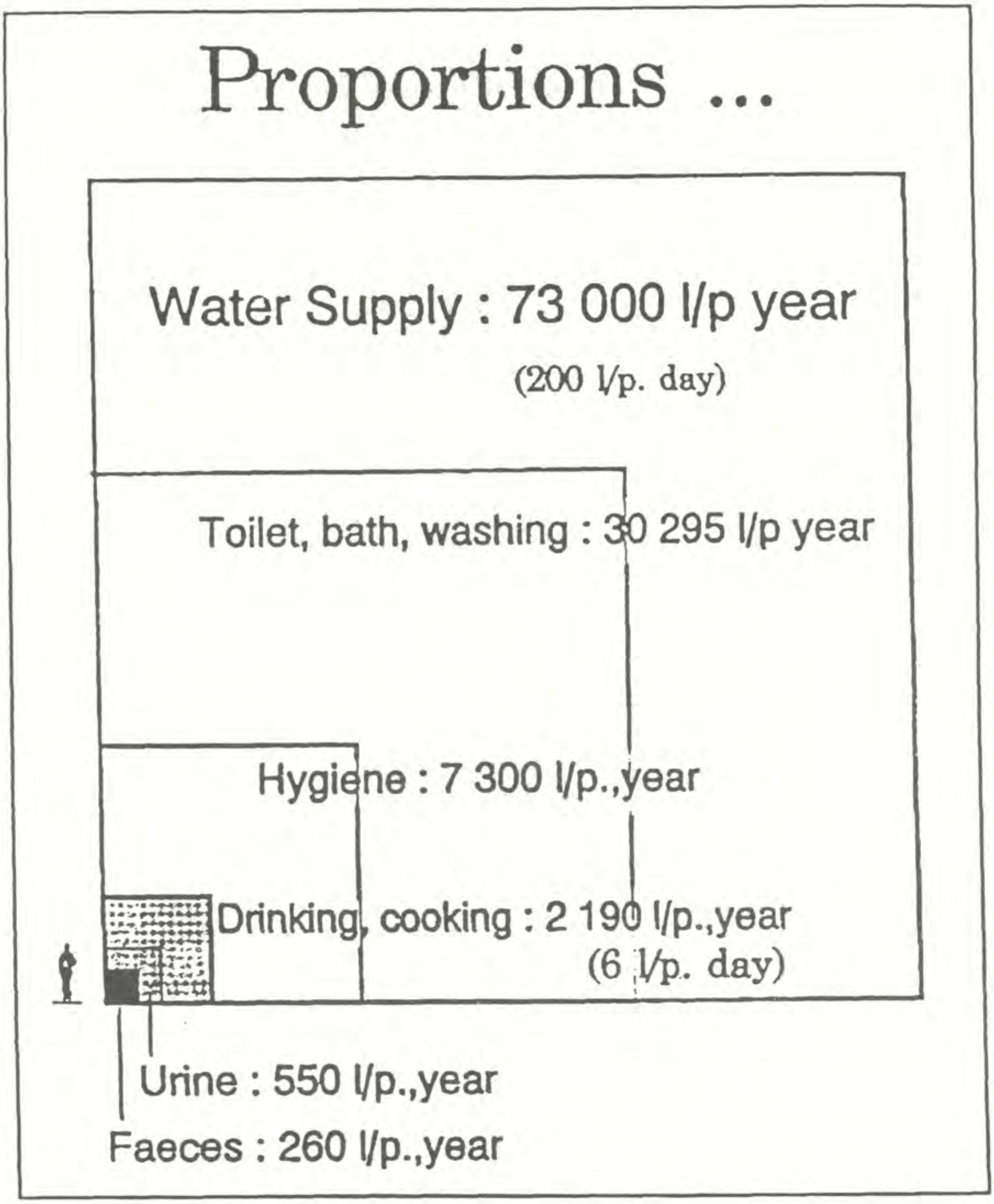


Fig 6. Typical proportions of various components in domestic water use. - From Niemczynowicz 1996.

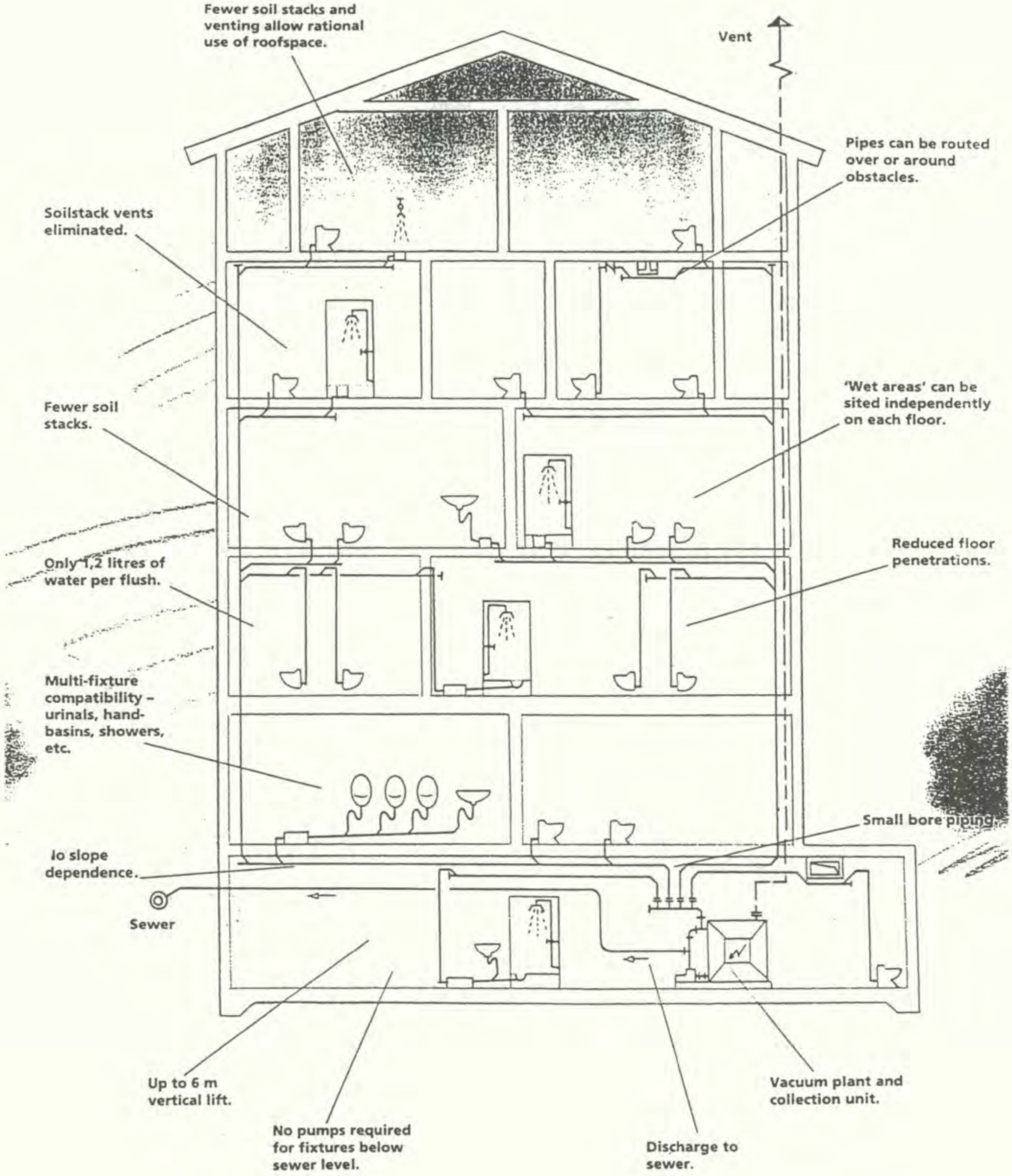
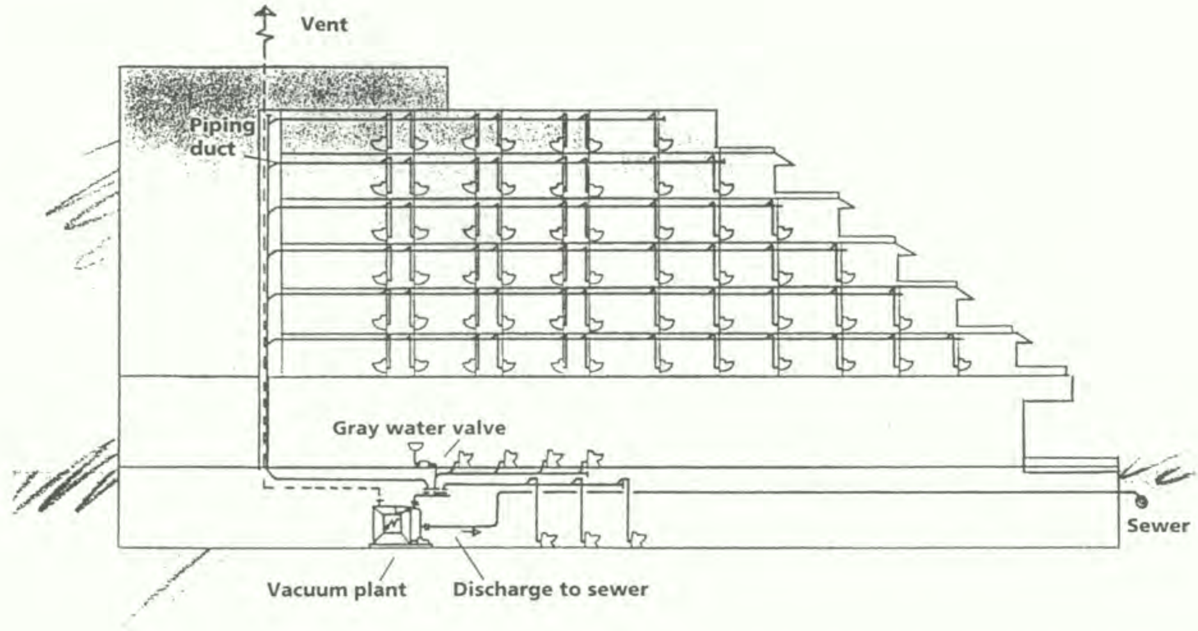


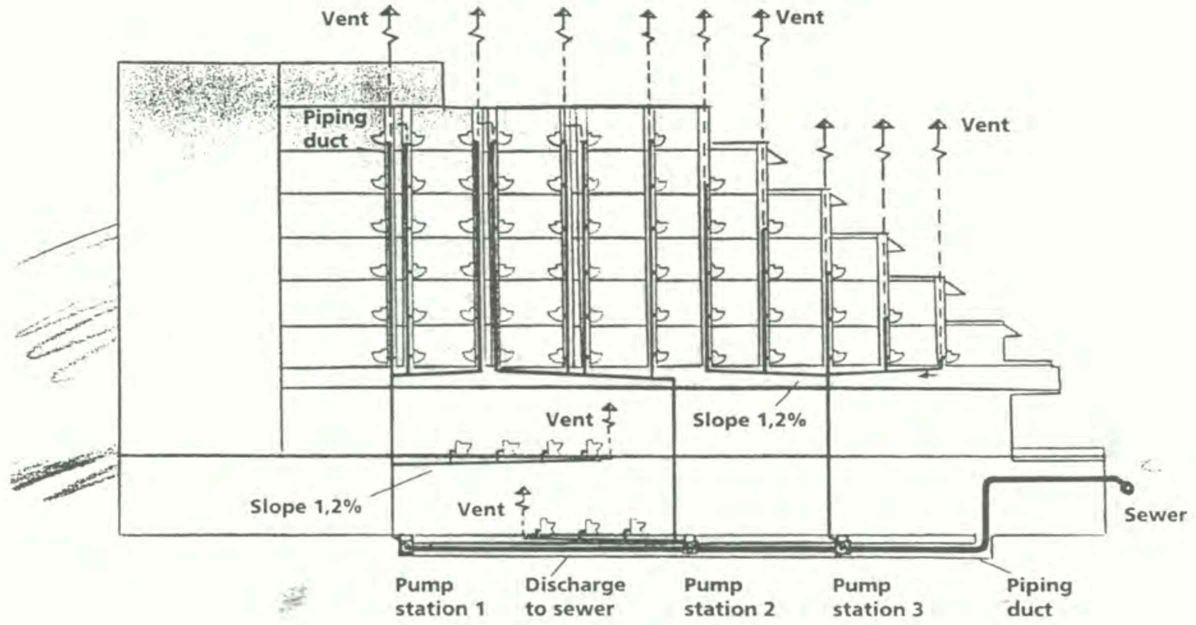
Fig 7. Vacuum sewage system for reduced water consumption. - From EVAC Vacuum Systems, Bromölla, Sweden.

Vacuum



Fewer soil stacks, no slope dependence, no individual venting, no pumping stations and simple routing for flexibility – vacuum systems make minimal structural demands.

Gravity



Multiple vents, large bore piping, large space requirement to accommodate slope requirement, fewer suitable locations for wet areas – gravity systems place unnecessary restrictions on building freedom.

Fig 8. Vacuum and slope-dependent sewage systems. - From EVAC Vacuum Systems, Bromölla, Sweden.

Securing a Blue Revolution via a Global Freshwater Convention

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INTRODUCTION

This paper identifies three major challenges facing the global freshwater sector:

- the mass of the public around the world is unaware of the challenges facing the freshwater sector. As a result public opinion on the issue is lacking and the political systems of the world generally do not recognise water issues as a high priority.

- there is a vacuum of leadership in the freshwater sector, at national, regional and international levels. This contributes also to the lack of concerted action by governments on freshwater matters.

- in order to meet the growing demands being made on the world's freshwaters, which are of finite quantity, a huge increase in productivity is needed.

Overall a *blue revolution* is needed in the way mankind manages its freshwaters, to secure the huge increase in productivity of freshwater usage needed for next century and to establish sustainable exploitation of water resources. AGENDA 21, Chapter 18 on Freshwaters has recommended what is needed - integrated water resources management, based on catchment basins or sub-basins as the management unit. Thus a series of measures is proposed to begin to implement AGENDA 21's recommendations and get the blue revolution under way. The catalyst for the needed changes would be a new global Freshwater Convention, with initially three principal objectives:- a) arousing public attention, b) focusing political will for executive action at international, regional and national levels, c) setting up a programme for the widespread establishment of Basin Management Agencies or Committees (for rivers and lakes) to carry out the necessary integrated basin management. In addition an international public relations exercise is recommended, led by a team of "champions", to promote the cause of the "blue revolution". This would extend also to the international and regional trade organisations, recognising the crucial links between economic activity and the environment.

The public relations campaign and the Convention would help to arouse public opinion and put pressure for change on the world's political systems. The proposed Global Freshwater Commission and the Basin Management Agencies/Committees would provide much of the leadership. And the application of the recommendations of AGENDA 21, Chapter 18 on Freshwaters, allied to the attitude and behaviour changes expected of the arousing of public opinion, plus the leadership of the Commission and

Basin Management entities, would begin to secure the *blue revolution* in productivity of freshwater use.

BACKGROUND

The water resources challenges facing mankind in the next century are vast and are poorly appreciated by the world's population. Hence there is little perceived urgency to begin to take the much needed steps to provide freshwater security to a rapidly increasing and urbanising world population.

The present situation has parallels with the potential food shortage situation which faced the world in the second half of the present century. That challenge was met by the "Green Revolution". By dint of improved farming practices, plant breeding, irrigation, fertilisers and pesticides, etc the required huge increase in food production was achieved.

What is needed now is a "*blue revolution*", to bring about a parallel massive increase in productivity of usage of the world's freshwaters. Attitudes and behaviours towards freshwater usage must be changed and systems for the sustainable exploitation of an increasingly scarce resource put in place. An important element in this will be the concepts set out in Chapter 18 of AGENDA 21 on a) the integrated management of water resources, and b) that such management should be carried out at the level of the catchment basin or sub-basin. Thus the early establishment of Basin Management Agencies (or Committees) for both river and lake basins will be one of the priorities. The reasons for this will become apparent later in this paper when it is pointed out how many of the world's freshwater basins are shared by more than one country.

It is recognised that the world presently does not favour large bureaucratic organisations and that there is a move also towards growing privatisation of government activities and introduction of market concepts. The suggestions in this paper recognise these facts and would endeavour both to keep bureaucracy to a minimum and permit widespread use of market mechanisms. Also acknowledged is that the proposed Convention and establishment of Basin Management Agencies would only be the start of many other much needed changes. But a start has to be made somewhere and soon, if crises and conflict are to be avoided.

CHALLENGES OF FRESHWATER MANAGEMENT

The overall theme is one of growing competition for a finite resource, combined with inefficient, harmful and frequently wasteful usage. Fundamental to the competition for freshwater are:- a fast growing population with rising expectations of quality of life and food consumption; expanding industrial activity; increased energy needs (hydropower included); widespread urbanisation with a concomitant increased demand for water, and a variety of others. Furthermore, in many parts of the world, responsibility for freshwater management is fragmented and inefficient.

Looking at some of these issues in more detail:-

- little attention is paid to combined land/water use policy. Irrigation usage is often inefficient and at times positively harmful in terms of salinated soils and poor quality drainage water. Urban areas waste vast amounts of water through badly functioning utilities. And industrial and municipal effluents and agricultural runoff are causing widespread and serious deterioration of water quality; not only is mankind threatened by water quality deterioration, but also the natural aquatic ecosystems of many parts of the world;

- the world population continues to increase apace. During the past century the world's population tripled and water usage grew tenfold. On present estimates the world population is expected to grow a further 45%, from its current level of 5.7 billion, causing a further huge increase in water demand. All of this emphasises the immediate urgency for a new global water strategy;(1)

- a high proportion of the world's water resources are in river or lake basins shared by more than one country. Such shared basins make up nearly 50% of the Earth's land area and some 60% of the area of both Africa and Latin America.(2) Currently almost 50% of the world's population lives in shared river or lake basins and it is estimated that there are some 214 river basins shared by more than one country.(3) Water shortage problems are growing. By definition, water shortage occurs when freshwater availability falls below 1700 m3/capita/year. By 2050 some forecasts have estimated that 65 countries will face water shortages and that 65% of the then projected world population will be affected, most of them in developing countries;(4)

- the worldwide incidence of waterborne disease remains high. Faecal contamination of water supplies, poor sanitation, inadequate domestic hygiene practices, malnutrition and lack of vaccination all contribute to this, but contaminated water supplies are a major source of the problem;

- within many countries responsibility for freshwater management is divided between several ministries, often with little coordination or cooperation. Division of responsibility for freshwater affairs is also apparent in agencies. As AGENDA 21 Chapter 18.6 has pointed out:

"The fragmentation of responsibilities for water resources development among sectoral agencies is proving to be an even greater impediment to promoting integrated water management than had been anticipated".

- frequently there is a serious lack of a national water resources management policy and, in the case of shared water resources, limited cooperation, if any, between riparian states to secure effective use of resources. The World Bank's Economic Development Institute has recommended National Water Strategy Formulation as one of four key criteria in water resources management.(5) However in the large number of shared basins around the world this can only be effective in collaboration with other riparian states and few mechanisms exist for the needed consultation and coordination;

- water is low on the political agenda of very many countries;

- it is widely accepted that, in water scarce areas, especially where tensions are high for other reasons, the risk of armed conflict over shared water resources is looking evermore likely.

The above emphasises how interdependent much of the world is set to become, in freshwater as in so many other areas of life. It points to the need for cooperative action and a big increase in efficiency.

THE BLUE REVOLUTION - OBJECTIVES

The principal objectives of the *blue revolution* would be to bring about the needed changes in attitude and behaviours in order to ensure that adequate freshwater of the right quality is available both for mankind and the rest of the planetary ecosystem. If successful, there would be a huge increase in the productivity of freshwater usage.

Looking at the objectives in more detail, the *blue revolution* would seek the following:-

Attitude Changes:-

- to raise awareness worldwide about the principal issues in freshwaters - pollution, wasteful use, the finite extent of available freshwater, threat to natural aquatic ecosystems

- to create in each citizen a sense of personal responsibility towards freshwater conservation and preservation

- to provide a climate for water resources sharing among nations in ways which have not been widespread before

- by mobilising citizen concern, put pressure on local, national, regional and international political processes to move freshwater issues high up the agenda

Behaviour Changes:-

- to introduce integrated water resources management at catchment basin level, taking account of integrated land use/water management

- to prevent wasteful water use practices in agriculture and industry

- to introduce efficient utility usage of freshwaters

- to minimise or prevent water pollution by industry, municipalities and poor agricultural practices

- to encourage technological innovation for more efficient usage of freshwater in agriculture, industry and domestic/municipal settings.

A VISION FOR FRESHWATER USAGE

Modern approaches to corporate strategic planning emphasise the need for a vision statement, which is then augmented by a more comprehensive mission statement. For the vision it is difficult to find a more eloquent and inclusive one than that of AGENDA 21 Chapter 18.2:-

"Water is needed in all aspects of life. The general objective is to make certain that adequate supplies of water of good quality are maintained for the entire population of this planet, while preserving the hydrological, biological and chemical functions of ecosystems, adapting human activities within the capacity limits of nature and combatting vectors of water related diseases".

THE FRESHWATER MISSION STATEMENT

A comprehensive mission statement, taken again from Chapter 18, would comprise:-

a) Need for Integrated Management:

"The widespread scarcity, gradual destruction and aggravated pollution of freshwater resources in many world regions, along with the progressive encroachment of incompatible activities, demand integrated water resources planning and management. Such integration must cover all types of interrelated freshwater bodies, including both surface water and groundwater and duly consider water quantity and quality aspects. The multi-sectoral nature of water resources development in the context of socio-economic development must be recognised as well as the multi interest utilisation of water resources for:- water supply and sanitation; agriculture; industry; urban development; hydropower generation; inland fisheries; transportation; recreation, low and flat lands management and other activities" - Agenda 21, Chapter 18.3.

b) Need for Management at Basin Level:

"Integrated water resources management, including the integration of land and water related aspects, should be carried out at the level of the catchment basin or sub-basin"- Agenda 21, Chapter 18.9.

c) Need for Harmonisation by Riparian States:-

"In the case of transboundary waters there is a need for riparian states to formulate water resource strategies, prepare water resource action programmes and consider where appropriate the harmonisation of those strategies and action programmes - Agenda 21, Chapter 18.10

d) Need for Demand Management and Economic Tools:-

"The role of water as a social, economic and life sustaining good should be reflected in demand management mechanisms and implemented through water conservation and reuse, resources assessment and financial instruments" - Agenda 21, Chapter 18.17.

e) Need for River Basin Management Systems:-

World Bank Vice President, Ismael Serageldin(6) has added his thoughts to the above and focused on the concepts of river basin management agencies or committees as a model for planning freshwater use, with other entities or utilities carrying out the actual work of freshwater delivery:-

"Water must be managed comprehensively. We must stop managing water sectorally - by its separate uses - and begin to treat water systemically; that is intersectorally. We have learned about the benefits of developing a comprehensive framework for water resources management that recognises the interactions between various elements of a river basin's ecosystem and allows for the incorporation of cross sectoral and environmental considerations in the design of investments and policies. Here the French and German systems of river basin management could serve as models. Under these systems, river basin committees decide long terms plans for developing water resources. Regulation and enforcement are conducted by various national ministries,

while operation and maintenance of the different components are left primarily to regulated private entities and public utilities".

f) Need for Peaceful Cooperation Among Riparian States:-

In his address to the 1994 Cairo World Water Resources Conference, Mahmoud Abu Zeid(2) made the following recommendations:

"While there are numerous treaties regulating the use of shared water resources, international agreements are often either inadequate or lacking entirely in some parts of the world where a water basin (river or lake) is in greatest demand. No region in the world with shared international waters is exempt from water related controversies though the most serious problems occur in water scarce regions. The key to peaceful solutions of disputes over shared water resources is continued communications between the states concerned, over everything from hydrologic and meteorological data to basin wide development plans".

Whilst peaceful cooperation among riparian states is the ideal situation, it is inevitable that disputes will arise. However, as Sandra Postel has pointed out, although more than 200 rivers are shared by more than one country,.... "no enforceable law governs the allocation and use of international waters". (3)

A PLAN FOR ACTION - THE MAIN COMPONENTS

From the foregoing, the challenges are clear, and formidable. AGENDA 21 has projected the vision. And AGENDA 21 and key international experts have articulated the main components of the mission which needs to be carried out. What is needed is a plan to carry through the blue revolution with the needed practical steps.

Central to this plan and acting as a catalyst for change, would be a new Global Freshwater Convention, consisting of both a Freshwater Treaty and a Global Freshwater Commission. Augmenting the Convention and motivated by it would be a programme for the widespread, early establishment of Basin Management Agencies or Committees. The final element, although it may need to be the first to be carried out, would be a global public relations campaign to urge the whole process forward.

Why a Convention? Experience in other sectors (and, interestingly most other sectors of the environment except freshwater have now or will have shortly Conventions, treaties or protocols) have shown that Conventions:-

- attract widespread media attention and publicity, sensitise the public to the issues involved, mobilise public opinion in favour of the needed changes and begin to bring about major changes in thinking and behaviour

- bring public opinion and concern into the political process and exert the necessary pressure for executive action at international, regional and national levels

Conventions have been shown to be effective in changing attitudes and behaviours on an international scale. They act as a symbol via

which public opinion is mobilised, a focus for subsequent executive action by governments and a banner under which needed change is carried
out. Today, few other devices, if any, are known to be as effective in making changes at global scale in a reasonably short time.

Given the challenges facing the freshwater sector it is difficult to see what other means could activate the *blue revolution* and achieve the needed changes within the required timeframe. And, thereafter, provide an appropriate framework for the care and sustainable and equitable use of the world's freshwaters, well into the future.

A GLOBAL FRESHWATER CONVENTION

This would consist of a new Global Freshwater Treaty, of the framework type, and a new Global Freshwater Commission. The purpose would be to focus on means of managing the world's freshwaters in an equitable, integrated sustainable way, recognising the catchment basin or sub-basin as the appropriate level for such integrated management and the high level of interdependence of the world's population living in shared basins - rivers, lakes and underground aquifers. A key would be to minimise bureaucracy and to seek to create an appropriate enabling environment for integrated water resources management to flourish in the many different forms which will emerge. The Convention should be crafted so that, not only can it embrace a framework for getting the blue revolution under way, but it can also provide a structure within which mankind can protect and exploit freshwaters both equitably and sustainably, far into the future.

It has been argued that a freshwater convention would be difficult and time consuming to achieve, that countries would oppose it because water is seen as a national issue. Yet nearly 50% of the world lives in shared water basins now and this percentage is likely to rise with population increase. And once public concern about freshwater is mobilised, the pressure for a convention to protect and preserve freshwaters for future generations is likely to be irresistible.

A crucial point to realise is that whereas water shortages may not be universal, water quality problems are worldwide, are bad and getting worse. Even in the European Union where expenditures on water protection are huge, progress towards significant water quality improvement is slow. A Freshwater Convention would be designed to secure <u>sustainable</u> exploitation of the world's freshwaters. Unless <u>all</u> countries agree to programmes of water quality protection, and a Convention is one way to seek this, their citizens cannot enjoy sustainable water use in the future.

Funding will be required to support the work needed for the Convention. Whereas initially this will need to come from the UN and supporting governments, the arrangements of the Law of the Sea Convention merit examination. That Convention has a Treaty, a Commission and a **commercial arm**. The latter is interesting. It raises money through the issue of licences for mineral exploitation of the sea bed. Clearly the Freshwater Convention could not imitate this directly. However freshwater activities worldwide involve multi-billion dollar expenditures and it seems feasible to consider a levy on major water users to raise the needed funds. Certainly this should be examined carefully so as to eventually move the Convention away from dependence on agency or government funding.

A GLOBAL FRESHWATER TREATY

This must be a **framework** treaty, setting down the main principles, but flexible enough for regional interpretation because of the very diverse nature of water resources systems worldwide. It is not proposed here to go into the detail of what it should contain but rather to point at certain general principles and also indicate some relevant initiatives in progress at present. In general the Treaty would include provisions for sustainable qualitative and quantitative exploitation of water resources. It would recognise the huge interdependence of nations on shared resources and would emphasise the need for equitable and reasonable utilisation and the need to avoid harm to a resource. It would highlight the need for formal arrangements to promote fair use of shared resources and make provision for resolution of disputes.

As far as international watercourses are concerned the UN International Law Commission (ILC) has recently submitted to the UN General Assembly a new set of "Rules on the Non-Navigational Uses of International Watercourses". These contain 33 articles covering such principles as:- watercourse agreements; equitable and reasonable utilisation and participation; obligation not to cause harm to other watercourse states; general obligation to cooperate; obligations to notify other watercourse states about planned measures; protection and preservation of ecosystems; prevention and control of pollution; protection/preservation of the marine environment; management; regulation; settlement of disputes etc. These Rules have been reviewed by member states, and a working group from the General Assembly will revise them late 1996. The ILC has requested then that the General Assembly should convene a conference to discuss the production of a convention based on the Rules. The ILC has specifically cast the Rules in framework form, so that they are flexible enough for interpretation in the light of different regional circumstances.

Elsewhere the Global Programme of Action for Protection of the Marine Environment from Land Based Activities (GPA) agreed an Action Programme at a meeting in Washington DC in November 1995. Adopted by more than 100 governments, the Programme aims to protect seas from pollution generated on coasts and far inland. It is currently addressing 2 priority areas: i. the proper treatment of urban waste water and sewage; ii. development of a global legally binding instrument on persistent organic pollutants. Both of these are of great importance not only to coastal seas but also the freshwater systems which drain into them.

Both the Rules and the GPA could be included, as appropriate, in a Global Freshwater Convention.

In Europe two initiatives offer guidance on how a region may actually go about implementing agreements on freshwater usage. Firstly, the UN Economic Commission for Europe (ECE) has adopted a Convention on the Protection and Use of Transboundary Watercourses and International Lakes. It is orientated to water quality issues and will come into force during 1996. Implementation is based on intended cooperative agreements between countries bordering the same waters.

Secondly, within the European Union (EU), the European Commission has recommended the development of a comprehensive strategy on freshwaters and seas. This will set out an integrated planning and management approach to groundwater and surface water resources, which will focus on both quantitative and qualitative aspects of Europe's freshwaters and will ensure also a sustainable management of regional European seas. The intention is to issue, in draft form, a Framework Directive for a European water resources policy in late 1996, with possible implementation by the year 2000.

The European examples are important, for two reasons. Firstly they show that a major politically and economically interdependent region has chosen already the route of Convention and Directive for its freshwater management. Secondly they suggest that other economically dependent regions (existing or becoming so) could have the necessary foundations for effective implementation of the Freshwater Convention, eg ASEAN in SE Asia, MERCOSUR in Latin America, etc.

TRADE AND THE ENVIRONMENT

The connection between trade and the environment is a key one, which is set to grow in importance. AGENDA 21 supports the view that an open multi-lateral trading system makes possible a more efficient allocation and use of resources and thereby contributes to an increase in production and incomes and to lessening demands on the environment. It thus provides additional resources needed for economic growth and development and improved environmental protection. However whilst free trade may be essentially supportive of environmental protection, this is a generalisation and there are significant exceptions.

Economic activity is building up in many parts of the developing world and in economies in transition. Unless properly controlled, this economic activity will have a deleterious effect on the world's freshwaters, which may make it impossible to achieve sustainable use. Given this strong connection between economic activity/trade and freshwater use, the following points are relevant:-

- the world currently has a growing number of free trade areas, either operating, developing or being put together. These include:- the European Union (EU), North American Free Trade Area (NAFTA), Association of South Eastern Asian Nations (ASEAN), the southern Latin American countries (MERCOSUR), Asia Pacific Cooperation Forum (APEC) and emerging ones in Southern Africa, Western Asia and elsewhere;

- nearly all of these agreements (except ASEAN) contain clauses on environmental protection, although none are as sophisticated as those of the EU in terms of freshwater. Whilst the EU freshwater protection programme has been slow to produce results so far, progress will accelerate in the next few years;

- the General Agreement on Tariffs and Trade (GATT) and the new World Trade Organisation (WTO) have to consider environmental concerns.

- thus there seems to be a strong case for greatly increasing the profile of freshwater concerns in both the WTO and all the regional free trade areas, to seek concerted action from the countries involved to protect freshwater.

There is a view in some quarters that existing UN organisations have been ineffective in protecting the environment and that a new Global Environment Organisation is needed. However many feel that the world is not prepared to accept this. As an alternative, and as a way of working towards this, an international expert panel has been suggested. This would be an Intergovernmental Panel on Trade and Sustainable Development.(7) It would work towards an international regulatory system which safeguards the environment and provides opportunities for sustainable development without jeopardising legitimate trade interests. Successful inter-governmental panels, it is claimed, exist already for forestry and climate change.

GLOBAL FRESHWATER COMMISSION

Its function would be to administer the implementation of the Treaty and promote and assist in the setting up of Basin Management Agencies or Committees (BMAs), including identifying and channelling needed financial assistance. The initial priority for setting up such Agencies or Committees would be in regions of water shortage, particularly those nearing crisis point and where armed conflict is possible. In addition the Commission would ensure the provision of machinery for settling disputes, using existing institutions where feasible, such as the International Court of Justice, but also making provision for arbitration and maybe establishing an International Tribunal on Freshwater Issues. The Commission would seek to identify and promote Best Management Practices (BMPs) for the sustainable exploitation and management of freshwaters. It would also identify research and training needs, then promote action to meet these needs. The Commission would seek to influence international and regional trade organisations to make freshwater protection a key element of their activities.

The **composition** of the Commission would be crucial. A big challenge to the Commissioners would be to broker agreements among riparian states to set up Basin Management Agencies or Committees. Commissioners would need to work at the highest levels of government, including heads of state. They could also be called upon to assist in dispute resolution and influence the allocation of funds from donor agencies. Thus it is vital that Commissioners be persons of influence and very high personal standing. They would provide the much needed leadership which, it is claimed, is seriously missing at present.[8]

Among the Commission's **resources** would be a small permanent staff, chosen from a wide range of organisations, including the private sector. However, the intention is not to establish a significant bureaucracy but rather to provide the necessary minimum staff to service the Convention. Thereafter the Commission would tap into the resources of the wide range of existing organisations, individuals and institutions in the many parts of the freshwater sector. These would include the Global Water Partnership, World Water Council, UN agencies, banks, international and national water professional associations, universities, the expertise within existing river basin agencies, bilateral aid agencies etc. A major challenge to the Commission would be to encourage these different organisations to view freshwater management more holistically, rather than the fragmented approach adopted to date. Almost certainly a new "water think tank" institution would be needed, but it is understood that such an initiative is presently under discussion.

A further challenge facing the Commission would be dealing with the concept of water sovereignty or "**our** water". In a very interesting recent project in the Middle East(9) a team of economists, water specialists and negotiators were able to move thinking away from the traditional conservatism about water sovereignty towards ideas of water values and water markets. A model was produced which will enable the countries concerned to trade available freshwaters to their mutual benefit and to attain further benefits from regional management of freshwaters which would not have been possible with a national management approach. Some important concepts are involved in this with potential for further and wider application, but more work is needed to evolve them further. Certainly water sovereignty issues, economic concepts such as those above and other aspects of water markets and economic activity will all play key roles in future freshwater management concepts. Trading activities involving water may not be restricted to water but could include other commodities, eg power.(3)

In all of this, one of the prime roles of the Commission would be to provide leadership. Emphasising the points made in the Introduction to this paper, one of the reasons why freshwater management is fragmented and why it suffers from relatively low political recognition, is attributable to a lack of leadership. Looking to the future, the freshwater sector could continue largely as it does now and wait for the crises and wars to erupt. Then leadership will have to emerge, to mediate the conflicts - this is reactive leadership. Or, by the means suggested in this paper, proactive leadership can be exercised, the blue revolution pushed forward and most of the crises/wars averted. This is a highly important point because it highlights that mankind does indeed have a choice and has the opportunity to seize the initiative of proactive leadership.

RIVER BASIN MANAGEMENT AGENCIES OR COMMITTEES

The main principles which should guide basin management systems have been laid down in AGENDA 21 Chapter 18.9. The stress is on integrated water resources management, including the integration of land and water related aspects. The advice is to carry out water resources management at catchment basin or sub-basin level and that four principal objectives should be pursued, as follows:-

(a) *To promote a dynamic, interactive, iterative and multi-sectoral approach to water resources management, including the identification and protection of potential sources of freshwater supply, that integrates technological, socio-economic, environmental and human health considerations.*

(b) *To plan for the sustainable and rational utilisation, protection, conservation and management of water resources based on community needs and priorities within* *the framework of national economic development policy.*

(c) *To design, implement and evaluate projects and programmes that are both economically efficient and socially appropriate within clearly defined strategies based on an approach of full public participation, including that of women, youth, indigenous people and local communities in water management policy making and decision making.*

(d) *To identify and strengthen or develop as required in particular in developing countries, the appropriate institutional legal and financial mechanisms to ensure water policy and its implementation as a catalyst for sustainable social progress and economic growth.*

(e) *In addition, in the case of shared basins, there is the need for harmonisation of water resources strategies among riparian states - Chapter 18.10.*

The above are the principles. In terms of actually setting up and evolving the Basin Management Agencies or Committees, Stockholm Water Prize laureate Madhav Chitale has offered some thoughtful guidance.(10)

"Rather than aiming at a standardised set up for all international river basins, basin organisations can best be allowed to grow in phases according to the needs of the respective basins. The nature of the basin organisation and its stage of evolution will dictate the type of personnel required. These organisations will have a federal set up to represent the interests of all stakeholders. Even though the governance of these organisations will be by a body of political representatives of the participating countries, the technical and professional wings should have the necessary freedom of action in their normal work. For healthy working of river basin management committees, negotiations between the participating countries will be the principal thrust. Still a provision for arbitration for resolution of disputes will be desirable.

These words emphasise the likely wide variation in character of basin management entities, depending not only on the particular circumstances of a basin but also the status of development of the riparian states and the activities carried out within the basin. Thus some basin management entities may be advisory committees whereas others would function as executive agencies including carrying out programmes.

Generally however as Serageldin(6) pointed out in the examples of French and German Basin Management Agencies, the priority would be to set policy and produce an enabling environment, including regulatory framework, for other agencies and utilities to carry out the actual freshwater exploitation programmes.

Privatisation of such programmes will continue to be of growing importance in many basins. Privatisation of the executive capacity of a particular Basin Management Agency should also be an option, where appropriate. In addition, as with the suggestion for the Global Freshwater Commission, it may be possible eventually for Basin Management Agencies to recover their costs from a levy on major freshwater users.

It is possible to foresee an Agency at some time in the future where trade and privatisation are the dominant features. For example:-

- the Agency is located in a free trade area which has strong freshwater protection programmes

- whilst the Board of the Agency consists of elected representatives, day to day management is by a private company. It uses a range of market mechanisms and economic tools to allocate freshwater and control water quality ("water trading and polluter pays" principle)

- all the major freshwater uses are privatised eg water and wastewater utilities, industry, hydropower, irrigation water supply companies, transport companies etc.

- volumes of water are traded within the Basin or with adjoining Basins using water and other commodity exchanges (eg power) as barter.

CAMPAIGN/PUBLIC RELATIONS INITIATIVE

At the beginning of this paper the lack of public perception and absence of serious concern about the magnitude of the looming freshwater challenges was highlighted. A major initiative is needed to educate the public about the issues involved and mobilise public opinion in support of the blue revolution. Experience in other sectors and with other important global issues, eg famine, poverty, etc suggests that a campaign led by some highly prominent, respected international figure, or better still, group of figures, could achieve the desired effect. He/she or they would "champion the cause". If effective this could bring about the necessary pressure on the political systems at national and international level and bring about reasonably speedy implementation of the Treaty, the setting up of the Commission and the BMAs and the crucial initial objective of achieving systems for the sustainable management of the world's freshwaters. One of the challenges then is to identify the person(s) to lead such a campaign and secure his/their commitment to action.

A significant proportion of the campaign would be carried out in developing countries. The successful water promotions in Morocco and India have shown how this can be done.

Also needed is a concerted programme to alert the World Trade Organisation and the regional free trade areas to the problem of freshwater and urge them to take action to deal with these, both internationally and regionally.

PRIORITY ACTIONS

A number of initiatives to get the blue revolution under way could begin very quickly, acting on a number of fronts in parallel:-

- seek the help of international citizens groups and organisations to promote the cause of freshwater protection through their national chapters - eg women's and children's movements, church organisations and environmental law associations

- look carefully at the water campaigns in Morocco and India and see if these could be replicated elsewhere

- send high level delegations of water experts to the WTO/GATT and the regional free trade organisations and seek commitment from them to give high priority to freshwater matters

- urge the UN Commission on Sustainable Development to recommend two actions to the UN General Assembly in 1997:

  the promotion of a Global Freshwater Convention
  the setting up of an Intergovernmental Panel on Trade and Environment with freshwater high on its agenda.

CONCLUSIONS

The ideas proposed in the paper have been tried and tested elsewhere. Thus there is every reason to believe they can work for freshwater too. Most of the ideas are based on AGENDA 21's recommendations.

A growing number of people around the world are questioning why there is no convention or treaty for freshwater. They compare water with other environmental sectors and see virtually all of them protected by convention, treaty or protocol. Yet freshwater, the life blood of planetary systems, has lagged behind.

Some water professionals question the need for a convention. They say that water is a national issue, that water shortages are localised, that "convention fatigue" is apparent among governments. Yet it is accepted that there is no body of international law to deal with freshwater disputes. And while present water quantity problems are regional, they are becoming more widespread. Moreover water quality is deteriorating alarmingly in most parts of the world. If we are to have usable freshwater for future generations and avoid water wars, governments must commit themselves to freshwater protection. The proposed Global Freshwater Convention is the obvious way to do this.

Furthermore the freshwater sector needs leadership. It needs it at international level and at basin management level. The proposed Global Freshwater Commission would provide international leadership. The River or Basin Management Agencies would provide the leadership at basin level. The present fragmentation of responsibilities would be overcome.

The crucial linkages between economic activity/trade and the environment have been emphasised. Given that the WTO/GATT system and the regional free trade areas nearly all have commitments to environmental protection, this needs to be exploited. These trade organisations must be informed about the challenges of the freshwater sector and a commitment obtained from them to give freshwater issues high priority.

The support of concerned citizens' groups must be sought, to assist in the promotion of awareness of freshwater's problems among the world's public. International NGOs for women, children and the various churches would be very supportive. They all have natural concerns about the future and the security of coming generations, as well as a sense of responsibility and caring about vital issues.

Time is short. Population increase will not stand still while arguments continue about whether there should be a convention or not.

Competition for increasingly short supplies of water will not diminish, nor will continued deterioration of water quality. In order to secure a suitable framework of international freshwater law, for the resolution of disputes etc; in order to get governments to commit to protecting freshwater for future generations; in order to change behaviour and attitudes to freshwater, there is little serious alternative to a Global Freshwater Convention. Thus action to set up and implement the Convention is needed soon. All of this will be central to the bringing about of the blue revolution.

This paper is not a blueprint for the action needed for freshwater. It does not propose any quick fix solutions, because there are none. Rather a framework is proposed. Many of these ideas are concerned with getting change underway, particularly attitude change and with getting certain priority activities started. It is accepted that much more needs to be done.

The final point is that the blue revolution is not an option. It is not a fancy slogan to catch the attention of the media and the general public, although it could become the motto and indeed the rallying cry for change. This paper has indicated ways of bringing about that change - public education to secure attitude/behaviour change; lobbying trade organisations to include freshwater protection in their policies; provision of leadership via the Global Freshwater Commission and the Basin Management Agencies; bringing all of this together via the proposed Freshwater Convention. However, whether these or other courses of action are pursued, the blue revolution is not an option; it is a necessity. Should mankind fail to react to this fact, then the consequences will be dire indeed.

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International Cooperation for Global Water Problems

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"A lake is the landscape's most beautiful and expressive feature.
It is the earth's eye; looking into which the beholder measures
the depth of his own nature".

Walden,
by Henry David Thoreau

INTRODUCTION

At an international forum organized by the Shiga Prefecture and ILEC, I'd ordinarily be discussing scientific aspects of the limnology of lakes and reservoirs, which reflects a continuing professional interest to me. My home state of Texas is very interesting in that it has more square kilometers of surface water than any other state in the United States. Except for a single, small natural lake located at one corner of the State, all this water resides in manmade impoundments, or reservoirs. Several years ago, prior to my going to UNEP, I worked for the Water Resources Division, U.S. Geological Survey, studying the limnology of a series of reservoirs near Austin, Texas. Part of my goal was to try to convince the State water agency that it should not blindly transfer limnological principles learned from natural lakes in central Europe and the northcentral United States, to attempt to manage reservoirs in the semi-arid southwestern United States. We simply do not know as much about the physics, chemistry and biology of reservoirs as we do about natural lakes. Hopefully, we have at least learned enough by now to know that reservoirs will not necessarily behave in the same manner as natural lakes to the same human influences.

In this forum, however, I am not going to talk about lakes or reservoirs. Rather, I will address you on the topic of international cooperation in global water problems. Noting the context of such global issues as climate change or biodiversity, a reasonable question might be "what is a global water problem?" The flows or quality of the Nile River Basin, for example, do not directly affect the Amazon River Basin. In fact, I use the term to describe common water problems that occur in many places around the world, even though their causes and impacts may be felt only within a region or sub-region.

Further, as was previously stated in a keynote address, "water is an extremely complex resource". Now, international cooperation on this issue involves consideration of a range of related and complicated issues, including sustainable development, integrated management, international waters, riverbasin approach, etc. It also involves bringing together many different people and disciplines, comprising a range of attitudes and thoughts regarding a common water resource or problem. Unfortunately, people can view the same problems differently, both between countries and within countries, depending on their circumstances. This automatically means the whole cooperation "process" will be unpredictable. Further, we are discussing the topic of transboundary or shared water resources, which itself can't be viewed comprehensively without some consideration also given to broader environmental issues.

HUMAN WATER USE

It sometimes is useful to remind ourselves of the importance of water in our daily lives. In the keynote address of UNEP's Executive Director, she described water as precious, finite and irreplaceable. It is *precious* because of its fundamental role in our physiological well-being and as the most basic commodity of our economic development. Further, we also use watercourses as a means of disposing of the unwanted byproducts and wastes of our development processes. It is *finite* because there is only so much water on Earth, and we do not have the ability to create more of it. Rather, we can only use and degrade it, discharge it, extract and treat it when we need it again, and then re-use it in a continuing cycle; one that is growing increasingly expensive to maintain as we find ever more ways to pollute and otherwise abuse our water resources. Finally, it is *irreplaceable* in that there is virtually no substitute for it. We can't make steel with orange juice, nor paper with milk; they both require large quantities of water. Indeed, we also couldn't make the orange juice or milk without water.

On the global scale, about three-quarters of human water use is for agricultural irrigation, with the remainder used for domestic and industrial purposes. It also is estimated that water use has increased ten-fold between 1900 and 2000. We already face water shortages in Africa, the Middle East and parts of North America, Asia and Europe. In fact, water deficits already exist in 88 developing countries, containing close to one-half the world's population, with resulting constraints on human and ecosystem health, as well as economic development. In addition to water quantity, bad water quality offers its own set of consequences. It is estimated, for example, that 80-90 percent of all diseases, and more than one-third of all deaths in developing countries are caused by contaminated water.

As said in the opening speech of the Executive Director, humans have faced the basic tasks of bringing water to its cities, of disposing of sewage and wastes, and of setting up and maintaining irrigation systems since ancient times. It still remains one of the fundamental tasks of our modern society as well. Ironically, in spite of its obvious importance in our daily lives and well-being, we do not sell or trade water as we do our other natural resources, such as oil or minerals. Rather, we continue to treat it as a cheap, abundant, and perpetually-available resource. As is becoming increasingly clear that this misconception can ultimately result in serious economic, social and political implications on a global scale.

Often forgotten in our focus on human needs are the water needs of nature. A wetland, for example, requires a certain amount of quantity of water flowing through it to remain a wetland, regardless of whether or not humans are present. Although we can't necessary quantify this amount of water, we know it is necessary. Further, water has a fundamental role in the movement of nutrients, minerals and other materials through ecosystems, as well as being a leading agent in biogeochemical cycles. Yet, we seldom consider maintenance of natural ecosystems, many being vital for our own existence, in our allocations of water between competing uses.

INTERNATIONAL WATERS

What constitutes international waters? There are doubtless legal definitions of this term. A simple definition is that international waters are rivers, lakes and/or groundwater aquifers shared by more than one country. They can be shared as a common boundary, or in an upstream-downstream relationship, in which the water flows from one country into another country. The latter situation is particularly troublesome in some situations; if you're located at the upstream end of a water system, and thereby have access to water resources not subject to the actions of your neighbors, you don't necessarily have any incentive to behave properly with respect to using water that ultimately flows to downstream states--other than perhaps the possibilities of armed conflict with downstream neighbors.

We have a large number of international water systems. A 1978 table illustrates the distribution of international riverbasins by continent, as follows: Africa - 57; Asia - 40; Europe - 48; North/Central America - 33; South America - 36. Since the breakup of the former Soviet Union, and the presence of even more independent States, there are an estimated 300 international water systems in the world. Under this definition, of course, Japan doesn't have any international freshwater systems.

SOCIO-ECONOMIC DEVELOPMENT

Bettering the standard of living of its citizens presumably is the long-term goal of all nations. This betterment typically takes the form of increased industrialization within a country. Until the last couple of decades, it was thought economic development could only be achieved at the expense of environmental change; that is, economic development always carries some degree of environmental change as an associated price tag. There is truth to this statement; it is said that humans spend much of our time gathering, extracting, moving, concentrating and dumping. The environment supplies the natural resources needed for these activities, and also acts as the recipient of their byproducts and wastes. As a result, the environmental change has usually been in the form of some degree of environmental degradation or depletion, with freshwater being the most sensitive of the affected natural resources.

Since about the mid-1970's, it has generally become realized, however, that economic development cannot be "sustained" (maintained over the long term) without consideration of the environmentally-sound management of natural resources (including water). The key to sustainable development is not to protect the environment at all costs, but rather to "balance" the resources needs of human economic development on the one hand, against the ability of nature to supply our resource needs, as well as our ability to preserve environmental quality, on the other hand. It has become abundantly clear that it is usually less expensive to address these concerns before degrading our water resources, than to wait until after the damage has occurred; that is, being conscious of a sort of "pay me now or pay me later" syndrome in regard to the natural environment.

Sustainable development automatically requires international cooperation, simply because no nation can readily produce all its needs by itself; some level of interaction with other countries is required. Further, in a tautology of sorts, economic development causes environmental problems. At the same time, it appears that economic development also is necessary to facilitate environmental concern. This appears to be due to the fact that poor people have few or no options; they simply must do what is necessary to survive. Thus, environmental protection and conservation often is difficult in developing countries, where basic survival issues may be primary national concerns. On the other hand, once a fundamental level of human livelihood and security is achieved, national priorities can more readily focus on broader issues, including environmentally-sustainable development.

SUSTAINABLE DEVELOPMENT AND AGENDA 21

An early description of UNEP's approach to conservation and management of water resources suggested the concept of sustainable development broadly encompasses the following elements:

- o Economic development within the constraints of the natural resource base (including water);
- o Cost-effective development, using non-traditional economic criteria;
- o Belief that development should not result in environmental degradation, nor in reduced productivity over the long term;
- o That poverty is a root cause of environmental degradation, primarily because the very poor have no options other than to degrade their own environment in their quest for survival;
- o Consideration of the issues of health control, appropriate technologies, and self-reliance in food, clean water and shelter for all;
- o Focusing on protection and conservation of the environmental systems at greatest risk.

Based on these concepts, a consensus for addressing sustainable development should include:

- o Improving indigenous capabilities for managing the natural resource base and the quality of the natural environment;
- o Building upon past experiences, as a means of avoiding past mistakes;
- o Ensuring environmental considerations are an integral part of development planning;
- o Acquisition and analysis of accurate data as a basis for sound development planning;
- o Public awareness of the needs and risks of not achieving environmentally-sustainable development.

Just as environmental issues must be viewed in a holistic manner, so must water issues be tackled in integrated fashion, and the linkages with other environmental issues clearly set out. In describing the reasons for addressing freshwater issues in an integrated, holistic manner, Agenda 21 notes:

> *"The widespread scarcity, gradual destruction and aggravated pollution of freshwater resources in many world regions, along with the progressive encroachment of incompatible activities, demand integrated water resources planning and management. Such integration must cover all types of interrelated freshwater bodies, including both surface water and groundwater, and duly consider water quantity and quality aspects. The multisectoral nature of water resources development in the*

context of socio-economic development must be recognized, as well as the multi-interest utilization of water resources for water supply and sanitation, agriculture, industry, urban development, hydropower generation, inland fisheries, transportation, recreation, low and flat lands management and other activities........."

In recognizing the importance of the sustainable management and use of transboundary water resources among multiple riparian states, Agenda 21 also highlights the need for cooperation among those States, including the utility of international agreements for the protection and conservation of these shared resources, taking into account the interests of all concerned riparian States.

INTEGRATED MANAGEMENT

The notion of integration can itself vary between countries and between agencies. One dictionary definition is that integration is the process of "making a whole out of the parts". In discussing freshwater resources, what are the parts? They include such scientific and engineering concerns as water quantity (supply, demand) and quality (state or condition), geological and physiographic conditions of the drainage basin, flora, fauna, etc. However, this is only part (perhaps the least significant part) of the equation. Effective management of freshwater resources also requires accurate knowledge and consideration of such "non-technical" issues as the development plans of the countries sharing a transboundary water system, their institutional structures, technology possibilities, legal frameworks, educational characteristics, social structures, public awareness and education opportunities, economic possibilities and political base--all of which can fundamentally affect how the inhabitants of a given drainage basin manage and use the available water resources.

To this end, strategies to implement integrated management of freshwater resources should include the following elements:

- o Recognition of the fundamental role of water in economic and social development and the well-being of basin societies;
- o Recognition of the fundamental multi-faceted environmental challenges emerging from water scarcity, water pollution and related land degradation;
- o Acknowledgement of regional differences in the sensitivity of the natural environment to human influences;
- o Recognition of the complex mix of water-related social, economic, legal and institutional issues to be addressed;
- o Appreciation of the necessary balance

between short-term needs and long-term perspective for protection of the natural resource base (including freshwater).

To provide an integrated perspective to the sustainable management and use of freshwater resources, UNEP developed a comprehensive water programme dealing with the multiple technical and social functions of water resources on equal terms, on both a national and international basis. This programme, "Environmentally-Sound Management of Inland Waters" (EMINWA), was launched in 1986 as a means of assisting Governments to integrate environmental considerations into the management and development of drainage basins and groundwater aquifers, as well as help ensure regional development of water resources in harmony with the natural and artificial water-related environment throughout entire water systems.

The EMINWA programme goals include (i) provision of assistance to Governments in developing and implementing environmentally-sound transboundary water management programmes; (ii) training of experts and establishment of networks in developing countries for environmentally-sound water management programmes; (iii) regular global, regional and sub-regional assessments of the state of transboundary water systems; and (iv) public awareness and education efforts directed to the need for, and achievements of, transboundary water management efforts.

The EMINWA Programme involved development, in cooperation with all riparian countries in a transboundary drainage basin, of an integrated water resources management plan applicable throughout the basin, in a two-step process. The first step is development of a "state-of-knowledge" report (Diagnostic Study), identifying the present status of environmental problems and water management in the basin, and the priority and long-term problems to be addressed to ensure sustainable water supply and use.

Upon acceptance by the riparian countries of the Diagnostic Study, the second step is the development of an Action Plan. Its objective is to alleviate or remediate the problems identified in the Diagnostic Study, thereby ensuring environmentally-sound management of the freshwater resources of the entire drainage basin. It also assists the riparian countries to incorporate water-related environmental considerations into their national development plans. Finally, UNEP also works with riparian countries to identify needed funding agencies and sources to facilitate implementation of corrective projects outlined in the Action Plan.

Although UNEP's approach attempts to consider all relevant scientific/technical and social, economic, legal and political considerations in facilitation of integrated management and use of transboundary water resources, other UN and international agencies also have developed other approaches for this purpose, UNDP and the World Bank being two prominent examples. However, in spite of such approaches directed to integrated management and use of transboundary water resources, we must face the reality that many, perhaps most, of the world's shared water resources are continuing to exhibit depletion or degradation as a result of their being used in an unsustainable manner. Why is this situation occurring? One answer is that Governmental officials, agencies and citizens within riparian countries are not sitting down to agree on the problems and their solutions. Further, some countries may find it difficult to justify giving priority to the needs of the drainage basin as a whole, at the expense of national water priorities. Even though nearly half the world's population lives in international riverbasins, lack of general agreement on the drainage basin as the fundamental water management unit also makes international cooperation especially difficult. The national development objectives of all riparian states of a transboundary water cannot be harmonized to arrive at a beneficial allocation of water resources according to an agreed development plan, to maximize the benefits of the resource for all the basin's inhabitants, without consideration of the drainage basin as the fundamental water management unit. Financial and human resource constraints also provide obstacles. Further, the ability of some riparian States to divert water flows, pollute waters or construct dams can affect the power relationship between the States. Ethnic, religious or ideological antagonisms in a transboundary drainage basin also increases the possibilities for conflicts over equitable water use, and makes establishment of water management and use agreements that maximize the benefits of the resource for all the basin inhabitants more difficult.

Within this context, the importance of establishment of adequate institutions to manage upstream/downstream issues should not be underestimated, especially for international rivers. Some institutions created for management of international waters are seriously flawed and/or lack features essential to build trust and confidence among riparian states. Otherwise, unwise water consumption, water pollution, or the discharge of wastes can provide a basis for potential conflict between upstream and downstream countries comprising international water systems.

SOME CONSIDERATIONS FOR INTEGRATED MANAGEMENT OF TRANSBOUNDARY WATER RESOURCES

Given the above explanations, what are some considerations that should be considered in addressing the problems related to international cooperation for transboundary water resources?

ACCURATE ASSESSMENT OF PROBLEMS--Accurate assessments of water-related issues, and their interlinkages to other technical and non-technical components, is essential. Although solutions to water resource problems will typically involve consideration of social, economic, legal and political issues, the fundamental problems must be defined on the basis of scientific and technical realities, rather than political or economic expediencies. This includes their analyses by competent scientists and engineers. In turn, scientists and technicians must describe the problems to decision-makers in a manner so that they can understand and use the information in the decision-making process. As a related component, sharing of relevant data and information between riparian countries is fundamental, as well as providing a basis for engendering trust between riparian States.

As well, in the absence of accurate knowledge, scientists and decision-makers will have to consider the possible consequences of a wrong decision. On the one hand, in the absence of sufficient data and knowledge, opponents of a given water project might be able to argue that we simply do not know enough to determine if a project is needed, particularly if its implementation requires a large sum of money. That is, if the project is not needed, but we do implement it, the result will be unnecessarily spending of public or private funds. On the other hand, within the context of environmental uncertainty, it also must be considered that not implementing the project, when it is actually necessary, could result in catastrophic consequences in a given situation, and certainly could be considerably more expensive if implemented at a later date.

CONSIDERATION OF DRAINAGE BASIN BENEFITS--An ultimate goal of sustainable management and use of transboundary water resources should be to maximize the water-related benefits for all drainage basin inhabitants. This may run contrary to the national interests of one or some of the riparian States, as well as enhance competition between competing water uses. However, if individual countries comprising a transboundary water system continue to base their development plans solely on national interests, without consideration of how these actions can affect the other riparian countries in the basin, there is little hope for cooperative development of the drainage basin water resources as a whole. Further, the possibility of water-related conflicts between riparian States also will be increased.

HONEST BROKERAGE--Many riparian States may be reluctant to give up any national sovereignty regarding their use of transboundary water resource. Fragmentation of responsibilities for management and allocation of water resources between many ministries or departments within riparian States also works to inhibit international cooperation. Thus, there is a fundamental need is for honest brokerage between riparian States regarding transboundary water resources. "Putting all the cards on the table" in this manner can be very difficult in any situation, but is necessary is progress is to be made. All parties must appreciate that their shared water resources are finite and irreplaceable, and that the benefit to the drainage basin as a whole is an overriding concern. Many related issues also are part of a larger land-freshwater-coastal hydrologic interlinkage. Thus, decision-makers must, in an honest, forthright manner, identify the major water issues to be discussed, and determine collectively how they can be resolved. The role of neutral "referees" for such interactions, with the long-term good of the basin inhabitants in mind, cannot be overemphasized.

ENCOURAGEMENT OF APPROPRIATE TECHNOLOGIES--In developing action plans for sustainable management and use of transboundary water resources, interest often focuses on advanced technology, at the expense of indigenous technologies. In the developed world, riparian States typically employ high-tech approaches to address transboundary water issues. Among other rationale, experience often has shown that purchase of equipment and structures to address water issues often is most cost-effective over the long term than employing large numbers of personnel. In contrast, the developing world often lacks the financial resources to make capital-intensive purchases of such equipment and technology. On the other hand, developing countries often have a large, cheap labor force. As a result, the use of labor-intensive approaches, that rely on local expertise often is a more appropriate approach for developing countries. Thus, efforts should be made to identify the appropriate technology for a given situation, examining past experiences, relative costs, information on successes and failures of past use, etc., as the basis for deciding on whether the "hard choice" or "soft option" is the ultimate approach to be used in a given situation.

CONSIDERATION OF WATER NEEDS OF NATURE--Often forgotten in the development of international agreements on allocation and usage of water resources is the fundamental water needs of the natural environment and its associated ecosystems. This is due in part to our incomplete understanding of the complex interlinkages between and within ecosystems, and their living and non-living resources. To this end, we must develop ways to assess and quantify the basic water needs of aquatic ecosystems, particularly those valued by humans. We also must incorporate these needs into national and international water allocation processes and development plans (i.e., some share of the water resources must be set aside to satisfy the basic functional needs of ecosystems). More study is required on this fundamental issue.

PUBLIC AWARENESS AND EDUCATION EFFORTS--Depletion and pollution of water resources in a drainage basin results from human activities in the basin. However, most people in a given drainage basin typically have little or no understanding of their roles, individually or collectively, in causing water problems. Further, they may have equally-little understanding of what they could do to assist in the alleviation of the problems. As previously noted, the poverty of many people in developing countries has restricted or eliminated their options for survival; they will require assistance to change their habits. In other cases, however, it is simply a matter of instructing or educating individuals as to their possible roles in alleviating water scarcity or pollution problems. The media can be especially helpful in this regard, in highlight the public role in the process of identifying the causes of, and the solutions to, human-induced water problems, as well as in changing the basic attitude of people toward protection and wise use of water resources.

INTERNATIONAL AGREEMENTS FOR TRANSBOUNDARY WATER RESOURCES--This is an ultimate goal of international cooperation; namely, the implementation of an international agreement for protection and conservation of a transboundary water basin, spelling out the rights and obligations of the riparian States. However, the reality is that, although there are about 300 transboundary water systems in the world, there are few existing international water agreements for the sustainable management and use of the water resources. One result of this deficiency is that efforts to manage water systems often suffer from a lack of continuity, particularly for developing countries. Further, although often implemented with good intentions, there often is little coordination or integration between Governmental ministries, agencies and/or organizations with regard to remedial programmes. Multiple agencies sometimes work in a given transboundary water system, or in a given region, without detailed knowledge or understanding of their common activities or interests. This situation can result in overlapping and duplicative activities; it also can work to dilute achievement of the intended goals of individual ministries and agencies. The synergism of coordinated analysis and remediation efforts, particularly within the context of an international agreement, cannot be overemphasized.

The few examples of international agreements that exist include those of the Zambezi River and Lake Chad basins of Africa, the Great Lakes Basin of North America, and UNEP's 13 Regional Seas Programmes. In varying degrees of the planning stage are agreements for the Aral and Caspian Seas, the Mekong River, the San Juan River and Lake Titicaca basins of South America, the Lake Erhai basin of China and the Nile River basin.

PROACTIVELY ADDRESSING EMERGING WATER ISSUES--As previously noted, humans have been faced with the problems of drinking water supply, sewage disposal and irrigation of food crops for as long as the existence of the human race. At the same time, one must not forget to remain proactive, as a means of trying to address problems at an early stage.

An example of one emerging issue meriting consideration is the predicted migration of the majority of the world's population to urban areas within the next half century. Humanity has never before faced the problems likely to arise with such concentrations of people in relatively small spatial areas. Further, recent estimates are that 17 of the top 20 "megacities" (cities with populations exceeding 10 million) of the future will be located in developing countries, which are those least likely to be able to address the problems, given their anticipated financial and human resource base. It is noted that all the basic "fuels" of urbanization (e.g., water, energy, food) typically are imported to urban areas from regions located some distance from the urban areas. Indeed, water was identified at the recent Istanbul Conference as the most critical single issue facing the growth of cities in the future. Thus, "sustainability" of the cities means not only increases in infrastructure and delivery services within the urban area, but also the protection and conservation of resource areas outside the urban areas. Further, humanity has never before been faced with the quantities and types of polluting materials likely to arise from megacities. There are obvious benefits to considering these issues now, rather than after they have become serious problems.

A second emerging issue is the protection of the marine environment from land-based activities. In recognition of the fundamental role of the coastal areas and oceans in economic development and global cycles, Governments adopted the Global Programme of Action for the Protection of the Marine Environment From Land-Based Activities, at an international intergovernmental meeting held in Washington, D.C. during November 1995. The same Governments selected UNEP as the Secretariat of this new global initiative. In recognizing the fundamental inter-linkage between the land-freshwater-coastal system as a single water management continuum issue, UNEP consolidated its Freshwater Unit and its Oceans and Coastal Areas Project Activity Centre (OCA/PAC) into a single, integrated Water Branch. The goal was to facilitate consideration of the fundamental hydrological continuum between these components, as a means of addressing their sustainable management and use. Because an estimated 80 percent of the pollution load to coastal waters comes from river basins draining to coastal areas, protection and conservation of the marine environment clearly will require implementation of remedial programmes within freshwater drainage basins. However, not only is the magnitude of the pollutant load reduction important, but also the modalities of achieving that reduction. This is because the most immediate and dramatic impacts of such remedial programmes will be felt by the inhabitants living within the riverbasins. Thus, the specific mix of remedial programmes developed to protect the state of the marine environment under this initiative must also consider their impacts on the riverbasin inhabitants as well.

In closing, it is noted many of the observations in this presentation may seem like common sense to many individuals. At the same time, however, serious environmental issues continue to worsen around the globe. Increasing population growth, particularly in the developing world, and the resultant increased poverty and competition for limited natural resources, are paramount among the causative factors. It is hoped some of the messages in this presentation provide guidance regarding fundamental water-related issues. It certainly can be argued that we are likely to experience increasing delays in coming decades in implementing new remedial programmes and projects to address water issues, due to such factors as escalating costs, lack of investment funds, increasing technical complexities and/or lack of understanding of fundamental water issues. Nevertheless, recognition that water is precious, finite and irreplaceable should provide an impetus for a proactive approach to its sustainable management and use, particularly among countries sharing transboundary resources. Indeed, without this recognition, the only solace is that nature will eventually step in and take care of the problems for us. Unfortunately, however, nature can be a cruel taskmaster, and we may well not be pleased with the results as they apply to human existence and well-being.

International Cooperation for Global Water Environment Conservation

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Abstract

The sea is a global water resource. For conservation of marine environment, international treaties were ratified from rather early stages. They include the UN Convention on the Laws of the Sea (1994), International Convention for the Prevention of Pollution of the Sea by Oil (1958), and the London Marine Wastes Convention (1973). They have promoted international anti-pollution initiatives. The UN Convention on the Laws of the Sea covers over all aspects of marine environments, requiring Members not to cause any pollution originating from their activities and not allow pollution to expand into neighbouring countries.

Moreover, one of the objectives of this Convention states the international co-operation for the conservation of marine environments. Specifically, co-operation for preparing international rules and regulations to preserve global/regional marine environments (article 197); notification to the country which may be affected by marine pollution (article 198); co-operation in pollution prevention among possible affected countries and joint preparation of emergency programmes (article 199); promotion of research of marine pollution and implementation of scientific research project and co-operation in exchange of the findings (article 200); co-operation in preparing rules and regulations on marine pollution prevention (article 201); aid from developed nations in the field of science and technology, such as capacity-building and provision of facilities in developing countries (article 202). It also requires the international organisations to give priority to financial and technical assistance to developing countries for marine environment prevention (article 203).

It is my understanding that this Shiga Forum will not cover the marine environment, and deal with environmental conservation of freshwater resources. In this line, you may think that my comments above are out of topic. However, the prescriptions on marine convention are not only for marine environment pollution prevention. It is to describe ways of international co-operation generally applicable to any kind of environmental pollution. The principles of the Rio Declaration of 1992 also referred to it. The above mentioned international co-operations would be a good help when you

think about freshwater environments, especially, international rivers and ground water resources which cross borders. There are many bilateral treaties to manage international rivers. However, the International Law Association approved the general rules for international co-operation in 1966, 'Rules for usage of international river waters.

Furthermore, there is a call for global partnership. People are talking about the developed nations' international co-operation in developing countries environmentally issues. The developed countries are requested to support the developing countries financially and technically. This important matter should be discussed to strengthen the collaboration of scientists and private sectors.

(In order to get detail paper please contact Professor Akio Morishima, Sophia University, 7-1 Kioi-cho, Chiyoda-ku, Tokyo 102-0094 Japan, original in Japanese.)

Application of Ecotechnology in Water Management

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INTRODUCTION

When the first green wave started in the late sixties, we naively relied only on environmental technology. In U.S., it was even seriously discussed to achieve zero discharge 1985! Few years after it became clear that we had also to rely on the self purification ability of ecosystems and that we had also to raise the question: How much pollution can a considered ecosystem tolerate and still meet our now more pragmatic quality standards? This started an extensive use of ecological models to find a relationship between emissions and effects in the ecosystems.

About 15years ago it become clear that environmental technology was not sufficient to solve the increasing water management problems. Particular abatement of non point pollution requires other measures. Consequently, ecotechnology developed as am alternative and supplement to environmental technology.

Ecotechnology is defined as a technology operating in the ecosystem with the scoop to find an environmental management solution to the benefit of man and nature.

Today we have realized that environmental management is a complex issue - which is not surprising as it deals with a complex problem in a complex system. We fully acknowledge that we need a wide spectrum of measures to solve the complex water management problems - see Figure 1. In addition to environmental technology, we need ecotechnology, cleaner technology and we need to consider the global problems.

CLASSIFICATION OF ECOTECHNOLOGY

We distinguish four classes of ecotechnology which illustrates different uses of the application of ecotechnology in ecosystem to the benefit of both man and nature:

A. Use (but not abuse) of the self-purification ability of nature to solve pollution problems. Example: use of wetland for treatment of waste water and use of adapted organisms to deal with specific waste problems in situ. Wetland should also be maintained along the shoreline of rivers and lakes to protect these waters from pollution. The wetlands along our fresh and saline water shorelines protect the ecosystems, as the membrane is protecting the cell.

B. B. Restoration of ecosystems. This has been extensively used in lake environmental management with ecotechnology: removal of lake sediment, biomanipulation, removal of hypolimnion water. These structure due to change in the impact, and show hysteresis phenomena (figure 2 and 3). Biomanipulatiion may for instance be important to obtain a much faster response to phosphorus removal in a certain regime.

C. Construction of ecosystems. The use of artificial wetlands to deal with non-point pollution is an almost classical example. Allow land is turned into wetland, and it is discussed how wide a belt of uncultivated land we should maintain adjacent to any aquatic ecosystem. Figure 4 shows some characteristic figures for the ability of wetlands to remove nitrogen by intensive denitrification.

D. Ecological planning in accordance with ecological principals. Examples are agroforestry and maintenance of landscape diversity.

ECOLOGICAL PRINCIPLES

It has been considered of utmost importance that the application of ecotechnology should be based on sound ecological principals. It has been therefore been fiercely discussed which principles to use as a basis of ecotechnology from an ecological point of view. Today these based on implementation of ecotechnology. Mitsch and Jorgensen (1989) have set up 12 principles, which however should be supplemented with others when we get more experience in the use of ecotechnology. The 12 principles are:

1. Ecosystem structure and function is determined by the forcing functions.
2. Homeostasis of ecosystems requires accordance between biological function and chemical composition.
3. It is necessary to match recycling pathways and rates to reduce the effect of pollution.
4. Work with the self-designing ability of ecosystems.
5. Use the right ecological time and space scale.
6. Maintain biodiversity for the ecosystem's selfdesigning ability to choose from.
7. Consider the importance of ecotones.
8. Ecosystems are open system.
9. Ecosystems are networks which implies that indirect effects are essential.
10. Ecosystems have history.
11. Ecosystems are vulnerable at the geographical edge.
12. Ecosystems are hierarchical systems (see figure 6).

CLOSING REMARKS

Environmental technology can not solve the problems of non-point pollution and will anyhow in many cases offer a too expensive technology with ecotechnology, environmental legislation, cleaner pertinent solutions to non-point pollution an should definitely be environmental problems cannot be solved by one method, but require a combination of methods - at least when a cost moderate total solution should be found.

Mitsch, W.J. and Jorgensen, S.E. (1989), Ecotechnology, An Introduction to Ecological Engineering. John Wiley, New York.

Reclaimed Wastewater as a Water Resource

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ABSTRACT

For the last quarter century, a repeated thesis has been that advanced treatment of municipal and industrial wastewater provides a treated effluent of such high quality that it should not be wasted but put to beneficial use. This conviction in responsible engineering, coupled with the vexing problem of increasing water shortage and environmental pollution, provides a realistic framework for considering reclaimed wastewater as a water resource in many parts of the world.

In this paper, fundamental concepts of wastewater reclamation and reuse are developed that include categories of water reuse, planning methodologies, economics for water reuse, and technological innovations for the safe use of reclaimed wastewater. The paper emphasizes the integration of this alternative water supply into water resources planning. In every wastewater reclamation and reuse operation, however, there is some risk of human exposure to infectious agents. Because of this concern, special attention is paid to tertiary/advanced wastewater treatment systems which produce essentially pathogen-free effluent for variety of beneficial uses such as toilet-flushing water in large commercial buildings; irrigation of parks, school yards, and golf courses; and groundwater recharge. The paper also reviews the emergence of modern wastewater reclamation and reuse practices from wastewater to reclaimed water to repurified water, and to discuss cost of wastewater reclamation and reuse.

KEYWORDS

Environmental engineering, health risks, reuse, treatment, water resources, wastewater.

INTRODUCTION

Wastewater reclamation and reuse is one element of water resources development and management which provides an innovative and alternative option for agriculture, municipalities, and industries. The water pollution control efforts in many countries have made treated effluent from municipal wastewater available that may be an economical augmentation to the existing water supply when compared to the increasingly expensive and environmentally destructive new water resources development. However, wastewater reuse is only one alternative in planning to meet future water resources needs. Water conservation, water recycling, efficient management and use of existing water supplies, and new water resources development are examples of other alternatives.

Wastewater reclamation and reuse involves considerations of public health and also requires close examinations of infrastructure and facilities planning, wastewater treatment plant siting, treatment reliability, economic and financial analyses, and water utility management involving effective integration of water and reclaimed wastewater. Whether wastewater reuse will be appropriate depends upon careful economic considerations, potential uses for the reclaimed water, stringency of waste discharge requirements, and public policy wherein the desire to conserve rather than develop available water resources may override economic and public health considerations. Through integrated water resources planning, the use of reclaimed wastewater may provide sufficient flexibility to allow a water agency to respond to short-term needs as well as increase long-term water supply reliability without constructing additional storage or conveyance facilities at substantial economic and environmental expenditures. Thus, wastewater reuse has a rightful place and an important role in optimal planning and more efficient management and use of water resources in many countries.

Wastewater reclamation is the treatment or processing of wastewater to make it reusable, and *water reuse* is the use of treated wastewater for a beneficial use such as agricultural irrigation and industrial cooling. In addition, *direct* wastewater reuse requires existence of pipes or other conveyance facilities for delivering reclaimed water. *Indirect* reuse, through discharge of an effluent to a receiving water for assimilation and withdrawals downstream, is recognized to be important but does not constitute *planned direct* water reuse. In contrast to direct water reuse, water recycling normally involves only one use or user and the effluent from the user is captured and redirected back into that use scheme. In this context, water recycling is predominantly practiced in industry such as in pulp and paper industry (Metcalf & Eddy, 1991).

Fig. 1 shows, conceptually, the quality changes during municipal use of water in a time sequence. Through the process of water treatment, a drinking water is produced which has an elevated water quality meeting applicable standards for drinking water. The municipal and industrial uses degrade water quality, and the quality changes necessary to upgrade the wastewater then become a matter of concern of wastewater treatment. In the actual case, the treatment is carried out to the point required by regulatory agencies for protection of other beneficial uses. The dashed line in Fig. 1 represents an increase in treated wastewater quality as necessitated by wastewater reuse. Ultimately as the quality of treated wastewater approaches that of unpolluted natural water, the concept of wastewater reclamation and reuse is generated (McGauhey, 1968). Further advanced wastewater reclamation technologies, such as carbon adsorption, advanced oxidation, and reverse osmosis, will generate much higher quality water than conventional drinking water, and it is termed *repurified water*. Today, technically proven wastewater reclamation or purification processes exist to provide water of almost any quality desired.

CATEGORIES OF WASTEWATER REUSE

In the planning and implementation of wastewater reclamation and reuse, the intended wastewater reuse applications govern the degree of wastewater treatment required and the reliability of wastewater treatment processing and operation. In principle, wastewater or any marginal quality waters can be used for any purpose provided that they meet the water quality requirements for the intended use. Seven categories of reuse of municipal wastewater are identified in Table 1, along with the potential constraints. Large quantities of reclaimed municipal wastewater have been used in four reuse categories: agricultural irrigation, landscape irrigation, industrial recycling and reuse, and groundwater recharge.

In California, where the largest number of wastewater reclamation and reuse facilities has been developed, at least 432 million cubic meters (10^6 m^3) of municipal wastewater are beneficially used annually. This figure corresponds to around 8 percent of municipal wastewater generated in the State (State of California, 1990).

In Japan,, there were 876 publicly owned treatment works (POTWs) operating in 1991, discharging approximately 110 x 10^8 m^3/year of secondary treated effluents. Of these, approximately 100 x 10^6 m^3/year of reclaimed wastewater from 99 POTWs are reused beneficially in such uses as industrial uses (41%), environmental water and flow augmentation (32%), agricultural irrigation (13%), non-potable urban use and toilet flushing (8%), and seasonal snow-melting and removal (4 %) (Asano, *et al.*,1996).

Contrary to the arid or semi-arid regions of the world where agricultural and landscape irrigation are the major beneficial use of reclaimed wastewater, wastewater reuse in Japan is dominated by the various non-potable, urban uses such as toilet flushing, industrial use, stream restoration and flow augmentation to create so-called "urban amenities." Fig. 2 shows the comparative diagrams for Japan and California, depicting the various reclaimed water uses and the corresponding volumes per year (State Water Resources Control Board, 1990; Japan Sewage Works Assoc., 1994). Recycling of industrial wastewater within factories, as well as wastewater reuse within the POTWs is not included in these diagrams.

Agricultural and landscape irrigation is the largest current and projected use of reclaimed wastewater in the United States. Irrigation uses can offer significant opportunity for wastewater reuse since, in many arid and semi-arid regions, 70 to 90 percent of applied water is used in irrigation. Much of the attention focused on reclaimed water over the last decade has been for its use in the urban environment, such as for landscape irrigation, and its potential for groundwater recharge. Nonetheless, the historical application for agricultural purposes continues to dominate in California, for example, amounting to 63 percent of the total reclaimed water used in 1987. At least 20 different food crops were irrigated with reclaimed water, as well as at least 11 other crops and nursery products (State of California, 1990).

The largest industrial application of reclaimed water in California was for paper manufacturing. Other significant industrial uses were power plant cooling, watering of log decks, and cooling water in a steel manufacturing plant (State of California, 1990).

ELEMENTS OF WASTEWATER REUSE PLANNING

The trends and motivating factors in wastewater reclamation and reuse are characterized as follows:

- Water pollution abatement in receiving waters
- Availability of highly treated
- effluents for various beneficial uses due to stringent water pollution control requirements
- Providing long-term reliable water supply in nearby communities
- Water demand and drought management in overall water resources planning
- Public policy encouraging water conservation and wastewater reuse

A first step in water reuse planning is to determine whether a wastewater reuse project is for predominantly water supply or water pollution control. The role of reclaimed wastewater in water resources planning has become much more important in the last decade. Water demands often exceed reliable water supplies, even in normal precipitation years, and new water resources development is increasingly costly and environmentally often prohibiting. Reclaimed water is, after all, a water resource existing right at the doorstep of the urban environment and a reliable source of water even in drought years that is capable of replacing potable water supplies for non-potable and sub-potable water uses.

Planning for water reuse normally evolves through three stages:

- Conceptual planning
- Feasibility investigation

- Facilities planning

During conceptual planning, a potential project is sketched out, rough costs are estimated, and a potential reclaimed water market is identified. If the concept appears worthwhile, a preliminary feasibility investigation takes place.

The preliminary feasibility investigation consists of: (1) performing a market assessment for reclaimed wastewater, (2) assessing the existing water supply and wastewater facilities and developing some preliminary alternatives, (3) developing or identifying the alternative non-reclamation facilities, such as wastewater treatment for stream discharge or constructing dams and reservoirs for future water supply, with which to compare a proposed water reuse option, and (4) performing a preliminary screening of wastewater reuse alternatives to consider technical, economic and financial attractiveness, and other constraints such as public health protection (Asano and Mills, 1990).

Based on the preliminary feasibility investigation, if wastewater reclamation and reuse appear viable, then detailed actual planning can be pursued, refined facilities alternatives developed, and a final facilities plan proposed. A key task in planning a wastewater reclamation project is to find potential customers who want and know how to use reclaimed wastewater for their applications. Whether a user is capable of using reclaimed wastewater depends on the quality of effluent available and its suitability for the type of use involved.

Although technical, environmental, and social factors are considered in project planning, monetary factors usually override other issues when decisions are made about whether and how to implement a water reuse project. Monetary analyses fall into two categories: economic analysis and financial analysis. Economic analysis focuses on the value of the resources invested in a project to construct and operate it, measured in monetary terms and computed in the present value. The basic result of the economic analysis is to answer the question: *Should* a water reuse project be constructed?

The financial analysis addresses whether a water reuse project is financially feasible. The project sponsor will need a source of capital and sources of revenue to pay for debt service and operational costs for both the proposed wastewater reuse project and any existing facilities. Thus, the equally important question to answer in the financial analysis is: *Can* a water reuse project be constructed?

A common misconception in planning for wastewater reuse is that reclaimed wastewater represents a low-cost new water supply. This assumption is generally true only when wastewater reclamation facilities are conveniently located near large agricultural or industrial users and when no additional treatment is required beyond the water pollution control facilities from which reclaimed water is delivered. The conveyance and distribution systems for reclaimed water represent the principal cost of most proposed water reuse projects. Recent experience in California indicates that approximately four million dollars in capital cost are required for each one million m^3 per year of reclaimed water made available for reuse. Assuming a facility life of 20 years and a nine percent interest rate, the amortized cost of this reclaimed water is $0.5/$m^3$, excluding O & M costs.

Facilities Planning Report

The results of the completed planning effort should be documented in a facilities planning report on wastewater reclamation and reuse. A suggested report outline is presented in Table 2 which also serves as a checklist for the planning processes. Facilities design is the next logical step. Equally important, however, is securing users to take reclaimed water once it becomes available. Detailed considerations for the user contracts can be found in Asano and Mills, 1990.

Other planning factors of particular importance are engineering and public health. Engineering involves more than water distribution system design. A water reuse project is a relatively small-scale water supply project that includes matching water supply and demand, appropriate level of wastewater treatment, reclaimed water storage, and supplemental or backup freshwater supply.

WASTEWATER RECLAMATION TECHNOLOGIES

The importance of tertiary treatment consisting of chemical coagulation, flocculation, sedimentation, and filtration processes has been demonstrated as a conditioning step in wastewater reclamation by removing particles and turbidity for effective disinfection as well as an esthetic enhancement towards "sparkling clean" reclaimed wastewater (cf.. Fig. 1). Presently, more than 50 tertiary treatment facilities are in operation in conjunction with wastewater reclamation and reuse in California to meet the most stringent water quality requirement of virtually pathogen-free reclaimed wastewater.

To illustrate the applicable technologies adopted in the wastewater reclamation and reuse, two landmark studies - the Pomona Virus Study and the Monterey Wastewater Reclamation Study for Agriculture - are reviewed in this section.

Reference Treatment Process - Full Treatment Process (Title 22 Process)

The most stringent treatment process specified in the *California Wastewater Reclamation Criteria* (1978) is the full treatment process (Title 22 Process) shown in Fig. 3-A. Although this process is economically feasible, it is costly due to the expenses associated with relatively high doses of coagulant chemicals (50-125 mg/L alum, 0.2 mg/L anionic polymer), sludge handling, and tertiary sedimentation tanks. Thus, considerable efforts have been directed toward the development of less costly tertiary treatment alternatives that produce effluent quality comparable to that of the full treatment process.

Alternative Tertiary Treatment Process in the Pomona Virus Study

The first effort to investigate alternative treatment processes was made at the County Sanitation Districts of Los Angeles County's Pomona Research Facility during 1976-77; thus, known as the "Pomona Virus Study" (1977). The study compared the attenuated poliovirus inactivation and removal capabilities of an alternative tertiary process - contact filtration (see Fig. 3-C) - to the specified full treatment process (Title 22 process).

Fig. 4 shows the results of poliovirus inactivation and removal in the tertiary treatment processes depicted in Fig. 3. When high chlorine residuals of approximately 10 mg/L were used, there was no difference in the overall removal or inactivation of the seeded poliovirus between the full treatment process and the contact filtration process. When low chlorine residuals of approximately 5 mg/L were applied, a slight difference of 5.2 log removal vs. 4.7 log removal was observed (Pomona Virus Study, 1977; Dryden, *et al.*, 1979). The log removal refers to the fraction of poliovirus remaining after treatment; thus, one log removal is equivalent to 90 % removal and five log removal is 99.999.

Comparative Treatment Studies in the Monterey Wastewater Reclamation Study for Agriculture (MWRSA)

The MWRSA was a six - year (1980-86), $7.2 million (1986 Dollar) field-scale project designed to evaluate the safety and feasibility of irrigating food crops (many eaten uncooked) with reclaimed municipal wastewater (Engineering-Science, 1987; Sheikh, *et al.*, 1990). The two alternative tertiary treatment processes - direct filtration (see Fig. 3-B) and contact filtration (see Fig. 3-C) - were studied for the removal of enteric viruses. These direct and contact filtration processes are typically operated with a small quantity of alum addition in the range of 2-5 mg/L and chlorine disinfection with 5 - 10 mg/L chlorine dose and 1.5 hour contact time.

Enteric viruses were monitored in MWRSA for the presence of naturally occurring animal viruses in influents to and effluents from the full treatment process and the two alternative filtration processes. During the six year field study period, no enteric viruses were detected in the chlorinated effluent of either the full treatment or direct filtration processes. A total of 186 m^3 and 160 m^3 were sampled from the full treatment process and direct filtration process, respectively. The unchlorinated secondary effluent (prior to tertiary treatment) contained measurable enteric viruses 80 % of the times sampled, averaging 2,200 viral units (vu) per 100 liters with a range of 100 to 73,400 vu/100 L (Engineering-Science, 1987; Shiekh, *et al.*, 1990).

As a result of the Pomona Virus Study and MWRSA, the California Department of Health Services has adopted direct or contact filtration as an acceptable alternative, providing certain design criteria are met. Consequently, almost all of the tertiary treatment plants designed in recent years to meet the full treatment process requirements, specified in the *Wastewater Reclamation Criteria,* use direct or contact filtration process.

HEALTH AND REGULATORY CONSIDERATIONS

In every wastewater reclamation and reuse operation, there is some risk of human exposure to infectious agents. The contaminants in reclaimed wastewater that are of health significance may be classified as biological and chemical agents. For most of the uses of reclaimed wastewater, pathogenic organisms pose the greatest health risks, which include bacterial pathogens, helminths, protozoa, and viruses.

To protect public health, considerable efforts have been made to establish conditions and regulations that would allow for safe use of reclaimed wastewater. Although there is no uniform set of standards existing, several international, national, and state wastewater regulations have been available (State of California, 1978; World Health Organization, 1989; U.S. EPA, 1992). Although these wastewater reclamation guidelines and regulations lack explicit epidemiological evidence on which to base an assessment of health risks, they have been adopted, nonetheless, as the attainable and enforceable regulations in the planning and implementation of wastewater reclamation and reuse projects (Asano, *et al.*, 1992).

For example, the State of California's *Wastewater Reclamation Criteria* (1978) requires that reclaimed water used for landscape irrigation of areas with unlimited public access must be "adequately oxidized, filtered, and disinfected prior to use," with median total coliform count of no more than 2.2/100 mL. To achieve these requirements, it requires the wastewater treatment processes consisting of biological secondary treatment and tertiary treatment with filtration followed by disinfection.

Table 3 presents a summary of the California requirements for reclaimed wastewater used for irrigation and recreational impoundments. Note that there are many reuse applications that do not require a high degree of wastewater treatment. The *California Wastewater Reclamation Criteria* (commonly known as the Title 22 regulations) are basically health regulations, thus, the *Criteria* do not specifically address the treatment technology or the potential effect of reclaimed water on the crops or soil. The median number of total coliform count and turbidity are used for the assessment of treatment reliability of wastewater reclamation plant. The *Criteria* is being revised and expanded to accommodate detailed regulations on groundwater recharge, cooling towers, and in-building applications including toilet flushing.

Further safety measures for nonpotable water reuse applications include: (1) installation of separate storage and distribution systems of potable water, (2) use of color-coded labels to distinguish potable and non-potable installation of the pipes, (3) cross-connection and backflow prevention devices, (4) periodic use of tracer dyes to detect the occurrence of cross contamination in potable supply lines, and (5) irrigation during off hours to further minimize the potential for human contacts.

ASSESSMENT OF SAFETY OF WASTEWATER REUSE PRACTICES

Despite a long history of wastewater reclamation and reuse in many parts of the world, the question of *safety* of wastewater reuse is still difficult to define and delineation of *acceptable* health risks have been hotly debated. In this section, a comparative assessment of the safety of wastewater reuse is discussed based on two recent studies by Asano, *et al.* (1992), and Tanaka, *et al.* (1993) on the enteric virus risk assessment. When treated municipal wastewater effluents are used in urban environments where there is a strong possibility of direct human contact, considerable health concerns may be justified. These health concerns are specifically directed, in the industrialized countries with high health standards, to control enteric viruses.

The risk of virus infection from exposure to reclaimed municipal wastewater was determined by applying risk assessment procedures to existing data on viral concentrations in treated wastewater. A database was developed using published reports from water and wastewater agencies in California and included enteric virus data from 424 unchlorinated secondary effluent samples in which 283 samples (67%) were virus positive and 814 chlorinated tertiary (filtered) effluent samples with 7 positive samples (1 %). Quantifying the virus concentration (expressed as viral unit, vu, per liter) in the treated effluent was the first step for estimating the risk. Virus concentrations reported in unchlorinated activated sludge effluents and in chlorinated tertiary filtration effluents were evaluated in the risk analysis. For the first risk analysis run, the geometric mean and the 90 percentile values for enteric viruses found in unchlorinated activated sludge effluents were used and 5-log removal (99.999 %) of viruses was assumed in tertiary filtration and chlorine disinfection. For the second run, two computer simulations used the virus concentrations of 0.01 vu/L and 1.11 vu/L from the chlorinated tertiary filtration effluents, which are reasonable estimates of the detection limit for enteric viruses and the maximum concentration found in tertiary effluents.

The estimates of risk of infection, expressed as annual risk, are shown in Table 4 for different wastewater reuse situations. The overall probability of infection due to ingestion of viruses is a combination of virus removal and inactivation by wastewater treatment, die-off in the environment, and dose-response. For each exposure scenario presented, the range of risks covers 2-3 orders of magnitude depending on the degree of infectivity associated with individual groups of viruses.

To evaluate the safety of wastewater reclamation and reuse, the U.S. Environmental Protection Agency's Surface Water Treatment Rule (EPA SWTR) was used as a point of reference. Acceptable risks for this evaluation were defined as meeting the 10^{-4} infection risk criterion at least 95 percent of the time, as well as by the expectation estimate using Monte Carlo methods. For golf course and food crop irrigation, and groundwater recharge, the reliability of wastewater reclamation and reuse is such that more than 95 percent of the time the criterion was met for all of the effluents examined. However, for recreational impoundments, the reliability of wastewater reclamation is not always as high as the use of drinking water supply specified in the EPA SWTR (Tanaka, *et. al.*, 1993).

The goal of virtually pathogen-free reclaimed wastewater contained in California's *Wastewater Reclamation Criteria* should not be interpreted to mean that the practice of using such water is risk-free. As Table 4 clearly shows, there is always some risk of infection due to exposure to reclaimed wastewater. However, this does not mean that the practice of wastewater reclamation and reuse is unsafe.

COST OF WASTEWATER RECLAMATION AND REUSE

To estimate the cost of the tertiary treatment system, several sources were used to determine costs from the published literature (Sanitation Districts of Los Angeles County, 1977; Dames & Moore, 1978; Engineering-Science, 1987; Young, *et al.*, 1988). The costs for both the "Title 22 process" and "direct filtration process" were estimated and shown in Table 5. The cost breakdown in one instance indicated that incremental tertiary treatment costs (chemical addition, filtration, solids treatment) were estimated to be only $0.06/m^3$ ($79/af) while distribution costs, administrative charges (accounting, monitoring, overhead), and replacement reserve fees were projected at $0.12/m^3$ ($142/af), $0.04/m^3$ ($54/af), and $0.04/m^3$ ($50/af), respectively. The critical importance represented by labor and energy costs in the water reuse system is noted (Young, *et al.*, 1988). The ratios of tertiary treatment costs for the "Title 22" treatment train to the "direct filtration" train ranges from 2.0 to 2.4 for capital cost, 3.9 to 5.6 for O & M cost, and 2.4 to 2.9 for life cycle cost for the treatment capacities ranging from 3,785 m^3/d to 37,854 m^3/d (Richard, *et al.*, 1990).

However, there is danger in comparing cost data from different studies and locations because of differing underlying assumptions, which often are not explicitly stated. As seen from the data shown in Table 5, costs are significantly affected by fraction of utilization of a facility over the course of a year. Economic assumptions of useful lives and interest rates affect the amortization of capital costs embedded in unit costs. Reported costs may represent current expenses for old facilities and do not reflect costs to construct those facilities at today's prices as seen in the Irvine Ranch Water District in California.

One factor which appears to significantly affect costs is the degree of utilization of available capacity in the treatment plant. Maximum utilization can be achieved by: (1) seasonal storage of effluent to compensate seasonal slack in water reuse demands, (2) obtaining a mix of reclaimed water uses to reduce seasonal demands, or (3) using alternative water supplies for meeting peak demands.

THE FUTURE OF WATER REUSE

Significant progress has been made with respect to developing sound technical approaches to producing a quality and reliable water source from reclaimed wastewater. Continued research and demonstration efforts will result in additional progress in the development of water reuse applications. Some key topics include: assessment of health risks associated with trace contaminants in reclaimed water; improved monitoring approaches to evaluate microbiological quality; optimization of treatment trains; improved removal of wastewater particles to increase disinfection effectiveness; the application of membrane processes in production of reclaimed water; the effect of reclaimed water storage systems on water quality; evaluation of the fate of microbiological, chemical, and organic contaminants in reclaimed water; and the long-term sustainability of soil-aquifer treatment systems (Asano and Levine, 1996). A key to improving the implementation of water reuse is the continued development of cost-effective treatment systems.

To date the major emphasis on wastewater reclamation and reuse has been for nonpotable applications such as agricultural and landscape irrigation, industrial cooling, and in-building applications such as toilet flushing. While direct potable reuse of reclaimed municipal wastewater is, at present, limited to extreme situations, it has been argued that there should be a single water quality standard for potable water. If reclaimed water can meet this standard, it should be acceptable regardless of the source of water. While indirect potable reuse by groundwater recharge or surface water augmentation has gained support, some concerns still remain regarding trace organics, treatment and reuse reliability, and particularly, public acceptance. A cautious and judicious approach is warranted to avoid potential health consequences that could result if a water reuse project is not successful. In addition, the importantce of public confidence cannot be underestimated. The results of the studies reviewed in this paper provide strong evidence that reclaimed wastewater has the potential to serve as a viable source of water for potable water treatment. Continued research and development efforts as outlined above are necessary to provide a sound scientific basis for crossing the threshold to direct potable reuse, when necessary.

SUMMARY AND CONCLUSIONS

Water reclamation and reuse have evolved to the point where significant benefits for augmenting existing water supplies can be realized. Water reuse systems, in effect, mimic the natural water cycle through engineered processes. The inclusion of planned wastewater reclamation, recycling and reuse in water resource systems reflects increasing societal demands for water, technological advancement, public acceptance, and improved understanding of public health risks. As the link between wastewater, reclaimed water, and water reuse has become better defined, increasing smaller recycle loops are possible. The potential for implementation of long-term potable water reuse is a reality that is being seriously considered in several locations in the U.S.A.

This paper presented a review of several landmark studies that have provided a sound technical basis for the safe use of reclaimed wastewater for various beneficial uses. Emphasis, however, was on direct nonpotable reuse applications. The era of wide-spread wastewater reclamation, recycling and reuse started in the 1960s with appropriate wastewater treatment and reuse regulations. The recent trends in wastewater reuse are for direct reuse in the urban environment such as landscape irrigation, toilet flushing, industrial uses, recreational and ornamental impoundments. With tertiary and advanced wastewater treatment, groundwater recharge has been implemented. Indirect or direct potable water reuse has been intensively studied and a few projects have been implemented or are currently under development.

Through integrated water reuse planning, as discussed in this paper, the use of reclaimed water may provide sufficient flexibility to allow a water agency to satisfy short-term needs as well as to increase water supply reliability. With an increasing emphasis on the planning and implementation of wastewater reclamation and reuse facilities, needs for accurate cost data are essential. Thus, cost information was presented, although there are significant variations in wastewater reclamation and reuse costs. Notes of caution were presented for the cost comparison, however. While droughts often underscore the need for wastewater reclamation and reuse, water reuse is by no means a water resources management alternative for drought years only, but should be considered an integral and permanent part of water resources planning.

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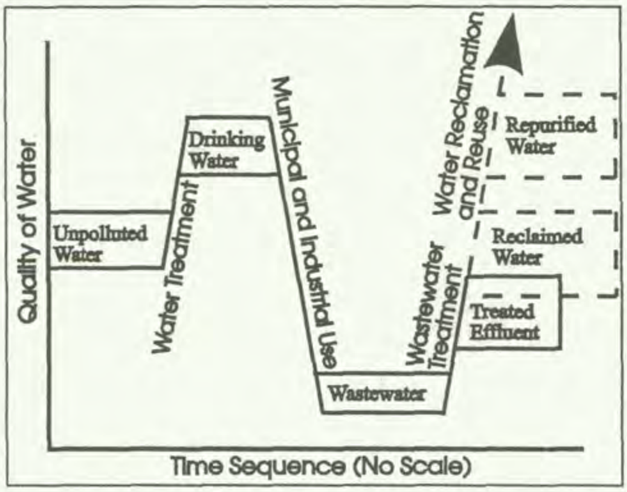

Fig. 1 Quality changes during municipal use of water and the concept of wastewater reclamation and reuse (Adapted from McGauhey, 1968).

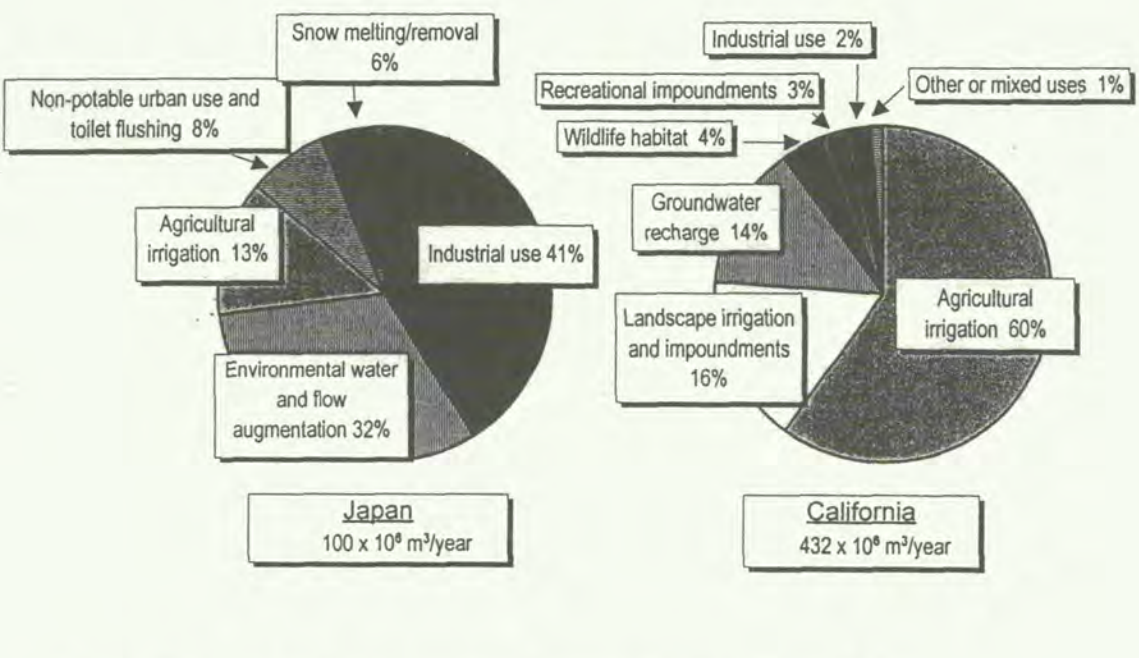

Fig. 2 Types and volume of wastewater reuse in California and Japan.

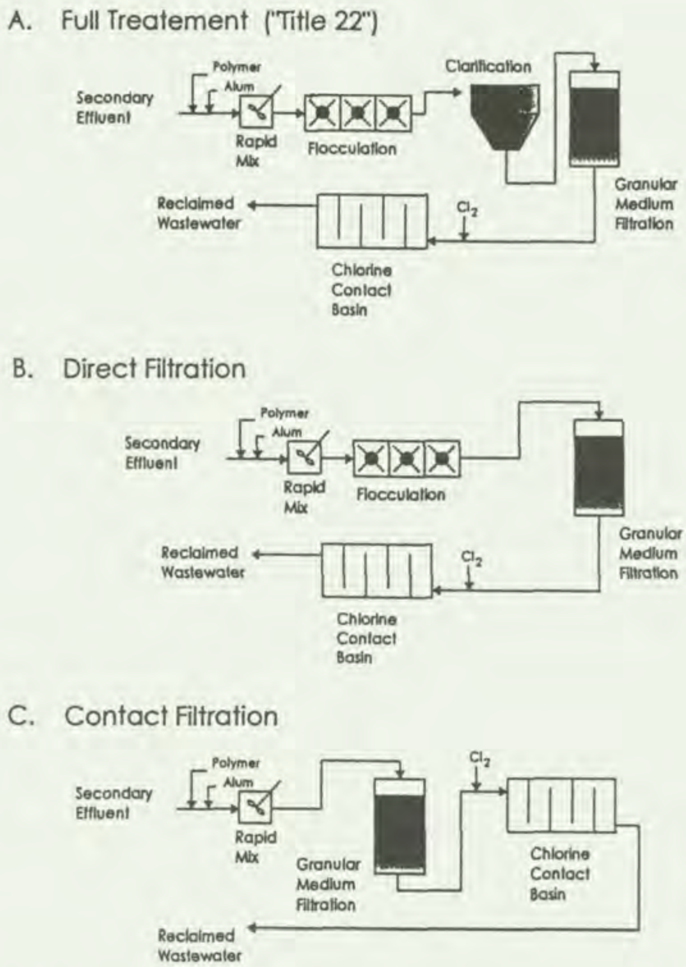

Fig. 3 Tertiary treatment processes used in wastewater reclamation and reuse.

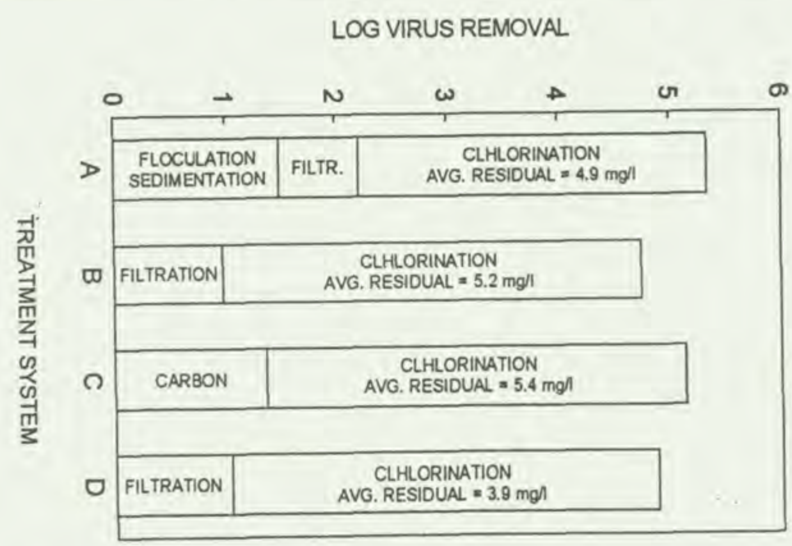

Figure 4 Results of poliovirus inactivation and removal in tertiary treatment processes (After Pomona Virus Study, 1977 and Dryden, *et al.*, 1979).

TABLE 1 Categories of Municipal Wastewater Reuse and Potential Constraints*

Wastewater reuse categories	Potential constraints
Agricultural irrigation: crop irrigation commercial nurseries	Effect of water quality, particularly, salts on soils and crops
Landscape irrigation: park school yard freeway median golf course cemetery greenbelt residential	Public health concerns related to pathogens (bacteria, viruses, and parasites) Surface and groundwater pollution if not properly managed Marketability of crops and public acceptance
Industrial reuse: cooling boiler feed process water heavy construction	Reclaimed wastewater constituents related to scaling, corrosion, biological growth, and fouling Public health concerns, particularly aerosol transmission of organics and pathogens in cooling water and pathogens in various process waters
Groundwater recharge: groundwater replenishment salt water intrusion subsidence control	Trace organics in reclaimed wastewater and their toxicological effects Total dissolved solids, metals, and pathogens in reclaimed wastewater
Recreational and environmental uses: lakes and ponds marsh enhancement streamflow augmentation fisheries snowmaking	Health concerns of bacteria and viruses Eutrophication due to nutrients Esthetics including odor

TABLE 1 Categories of Municipal Wastewater Reuse and Potential Constraints* (Cont.)

Wastewater reuse categories	Potential constraints
Nonpotable urban uses:	
fire protection air conditioning toilet flushing	Public health concerns about pathogen transmission by aerosols Effects of water quality on scaling, corrosion, biological growth, and fouling Potential cross-connections with potable water systems
Potable reuse (repurified water)	
blending in water supply pipe to pipe water supply	Trace organics in reclaimed wastewater and their long-term toxicological effects Esthetics and public acceptance Public health concerns on pathogen transmission including viruses

*Arranged in descending order of volume of use.

TABLE 2 Outline for Wastewater Reclamation and Reuse Facilities Plan

1. Study area characteristics: Geography, geology, climate, groundwater basins, surface waters, land use, population growth.

2. Water supply characteristics and facilities: Agency jurisdictions, sources and qualities of supply, description of major facilities, water use trends, future facilities needs, ground water management and problems, present and future freshwater costs, subsidies and customer prices.

3. Wastewater characteristics and facilities: Agency jurisdictions, description of major facilities, quantity and quality of treated effluent, seasonal and hourly flow and quality variations, future facilities needs, need for source control of constituents affecting reuse, description of existing reuse (users, quantities, contractual and pricing agreements).

4. Treatment requirements for discharge and reuse and other restrictions: Health and water quality related requirements, user-specific water quality requirements, use area controls.

5. Potential water reuse customers: Description of market analysis procedures, inventory of potential reclaimed water users and results of user survey.

6. Project alternative analysis: Capital and operation and maintenance costs, engineering feasibility, economic analyses, financial analyses, energy analysis, water quality impacts, public and market acceptance, water rights impacts, environmental and social impacts, comparison of alternatives and selection.

   a. Treatment alternatives
   b. Alternative markets: based on different levels of treatment and service areas
   c. Pipeline route alternatives
   d. Alternative reclaimed water storage locations and options
   e. Freshwater alternatives
   f. Water pollution control alternatives
   g. No project alternative

7. Recommended plan: Description of proposed facilities, preliminary design criteria, projected cost, list of potential users and commitments, quantity and variation of reclaimed water demand in relation to supply, reliability of supply and need for supplemental or back-up water supply,

implementation plan, operational plan.

TABLE 2 Outline for Wastewater Reclamation and Reuse Facilities Plan (Cont.)

8. Construction financing plan and revenue program: Sources and timing of funds for design and construction; pricing policy of reclaimed water; cost allocation between water supply benefits and pollution control purposes; projection of future reclaimed water use, freshwater prices, reclamation project costs, unit costs, unit prices, total revenue, subsidies; sunk costs and indebtedness; analysis of sensitivity to changed conditions.

*After Asano and Mills, 1990.

TABLE 3 Summary of the *California Wastewater Reclamation Criteria* (State of California, 1978)

Reclaimed wastewater applications	Primary effluent[a]	Secondary and disinfected	Secondary, coagulated, filtered[b] and disinfected	Median total coliform /100 mL
	Description of minimum wastewater characteristics			
Crop Irrigation:				
Fodder crops	X			NR[c]
Fiber	X			NR
Seed crops	X			NR
Produce eaten raw, surface irrigated		X		2.2
Produce eaten raw, spray irrigated			X	2.2[d]
Processed produce, spray irrigated		X		23[e]
Landscape Irrigation: golf courses, freeways			X	23
Landscape Irrigation: parks, playgrounds			X	2.2
Recreational Impoundments:				
No public contact			X	23
Boating & fishing only			X	2.2
Body contact (bathing)			X	2.2

[a]Effluent not containing more than 0.5 mL/L/hr of settleable solids. No primary effluent is used presently in California and this category is expected to be deleted in the future regulations.

[b]Effluent does not exceed an average of 2 turbidity units (NTU) and does not exceed 5 NTU more than 5 percent of the time during any 24-hr period.

[c]No requirement (see footnote [a] above).

[d]The median number of total coliform organisms in the effluent does not exceed 2.2/100 mL and the number of total coliform organisms does not exceed 23/100 mL in more than one sample within any 30-day period. This requirement is often erroneously referred to as the "Title 22 requirement" or the "Title 22 treatment process" (see explanation in text).

[e]The median number of total coliform organisms in the effluent does not exceed 23/100 mL in 7 consecutive days and does not exceed 240/100 mL in any two consecutive samples.

TABLE 4. Annual Risk of Contracting at least One Infection from Exposure to Reclaimed Wastewater at Two Different Enteric Virus Concentrations (Asano, *et. al*., 1992)

	Exposure Scenarios			
Virus	Landscape Irrigation for Golf Courses	Spray Irrigation for Food Crops	Unrestricted Recreational Impoundments	Groundwater Recharge
Maximum enteric virus concentration of 1.11 vu/L in chlorinated tertiary effluent				
Echovirus 12	1E-03	4E-06	7E-02	6E-08
Poliovirus 1	3E-05	2E-07	3E-03	5E-09
Poliovirus 3	3E-02	1E-04	8E-01	2E-08
Minimum enteric virus concentration of 0.01 vu/L in chlorinated tertiary effluent[a]				
Echovirus 12	9E-06	4E-08	7E-04	5E-10
Poliovirus 1	3E-07	1E-09	2E-05	5E-11
Poliovirus 3	2E-04	1E-06	2E-02	2E-10

[a] The limit of detection

TABLE 5 Comparison of Tertiary Treatment Costs for Water Reuse[a]

Data Source	Life Cycle Costs			
(Plant Flow)	Title 22		Direct	
Filtration	$/m^3$	$/af[b]	$/m^3$	$/af[b]
Pomona Virus Study[c] (3,785 m^3/d)	0.16	197	0.09	104
EPA Cost Estimation Method[d] (3,785 m^3/d)	0.23	284	0.15	182
City of Santa Barbara, CA[e]				
(5,262 m^3/d)[f]			0.21	259
(17,034 m^3/d)[g]			0.10	120
South Coast County Water District., CA[e] (2,915 m^3/d)[h]			0.42	512
(9,880 m^3/d)[i]			0.14	168
Irvine Ranch Water District (56,781 m^3/d)			0.09	104
Los Angeles County Sanitation Districts (Average of 4 treatment plants) (96,528 m^3/d)			0.03	41
Monterey Regional Water Pollution Control Agency[j] (113,562 m^3/d)	0.16	192	0.06	79

[a]Costs adjusted to March 1993, using the Engineering News-Record Construction Cost Index (ENR CCI) of 5,106 for 20 U.S. cities average. Reported costs include capital and O & M costs for tertiary processes only.
[B]One acre-foot = 1,234 m^3.
[c]Costs include design and contingencies.
[d]Costs include facilities planning,design, administrative and legal costs.

[e]Costs include design, administrative, legal, and contingencies costs.
[f]Cost for seasonal operation for landscape irrigation at 5,262 m^3/d average annual flow.
[g]Cost for continuous operation at the design capacity of 17,034 m^3/d.
[h]Cost for seasonal operation for landscape irrigation at 2,915 m^3/d.
[i]Cost for continuous operation at the design capacity of 9,880 m^3/d. [j]Cost estimates based on Engineering-Science report (1987) adjusted to October 1990 dollars.

Sustainable Water Management: Technology, Financing and Information Systems

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INTRODUCTION

Water quantity and quality issues continue to loom in importance globally. Increasing global populations face a future with a finite supply of water that will have to be divided between ever increasing numbers of people. These numbers and projections are not new yet they bear repeating. As we look at our water future and what we need to do to address the challenges facing us, we must keep in mind the framework within which we work. Our margins for error are increasingly getting smaller.

World population doubled between 1940 and 1990, from 2.3 billion to 5.3 billion people. At the same time per capita use of water doubled from approximately 400 to 800 cubic meters per person per year. The result is that water use increased which means even less water is fit for human use. There is not enough water for usage to increase globally at the same scale yet every year approximately 90 million people are added to the globe. It is obvious that if future generations are to have enough water, different ways of doing business need to occur.

There is, in fact, a substantial amount of room for us to management water resources in smarter, more sustainable ways. Some of these are simple, obvious solutions, others more complex. It is always tempting, and in fact necessary, to look for technological solutions complex. It is always tempting, and in fact necessary, to look for technological solutions to solve problems. Technology is part of the solution, but it needs to be examined within the framework of the entire issue. Knowing the factors necessary creating and maintaining sustainable water technology is of paramount importance.

There is a triangle of appropriate technology selection, financing and information exchange that needs to be future built upon if we are to ensure that good technologies are chose, unitized and maintained. These issues have been recognized at various United Nations conferences and both governments and civil society have recognized these needs.

The New Delhi Statement 1990 recognized one of the four guiding principles as sound financial practices, achieved through better management of existing assets, and widespread use if appropriate technologies. The Rio document, Chapter 18 on Freshwater Resources has a statement concerning the development and application of clean technology. It is urged that development of appropriate methods for water pollution control, take into account sound traditional and indigenous practices." The Beijing Conference and the Istanbul Conference in 1996 also discussed mobilizing financial resources as a critical factor to effective water resources management.

The principles of both the Delft symposium in 1991, A Strategy for Water Sector Capacity Building, as well as the Dublin International Conference on Water and Environment held in 1992 articulate the basic tenets on which this paper is based. The Delft symposium stressed capability building and stated that it consists of three elements: creating and enabling environment with appropriate policy and legal framework (with attention for the economic value of water), institutional development, including community participation and human resources development.

The Dublin meeting recognized four principles: Fresh water is dealing and vulnerable resources, essential to sustain life development and the environment; water development and management should be based on a participatory approach, involving users, planners and safeguarding of water; and water has an economic value in all its competing uses and should be recognized as an economic good.

It is upon these principles and form our experiences in dealing with technology that this paper is written. There are certainly

other ways to look at technology selection and in order to promote different views of technology selection, one of the these designed by the IRC International Water and Sanitation Centre in The Hague is presented as an annex.

It is the role of UNDP to serve the poor through sustainable human development. To do this properly, we feel technology issues must be addressed. This involves an entire spectrum of customers and providers providing various degrees of technological sophistication depending upon the particular circumstances.

PRINCIPALES OF WATER TECHNOLOGY SELECTION

Looking at technology by itself, as the solution, is inviting the future to repeat the past.

Numerous examples exist of solid appropriate technology that did not work for one reason or author. Learning lessons from the past will hopefully guide the selection of technology. What follows is one approach to sustainable selection of water technology.

The table is broken into five separate factors: human, mechanical, financial, environmental and information. A discussion of each of the inputs follow.

Human Factors

Human factors are the most complex but it order to choose the most appropriate technology certain guidelines are consistently necessary. Certainly one of these is understanding and contact with the local community. The need to understand the developed world without much through as to what the local community desires and can maintain.

Sustainable Selection of Water Technology

Factors	Inputs
Human	Local`community contact, input and expectations Gender inclusion Addressing instituuional weaknesses and malfunctioning Inclusion of the household
Mechanical	Skilled local technical operators for operations and maintenance Ability to replace parts Openness to both high and low tech solutions Contractor ability to install technology
Financial	Access to credit Examination of possible hidden costs Considering all methods of cost recovery selection of sustainable affordablke energy Having enough revenue to cover operations and maintenance
Environmental	Inclusion of demand management Ability to meet environmental rules or regulations Available and renewable water and energy sources Quality of waste generation and disposal options Reuse of effluent Land requirements Meeting instream flow requirements
Information	Forecasting future needs South to south contact Improving information systems

The issue of gender inclusion was poignantly brought home when a recent discussion with women living in a refugee camp let one of the women to comment. She stated that when a simple sanitation technology was selected no one ever talked top them concerning location of the facilities. The latrines were avoided at night because their were sited in a dark remote area. Consequently money was spent on technology that was only used during daylight hours although the need was for around the clock facilities.

For a technology to work institutional weaknesses and malfunctioning must be addressed. Putting a good technology into an area where it cannot be sustained is an experience many of us have seen. Institutional capacity at all levels need to be more demand responsive and allow better overall management of water resources. Policies, rules, organizations and management skills need to have higher priority.

Inclusion of the household as a unit is also key. In many cases sanitation systems are dependent upon the household for maintenance of individual systems. Including them in discussions and education is necessary if they are to understand how and why they need to maintain the technology.

Mechanical Factors

Skilled local operators to operate and maintain systems are necessary for without this the best technology cannot work. Yet this is one of the more difficult challenges facing us since education and training continuously needs to be updated and needs to be more holistic than ever before.

Ability to replace parts is a legendary issue, even in the developed world. The best irrigation system or water treatment plant that cannot replace worn or defective parts is handicapped t best and possibly worthless in the long run.

Assuming that the newest high tech advance is the right one for all or concomitantly that only low tech solutions should be utilized is not uncommon to hear. Many communities state that they want the newest high tech system and nothing less because they do not want a second rate system. Developing objective criteria and questions to be asked are of utmost importance if we are not to fall into the false assumption that either low tech or high tech is always best.

The reputation of the contractor installing the technology as well as investigation into the past work minimize surprises. Their ability to understand installation of the technology of choice helps to minimize installation difficulties. The best technology inadequately installed will not only cause problems locally but it can give an otherwise solid technology and undeserved reputation that could keep others from utilizing it.

Financial Factors

Access to credit is certainly difficult in the developing world and future discussion of this topic follows this section. Where coverage is most needed in the developing world is frequently the areas where governments have traditionally been the providers. In many cases governments have not been able or willing to supply the necessary financing. This leaves many of the poorest, who are willing to pay, without access to credit so systems can be built.

Hidden cots frequently, if not always, are present. Being aware of hidden costs means disseminating information so lessons of other experiences can be used and mistakes do not have to be repeated. Privatization of utilities can result in low costs initially offered. If there is not built in long term cost containment, costs could rise dramatically after the first few years. The life expectancy and quality of equipment purchased is also a key cost that should be considered at the outset. The financing terms themselves need to be clearly understand so that the costs if and appealing long term loan or bond is placed in the context of who will pay the costs and will this cost still be incurred after the life of the equipment or technology is over. Customs fees on incoming equipment can significantly increase the project cost and should be investigated at an early stage of analysis.

Considering al methods of cost recovery needs to be included. There are still too many examples of facilities installed without adequate methods to collect money for the water received. Without the necessary revenue stream, operations and maintenance become an overwhelming task.

Affordable energy is a significant factor in water costs yet this usually has not been given high consideration. As the price if energy and water continue to climb this has to become a larger consideration. Desalination is the classic case where energy requirements are presently huge. For this technology to be utilized more widely, it will have to involve significant reduction of energy needs.

Operations and maintenance cannot be neglected when financial costs are calculated. There costs need to be sure to include ongoing training for operators, not only equipment upkeep. Financing and charging for water that allows for upkeep and maintenance needs to be well thought out. The users ability and willingness to pay is a driving factor in technology selection and success.

Environmental Factors

Meeting environmental requirements, regulations or laws is a relatively new significant consideration for some. Current requirements, regulations and laws need to be analyzed as well as a forecasting of foreseeable upcoming trends that could impact the technology.

Inclusion of demand management should be a mandatory part if planning. Increasing cots of water lessening quantities available on a per capita level, and the need to produce needed has to be one of the keys to selection.

Available and renewable water and energy sources need to be examined with an emphasis on the renewable aspect. Not using more than can be renewed is key I future generations are to have resources. In some cases mining water without consideration of renewable capacity can result in the source totally disappearing as is the case of some aquifers where the fissures can actually compact, eliminating the pores and spaces that held the water.

Waste generation quantity, composition and disposal need examination. Local or regional disposal facilities need to be analyzed. Acceptability of receiving waste in the community where facilities are located needs to be examined if waste removal or reuse is to proceed as planned. Ultimately the total cost of treating waste will need to be considered. The types and quantities of sledges or biomass that will be produced is particularly important.

Reuse of effluent has to become part of normal technology consideration. We can no longer afford to not care about the effluent that is produced from a treatment pat or from a irrigation field. As the amount of land available for crop production shrinks, we need to look ever more at where the used water is going and if it is enriching or destroying valuable cropland and fisheries.

Land requirements deserve more attention than it has received in the past. Growing populations can expand cities and peri-urban areas in directions that were not originally considered. Some technologies need and require far more land than others. Land use analyzed in the context of food security needs.

Instream flow requirements mean making a conscious decision about the best use of available renewable water which is key to any sustainable development. Where surface water flows are affected, questions concerning impact on fisheries, a significant food source for many, needs to be taken into account. Other factors to be examined are impact on recharge, and protection of habitat used for flood protection.

Forecasting and Information Exchange

Future needs present one of the more difficult tasks for water resource professionals which is forecasting. While population increases can be predicated on a global basis, factors are much harder, if not in some cases impossible, to predict. That still does not remove the responsibility to attempt building at least an interim needs assessment. Building for today's needs only will result in an inadequately sized technology solution at a very early stage.

South to south information flow is critical if relevant experiences and lessons are to be exchanged . there is, of course, no one "right" technology for any given situation. But frequently the ones that reach the developing world originate in the developed world. Including more indigenous solutions that have worked and assisting with the dissemination of this information would allow us to look at all possibilities and maximize appropriate choices.

Information systems can provide the possibilities in a manageable manner if done correctly. The sheer number of technologies, both existing and still emerging, cries out for information systems that can handle dissemination of this information. Presently the sources information are scattered and not readily accessible. UNEP has taken steps to identify these through a survey of information systems related to environmentally sound technology. WHO and others are also working on a global environmental technology network. Coordination will be a key factor.

FINANCING THE FUTURE

Meeting the needs of tomorrow requires financing. Having enough water of good quality to ensure food security, protection of public health and economic development means financial resources in the billions of dollars are needed. Yet within the context of money available for development assistance, the outlook for public sector financing is not positive.

Private sector funding and management is increasingly sought and used for large-scale investments in urban areas serving the better-off consumers. Since funding for the urban and rural poor has traditionally been the domain of public sector grant funding, including subsidies - and therefore stagnant at best - new approaches need to be explored to attract private sector finance. Full self-financing by poor communities need to evolve over time. Indeed, communities may be able to progressively generate cash flows to meet all costs of a project, including the cost of debt incurred.

This means one area of focus will need to be increasing the numbers of people, organizations and groups that can gain access to credit. A 1995 UNICEF/USAID study showed that communities are willing to shoulder portions of investment costs and to pay for full operations and maintenance.

Communities would pay for these costs from savings realized through or caused by the new water supply system and from improved income generating opportunities. Some examples follow.

In urban areas with large water supply systems, poor people have limited or no access to the municipal piped water system. They buy water retail. The premium they pay for their vendor-bought water could be saved, and instead be applied to the construction. Operation and maintenance of a water distribution system. The community would be able to generate a cash flow.

In rural areas women spend as much as five hours a day to fetch water. It is obvious that by bringing water close to their residences, much time would then be available that could be used for income generating activities among other things. It should also have health benefits. This should in turn increase overall productivity, with positive effects on the water supply system cannot be raised in full by the community, the shortfall could be financed by grants or loans.

Thus, what is saved on high vendor prices, and gained in productivity, can be applied towards the costs of capital, operation and maintenance. And with the emphasis placed on sustainability, open of the most important criteria for measuring capacity building success would be the extent to which activities in the water sector are sustained locally, recognizing that this implies the acceptance of an appropriate degree of cost sharing.

Drawing on experience from both inside and outside the water sector, one promising approach is to attract loans from banks for community water supply or small scale irrigation projects, the repayment of which is guaranteed by a loan guarantee fund. The success of this approach hinges on a number of factors including community organization and management, an enabling policy, legal and regulatory environment, choice of appropriate technology, and support of an intermediary (a government agency or a nongovernmental organization). The intermediary is instrumental in supporting the community in getting organized, developing the ability to apply for a loan, bookkeeping, choice of technology, contracting, operation and maintenance, the collection of water charges and the repayment of the loan.

On using the above funding mechanisms for financing water supply and sanitation services for the poorest strata, an essential part of the investment for the infrastructure would have to include income generating facilities, such as small scale irrigation projects. This would allow even the poorest to create financing sustainability and thus allow the community to generate the essential collateral needed to loans or credit.

Other interesting approaches need to be explored as well. Enabling legislation which would allow bonds to be sold on the local level have been widely used for years in some countries. This allows for responsible borrowing with strict accountability for needed projects. Other possibilities include the possible use of joining together in cooperatives in suggested that areas such as increasing small business development assistance, environmental trading of pollution rights, the use of economic incentives, effects of pollution taxation, and economic advantages of regulatory compliance are all modalities that could be further explored.

LESSONS LEARNED

In making choices for technology, the lessons and research of others needs to be better disseminated. There are examples of well working, low-cost technologies in the industrialized countries that are not widely disseminated in the developing world, e.g. rainwater harvesting and water storage techniques. Inflatable tasks are successful in a number of countries and can be made operational in developing countries requiring only marginal adaptation.

Wastewater reuse for agriculture needs to be encouraged but to do this requires a more thorough examination of alternative sewer systems so the effluent that the farmer receives is beneficial and cost effective for the types of crops being produced. Since the piping system itself can cost up to 80% of the total sanitation project, ways to cut these costs through use of small diameter pipes is significant. Also important is the concept of the condominial sewerage systems which eliminates the need for numerous manholes, another expensive project cost.

Due to the vast number of small farmers in the developing world, appropriate irrigation systems that fit their needs are significant. Promising technologies are improved surface hose basin irrigation. The last two have been successfully utilized in Cyprus. Micro-irrigation (localized irrigation) need to be more fully explored. The Bas-Rhone system developed by the French in 1969 work well for tree crops. Yemen successfully used bubbler irrigation systems which have a longer life expectancy than above ground systems. Another model to be further explored is modular drip systems.

On water quality surveys, portable kits have been developed for emergency situations. With certain adaptation, these kits could be made feasible for use in developing countries. Additionally, it was agreed that traditional technologies for water treatment deserve more attention.

The United Nations Development Programme faces many challenges in promoting sustainable development. These are less funds available, the scope of the work has broadened significantly, and there are growing numbers of people that need assistance. There is general acknowledgment that "one size does not fit all". Therefore, it has been important that different models or approaches are tries and documented. A few examples of these approaches follow.

The Bolivia Experience

Bolivia has long built water and sanitation systems in rural areas. Traditionally project planners have exclusively focused on their technical merits, with little consideration given to economic efficiency or sustainability of services. The basic premise underlying these projects has been that economic demand for water services is too low for the rural population to be willing to pay for the services provided. Projects have therefore been primarily supply side driven with the community needs being decided by a central government agency.

The Yacupaj project was initiated as a pilot project in 1991 and implemented in four provinces over a three year period at a cots of US $2.8 million financed mainly by the Government of the Netherlands. Its objective was to design and test implementation strategies for delivering services to the dispersed rural population of the Altiplano and to use these lessons to prepare a national project.

The project operated in more than 520 communities, training rural teachers, health workers, masons and water system operators. The project installed water systems, handpumps, and sanitation facilities that provided 31,000 people with water services and 30,000 with sanitation services.

The project built upon experiences in the numerous countries in which the UNDP-World Bank Water and Sanitation Program was active and introduced innovative approaches to sector development. They included building on the following principles:

- Community responsibility and participation at all stages of project planing. Construction, and operations and maintenance was considered essential to its sustainability as was the involvement of women at every stage.
- Low cost technologies should be promoted to make facilities affordable to low income communities.
- Cost recovery mechanisms that are realistically geared to family incomes should be used to ensure sustainability of the services.
- Water supply and sanitation services should be linked with health, hygiene, environmental education, and income-generating activities.
- Planning and implementation should be executed by local and national people to the greatest extent possible.
- Nongovernmental organizations and the private sector are able to implement rural water and sanitation projects effectively and efficiency, but local capacity does need to be strengthened.
- A wide range of technologies and adequate financial policies are essential to project success.
- Training in operation and maintenance and sanitary education are crucial project components, and operations and maintenance are highly dependent upon project design and implementation.

The Yacupaj project also introduced an adaptive approach and encouraged stakeholders to develop project rules and processes. These approach was then taken to the next step, eliminating what had been an unworkable top down approach.

The Kumasi Strategic Sanitation Project in Ghana

Kumasi is the second largest city in Ghana and is a major center for a wide range of services and activities. The current population is approximately one and one half million people made up of permanent and transient residents. Congestion and an overstrained physical infrastructure has been a serious problem. The city government opted for a prohibitive and alternative were sought.

In 1989 the UNDP-World Bank Program in partnership with the Regional West African office initiated and prepared a strategic sanitation plan that included an examination of widening and unbundling technological options and institutional reform. Based on the results of surveying the population, the range of technically feasible sanitation technologies was identified and divided into three levels: in house sanitation infrastructure, feeder sanitation infrastructure and trunk sanitation infrastructure.

In this case privatization of service delivery became key. While the government conducts policy, planning contract management, formulation and enforcement of standards and regulations, the private sector provided operation and maintenance of public latrines, installation of in house sanitation infrastructure, installation of simplified sewerage and waste stabilization ponds, operations and maintenance of all feeder sanitation infrastructure and septic tank emptying services.

Involving the private sector in a competitive way in operations and maintenance of installed facilities were conducive to investments. It also brought out a number of skilled contractors that no one knew existed.

A major lesson of this project is that you do not need to limit technology selection to one, nor do you need to assume that it should be managed by government. Providing private sector employment opportunities maintained revenue and brought together the positive combination of an enhanced environment and an improved economy.

The Palestinian Experience

The UNDP office in Jerusalem is a partner in promoting peace and sustainability in the Middle East. With the U.S. Government as the main sponsor, technical experts from the region identified the need to increase sanitation treatment in villages where treated effluent can be used for agriculture. This was done after numerous consultations with their communities. A low cost, low tech solution was identifies that utilizes a small bore sewerage system with an intermittent sand filter. This will be used to convey treated effluent to local farmers.

All members of the community have been involved with this project. Community meetings have taken place as well as scheduling individual meetings with women. This is being done to ensure that all voices will be heard. It is frequently difficult for women to ask questions other women in their homes, that hygiene practices can be discussed as well as the required maintenance of the system, albeit low. Educational materials have been given to schools and teachers in order to increase the environmental educational focus.

There have been numerous health problems in the area from using raw effluent to grow vegetables. It is hoped that by producing a safe effluent, more water which is safe to use the village will generally be assisted by supplying a sanitation system. And finally, it is viewed of utmost importance to protect the aquifer so that future generations will be allowed to still be able to draw from it.

CONCLUSIONS AND RECOMMENDATIONS

We are entering into a new era of water resource management. Never have so many factors needed to be taken into consideration. We have solid experience from the International Water Supply and Sanitation Decade (1981-1990) to know what works and what needs improvement. Inclusion, sustainable approaches, appropriate technology, information exchange and innovative financing are high on the agenda of needs.

While sharing experience is a need that few would dispute, the ways do so need work.

The overwhelming conclusion of even the casual observer is the proliferation of information on water technology but the lack of coordinated or uniform access. Information systens that can rate technologies and how they have been received in the communities where they have been placed is a major contribution that several agencies are attempting. The growth of the Internet has led to both promise and frequently. Information is scattered, access is slow for those lucky enough to have access and the data are frequently superficial and not verifiable.

Innovative financing networks and experiences also need to share experiences. One data base that could be built upon is the Environmental Financing Information Network (EFIN) which was run by the U.S. Protection Agency. EFIN services include an online database, hotline, the maintenance of the World Wide Web site and distribution of publications pertaining to financing. In addition to innovative approaches to financing in the United States, approaches for Central American and Eastern Europe are also documented.

A major step would be to build upon and publicize information clearinghouses, whether they be on technology or financing. For those of us involved in the challenging job of guiding the future of water resources, access to good information has become increasingly critical and complex. Keeping up with challenges, knowing what technologies and techniques work, as well as innovative ways to finance projects and who to contact on these issues are the future challenges, knowing what technologies and techniques work, as well as innovative ways to finance projects and who to contact on these issues are the future challenges we face today.

For water professionals and the public to substantively benefit from the work done by others, information specialists need to be increasingly brought in as partners. Information specialists need to look at existing database systems on technology and finance to advise relatively small amount of money could yield great benefits to all.

Because of the increasing demands of global water use, our challenges remain large. By developing appropriate technology, looking at new ways to finance and effectively exchanging information, these challenging can be met.

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Annex

IRC, (the Hague, Netherlands)

Table 1: Choosing an appropriate water supply system

QUESTIONS	CONSIDERATIONS
1. INITIAL SERVICE LEVEL ASSUMPTION	- improved traditional source
What service level is reasonably expected?	- handpumps
	- public standpoints
	- neighbourhood taps
	- yard taps
	- house connections
2. WATER SOURCES	- springs
Which reliable water source is available?	- groundwater
Can this provide the required amount of water?	- rainwater
	- surface water
	- streams
	- lakes, ponds
3. ENERGY SOURCES	- gravity flow
What reliable energy source is available?	- electricity
	- diesel supply
	- wind
	- solar energy
	- biomass
	- human power
4. WASTE WATER DRAINAGE	- soakaways
In which way can waste water be disposed	- gardens
hygienically?	- sewers
	- drains
5. TECHNICAL RESOURCES	- skills/technical advice:
What skills and materials can be made	diesel/electro mechanics, pump mechanics,
available to sustain the desired service level?	plumbers, carpenters, masons, caretakers

- materials: pipes, pumps, taps, valves, fuels, stores, chemicals, spare parts

6. ORGANIZATION

What is the most appropriate organizational structure to sustain desired service level?

- village organization
- water committee
- water supply agency
- extension service
- power utility
- training opportunities

7. CAPITAL RESOURCES

What are the financial resources available for the desired level of service?

- users's funds
- government subsidies
- ESA support

8. RECURRENT RESOURCES

What kind of payment system is most appropriate for the users's ability to pay?

- fund raising
- communal income
- regular contributions
- water vending
- contribution in kind

9. APPROPRIATE LEVEL(S) OF SERVICE

Is/are the level(s) of service chosen appropriate for all segments of the community?

- acceptability of different levels of service
- social justice
- rates tailored to users' ability and willingness to pay

10. SELECTION OF APPROPRIATE SERVICE LEVEL(S)

Community Water Supplies in Developing Countries

G. Whiteside.
WaterAid
Country Representative to Nepal

INTRODUCTION

The Global Water Crisis is not a new phenomenon. For over 1000 million of the world's population it is an ongoing reality. Long journey times to collect water of poor quality combine with low levels of knowledge on hygiene to have a tremendously debilitating effect on community health and the overall quality of life.

But it is a silent crisis that rarely catches the attention of the world's media. Its consequences, after all, are most usually hidden from public view - the death of an infant at home, the routine under performance of a child; regular bouts of sickness and restricted opportunities throughout an entire lifetime.

The present population of the world stands at around 5.6 billion. By 2050 it is estimated to reach 10 billion with most of the increase taking place in the poor countries of the South. The demand for water resources will place enormous strains on governments, who already struggle to provide basic services, and will make it essential that rural communities play an increasing role in the management of their own supplies.

The concept of community managed water supplies was conceived and developed during the International Drinking Water and Sanitation Decade of the 1980s. The key working guideline adopted was:

> "Maximum participation by those who will benefit from the new system is central to the approach. Members of local communities will be involved in all aspects of water/sanitation - from planning and financing, to training, operation and maintenance."(UNDP,1980)[i]

Self reliance has long been an inherent strength of rural communities, particularly in relation to agriculture and the management of local natural resources. These traditions could, so the argument went, be built on so that communities directed their energies towards the construction and management of water supplies. If fully involved, they would feel a strong sense of ownership and an all important commitment to the long term maintenance of projects.

Successful projects could also, as Pacey (1977)[ii] pointed out, serve as "catalysts for social development" by imbuing communities with the skills and confidence necessary to tackle other development tasks.

It was a grand vision but a risky one. Without a full commitment to the process of empowering communities, water supplies would almost certainly be poorly maintained and have short operational lifespans.

WATER AID

At the beginning of the 1980's a number of senior figures in the U.K. water industry got together to found a non-governmental organisation called WaterAid with the specific goal of supporting community water supplies and sanitation in developing countries. It adopted the community management model and has, for the past 15 years been at the forefront of field experience in this area. WaterAid currently has full time representation in 12 countries in Africa and Asia and directly funds projects in two others. In 1995 it was awarded the Stockholm water prize for its work in the sector.

So what then are the major lessons learned in that time? My personal view is that the following six themes have a critical bearing on the outcome of projects and need to be considered:

- technology
- culture and society
- partnerships
- participation
- integrating water, sanitation and hygiene inputs, and
- training

TECHNOLOGY

Investment in water and sanitation in developing countries during the 1980s was estimated to be around $13 billion per annum with the greater portion of this total being spent on technologies. These ranged from sophisticated water supply and sewerage treatment plants to simple suction handpumps and pit latrines.

In terms of reported coverage the decade was moderately successful. From a project sustainability and community development perspective there remain considerable doubts about its overall effectiveness

I think it would be true to say that many governments, and some donor agencies saw the problem principally in terms of <u>technology</u> and <u>coverage</u> as they battled to meet overly ambitious targets. This was perhaps understandable given the urgency of the task at hand but to view development in terms of mere access to technology is historically one of the great failings of aid programmes. As E. F. Schumacher (1974)[iii], the father of the concept of "Appropriate Technology" noted at early as 1961:

> "industrial estates can be found in almost every developing country where high-grade modern equipment is standing idle because of lack of organisation, finance, raw material, supplies, transport, marketing facilities and... a lot of scarce capital resources - normally paid from scarce foreign exchange - are virtually wasted.

In Nepal I am personally aware of a foreign built sewage treatment plant which remains unconnected to the mains sewer several years after its completion all for the want of a short section of sewage main which is not available locally.

The reasons for failings such as these most usually derive from two sources. These are a desire on the part of donors to use aid as a means of boosting domestic exports markets and the tendency of both donors and implementors to underestimate the importance of cultural, social and economic conditions, as these relate to technology, in the recipient country.

This last point was made more succinctly by Smilley (1991)[iv]:

> "The cultural, historical and organisational context in which technology is developed and applied is always a factor in its success or failure", and:
>
> "The 'transfer' (of technology) will almost always involve modification ...and....in adapting technology to local needs and conditions, local skills must be available. There must be a supply of 'dirty fingernail people', thinking people who have an intimate knowledge of the material with which they are working."

The emergence of the concept of Appropriate Technology in the 1970s was an attempt to develop technologies which built on traditional skills and practices or for which a group of "dirty fingernail people" could be readily trained up. The test of whether a technology was appropriate or not was defined chiefly by the ability of local people to operate and maintain it. Such a definition holds true for community water supplies, but it is a deceptively straightforward statement which belies the complexities involved. Broadly speaking, projects succeed or fail on the basis of:

- the choice and affordability of technology,
- the availability and affordability of spare parts in local markets,
- community ownership of the process of implementation
- community ownership of the completed scheme and a willingness to meet its recurrent costs
- the training and confidence building of villagers
- follow up support for maintenance.

Only the first, and to a lesser extent the second, of these relates directly to technology but there have been some notable successes here - particularly in relation to the development of low cost "village level operation and maintenance" (VLOM) handpumps and improved household latrines such as the pour flush and ventilated improved pit types. Each was developed and field tested in the South bearing in mind local skills, levels of income and cultural conditions.

Less clear cut has been the progress made in empowering, training and supporting communities. Some of the reasons for this are dealt with in the following sections.

CULTURE AND SOCEITY

Patterns of development assistance in community water supplies usually involve three main players. These are the community, the implementing agency, which may be government though is increasingly non-governmental (NGOs), and external donors and creditors. Each has a distinctive set of cultural and social values which broadly inform its approach to project work, and the misunderstanding and undervalueing of which are a common cause of dispute and poor project work. Below are a few examples to illustrate this point.

In many countries of the South, individual relationships between people are seen as more important than organisational performance and efficiency. This is particularly true of government departments which, while extremely hierarchical, tend to value links to seniors, personal status, maintenance of the status quo, and access to resources as high priority objectives.
This has some fairly predictable consequences for community projects which require an alternative culture in which government workers transfer authority and resources to communities and generally empower their "lowers".

In trying to solve this problem, many donors, who tend to value efficiency above relationships, have recommended changes in the structure of government and in particular de-centralisation involving the creation of new posts at the local level. This proposal, while usually adopted by implementors, has often be "hi-jacked" by the prevailing institutional culture such that the new positions do not serve their intended purpose but are used as "exile or punishment postings" for workers who fail to conform to the prevailing social and cultural norms of the institution.

A further example, this time highlighting how the culture of donors can adversely affect project work, relates to the way in which expatriate development workers are deployed. Expatriates tend to be on relatively short term contracts of two to three years, are based in urban centres and can pay only brief and hurried visits to the field. Their own institutional culture, being a northern one, is impatient, and so there is considerable pressure for action and results. Because donors control resources and come from sophisticated, well educated, societies there also tends also to be a strong culture of paternalism.

A combination of all these factors can lead to prematurely conceived master plans, which implementors can rarely afford to turn down, and, perhaps worst of all, a degree of self delusion about the real impact one's assistance is having, even, in some cases, the creation of self-sustaining myths (Chambers, 1983)[v].

There are also, I'm afraid, a number of questions to be asked about the personal culture of many working in the Aid business. Where lucrative contracts and lordly lifestyles are the key motivating factors it is unlikely that aid workers will have the degree of sensitivity and humility necessary to work effectively with underpaid local civil servants and even poorer rural communities.

Many of the problems associated with differing cultural and social values could be reduced if all parties, and particularly donors and implementors, were to adopt new voluntary codes of conduct which would regulate the use of aid assistance. This would which place considerable emphasis on agreed common goals, the fiscal propriety of implementors, the avoidance of family first mentalities, the adoption of non-hierarchical ways of working and on appropriate attitudes and behaviours of professional development workers.

PARTNARSHIP(Not Paternalism)

Any such code of conduct would also, most surely, feature partnership as a central theme - partnerships between both donors and implementors and between implementors and communities. Here partnership is defined as being where each party contributes its skills and resources to meet a common goal and where learning from each other is an implicit part of the process (as Will Rogers poignantly noted "Everyone is ignorant, only on different subjects"). This approach should replace top-down styles of paternalism and serve as a model for other development activities.

Partnership has long been one of WaterAid's main areas of interest. Indeed, historically, it has directed all of its overseas' assistance through local partners rather than implement projects directly itself, and has seen institutional strengthening of partners as a key goal.

More traditional arrangements between donors and implementors have tended to fall well short of this and normally been regulated by official agreements and contracts which, while indispensable for certain functions, are usually mechanistic, self limiting and contain little to inspire the grand vision of the task at hand. In the development world they also tend to be one sided; the party with most resources defining the terms. This is as true between implementors and communities as it is between donors and implementors.

Partnerships require significant shifts in priorities and authority to the point where both parties acknowledge the importance of the task at hand, subsume personal self-interest and thereby create an environment in which those most affected by inadequate water supplies can have the greatest say in project design and implementation. This also requires that partners share similar rewards for success and penalties for failure.

This is by no means an easy task, but it is not impossible. Donors can take a lead firstly by choosing the most suitable partners to work with in a country and then offering a package of assistance which will help strengthen the partner, aside from any support for community projects. In building the <u>capacity</u> of implementing partners it becomes more likely that good practices can be replicated and funds spent effectively. Specific areas for support might include:

- advice on management systems
- advice on financial control
- allocating significant sums for human resource development
- assisting in fundraising from other donors.

An appropriate series of guidelines for donors involved in this work might include:

- Respect the policies and capabilities of the implementor
- Build on existing strengths rather than seek to correct all weaknesses
- Perceive the fate of the partner to be one's own
- Resist pressure to disburse funds and rush the job
- Be willing to transfer authority and resources
- Focus on institutional strengthening
- Provide flexible funding to include overheads

- Share the same working environment
- Promote the partner, not the donor

PARTICIPATION(Especially of Women)

Effective partnerships between implementors and communities are of even greater importance if projects are to prove sustainable. As noted above, sustainability depends crucially on a community's willingness to take responsibility for the operation and maintenance of schemes which depends, in turn, on the extent to which the community participated during the stages of planning and implementation.

According to Marsden and Oakley (1984)[vi], the key concepts that describe the process of community participation are:

- Project work is a continuous process and therefore it is difficult to establish fixed quantifiable parameters
- The approach is a bottom up one
- The main principle involved is that of self reliance
- Project activities are controlled by community groups
- It is important for groups to act collectively in tackling problems that emerge

Most implementing agencies do claim to promote participation but this is usually of a narrowly defined type such as the provision of free labour for construction. NGOs tend, by their very nature, to be better suited to encouraging participation than does government, and have had a major influence in its thinking and practice (Oakley, 1995)[vii]. Where the process has been facilitated well then community control over project activities has become a realistic goal.

The greatest advances in techniques to encourage participation have occurred since the mid-'80s, most notably through the widespread adoption of Participatory Rural Appraisal (PRA) methods. These involve communities describing their own situations, needs and aspirations through a series of methods such as mapping, modeling, matrix ranking, seasonal calendars, cause and linkage diagrams.

Initially it was thought that these methods were, of themselves, sufficient to facilitate meaningful participation. Later on it became clear that the behaviour and attitudes of outsiders facilitating the process mattered more. Or to quote Chambers (1994)[viii]:

> "A watershed was a PRA training in Karnataka where a participatory planning session was monitored, finding that villagers spoke for only 11 out of 45 minutes and that they were interrupted 45 times."

Clearly implementors need guidelines on their role in their partnership with communities. An appropriate list might include (op.cit.):

- respecting, listening to, learning from villagers
- learning to give up power and authority
- living and sleeping in the village
- sharing food
- taking the role of the novice
- being taught village tasks

Of all the notable successes of PRA techniques it is perhaps their ability to elicit the views of those who would not normally speak up in public that is their most valuable feature. The most significant of these groups is women who as the main collectors, transporters, storers and users of water should be most involved in the design and management of schemes. It is WaterAid's experience that, when given the chance, women generally make more conscientious members of management committees than do men and that, because they suffer directly when facilities break down, they are more apt to appreciate the benefits of projects and to maintain facilities.

INTEGRATED PARTNAR

There is, by now, sufficient evidence to show that projects which integrate water supplies, sanitation and hygiene education can have a far greater impact on health and quality of life than each taken independently (Cairncross, 1989)[ix]. For this reason I hope it is clear that integrated projects represent the most cost effective means of involvement in the sector.

The major challenge therefore is not to accept the principle of integrated projects but to learn how best to integrate. It is a task which requires a broad knowledge of the issues relating to each component, considerable flexibility and patience, plus a thorough understanding of the local cultural context. In particular it requires that development specialists, whether they be engineers, health workers, or whatever, de-professionalise and embrace a more holistic, community centred approach. This is not to say that professional skills become unnecessary, rather that they take second place to the overriding need to maximise benefits.

Of course there is no point in promoting integrated projects if communities do not want them. And indeed while communities nearly always see water as an urgent need, they rarely give a high priority to health and sanitation - at least initially. This problem is nearly always solvable provided implementing staff take the time at the outset to explain the benefits that can result from improved knowledge on hygiene and sanitation and the relatively small investment in time and energy required to achieve these benefits. The task is also made easier by the very high levels of disease that exist in most rural communities in the South and by the high value placed on education generally.

It is of course difficult to generalise with regard to the order and duration of the different activities that comprise an integrated project - much will depend on community preference and other factors relating to climate and seasons. But broadly speaking, it is WaterAid's experience that where hygiene work is started first, and is a constant theme which continues beyond the end of construction activities, then the overall process of integration is made easier and overall benefits are maximised. The hidden value in hygiene work is the regular opportunity for dialogue and discussion at the household level - not only about health matters but also all aspects of the project. In many cases these opportunities translate into improved levels of motivation, participation and ownership.

It is also WaterAid's experience that where hygiene education is done well, then the demand for sanitation, and in particular, latrines is automatic.

TRAINING

The final, and perhaps central component of all successful community water supply projects is training. It is a constant theme and the principal means by which the capacity and capabilities of communities and partners can be developed. It is therefore absolutely vital for the long term sustainability of schemes.

Yet it is all too often done badly, if it is done at all, by people who have not themselves received the necessary degree of support and guidance. This is symptomatic of a general tendency in the sector to under-invest in people and to undervalue the skills that already exist in communities. The most common areas of neglect in this respect are the training of implementors in facilitating community participation and the training of communities in establishing sustainable maintenance systems.

A useful concept which may help to increase the value given to training is to recognise that each stage of project implementation provides opportunities for people to learn and, therefore, that projects may be seen as a series of carefully arranged, fully integrated, training exercises which build on local competencies. When field staff are attuned to this viewpoint and have learned the necessary training and communication skills, then the process of implementation can be truly revolutionised.

A further key insight into Training is to see it as the hub of a wheel about which all project activities (water supply, hygiene education and sanitation) turn. The spokes that connect the hub to the rim can be seen as community participation. Around the circumference of the wheel are the benefits of:

- improved health
- better quality of life
- increased self reliance
- greater capacity for development

The degree of attainments of these benefits can thus be seen to depend on the investment in training in any project.

CONCLUSION

In the light of the experience of the past fifteen years, it would appear that community managed water supplies will continue to be a key element in global water strategies. If they are to be effective and sustainable then there remains a pressing need for a re-alignment of power via changes in institutional arrangements such that communities gain control over resources and the process of implementation. The major lessons relating to appropriate technology have, I believe, largely been learned but project work remains dourly mechanistic in far too many places. Until the process nature of project work is appreciated and participation recognised as its main theme, then the long term sustainability of projects by communities will remain uncertain. Training inputs which build on local competencies stand the best chance of realising maximum benefits of projects and ensuring that sustainability becomes a matter of applied self reliance rather than a quantum leap to an alien technological culture.

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1st Panel Discussion

Technology for Developing Countries

Chair **Dr. Vicente Santiago**
Panel **Professor Takashi Asano**
Dr. Madhav A. Chitale,
Mr. Hector Garduno
Dr. Walter Rast
Dr. I. H. Olcay Unver
Mr. Greg Whiteside

***** Interpreter for unidentified speaker
The Technology for Developing Countries - this is the first panel discussion. We have asked Dr. Vicente Santiago of UNEP-IETC to be the moderator. In the programme we have only four names; however, since we have distinguished guests from all over the world, we have decided to increase the number of panelists. We have Professor Asano, Dr. Chitale, Mr. Garduno, Dr. Walter Rast, Dr. Unver, and Mr. Whiteside. May I ask Mr. Santiago to moderate the session.

***** Dr. Santiago
Good afternoon, konnichiwa. We are starting now one of the most interesting parts of this Forum which is going to be like a brainstorming session about what we have been seeing so far with regard to the technologies, development of technologies and how they have been applied. Also during this morning we have had discussions about very important issues such as traditional technologies and how traditional technologies should be considered for developing agencies or developing countries, so that there could be a merging of interests between the needs of the countries for water management and for the interest of those developed countries in helping developing countries and transition countries in this endeavour.

So the idea this afternoon is going to be to ask some of our panelists to tell us about their experiences. And then the panelists will in turn start to comment about their views considering different subjects such as how much environmental education, community involvement, planning, and banking, finance have been incorporated in the development of their specific project, so that we could see which could be considered as some of the drawbacks.

So based on this, I would like to start with one of the panelists to tell in five or seven minutes, his specific experience that he feels relevant to this forum. So to start I would like to ask Professor Chitale.

***** Dr Chitale
Thank you Mr. Chairman. To begin with let me try to put across in brief five points for the consideration of the gathering.

The first step should always be to identify the technological needs of the society. Because societies differ according to their economic status and stage of development in respect of the technological needs.

The next step is to see if a choice is possible from the available technology already developed elsewhere, either in the developed world or in other developing countries. If not, develop a technology to solve the problem that is being faced. This second part is the more important part where the developing countries are still suffering. We have to initiate the process of development of technology required by the developing societies. And it is in that direction that the international programmes for technology research in irrigation and drainage have been initiated by the International Commission on Drainage, the World Bank and the UNDP. This is exclusively for the irrigation sector. On similar lines we should initiate a similar programme for the other water sectors like water supply and sanitation.

The third aspect is regarding the transfer of technology. Generally the process of transfer is easy and valid for transfer of industrial technologies like the design of a car engine or a television or fertilizer production. But the technologies required for land and water management by and large are location specific. Therefore, they are essentially to be developed, maybe sometimes through adaptation adoptions, but on the ground where they are really to be put to use. On this background let me count a few topics that new technologies are required in countries from South Asia in particular.

Take the case of the tube wells. There are millions of tube wells in Pakistan and India. And they are almost outliving their proposed life of 20 to 25 years. This has been a new phenomena in the development of tube wells. Now the design of cheap, non-clogging, non-rusting suction heads is still a problem. This is a challenge for the technology. Otherwise you have to replace the entire tube well. The cleansing and reactivating of choked tube wells is another technological challenge.

The second group is regarding the productivity of crops in the high rainfall areas because they loose a lot of nutrients by leaching. The productivity of tea, coffee, rubber, spices is all on a plateau. And the world's demand of these products is growing, but the high rainfall areas are not able to cope with this demand.

The third question is regarding sustainability of the amenities in the flood submergence areas. The first victim after the flood is sanitation because all the sewage spreads around. There is no water to drink when there is all water around the villages that are submerged. We need a disposal system that can stay under submergence. Proper facilities for grain storage are also required to avoid air dropping of the food packages, when there is no grain available. A proper technology to store the grains in the villages which not get affected by the submergence needs to be developed. Civil amenities in flood submergence areas need a new technology. In absence of these, the flood submergence areas and the high rainfall areas are paradoxically the poorest in the world today. One of the reasons is that technologies have addressed the issues of water-scarce areas, arid areas, semi-arid areas, but we have not yet addressed the issues of the technological requirements of high rainfall and flood submergence areas.

And finally, the question of use of low-quality water, whether from industrial effluents or from treated municipal sewage. This is also going to be a location-specific challenge. The technology cannot be just transferred from, say Israel to India.

And the last point is the technology and society interface related with organizational and educational issues. Something has already been said in the last few days so I would not like to add immediately now for want of time. Thank you for listening.

***** Dr. Santiago
Very good. Now we have seen one of the points of view from one of the panelists with regard to what are some of the problems of developing countries, particularly in the Asian region with regard to flooding, rainfall, problems with crops, with agriculture, leaching of nutrients. And with that I suppose that some of our panelists in here will have some experience to share on that regarding their own countries. Perhaps there is the same situation in coping with these type of problems and give us some ideas about it. Please Dr. Garduno.

***** Mr. Garduno
Not specifically related to that subject. But probably we can first finish with Dr. Chitale's subject and then I will be glad to present a different experience.

***** Dr. Santiago
OK, the idea is that after each of the panelists present something, some examples, is for all the panelist to provide some comments on the idea.

Do any of our panelists have any comments or experiences in their own countries that maybe relevant to our discussion. So, indeed, it seems that this is an issue that has not been considered a very important one. And one Professor Chitale has brought up to us is the need to look specifically at some of the problems relating to some of the developing countries that have not been as yet looked at by some agencies and need strong support. OK then, from that I will now go to Dr. Garduno please, your presentation.

***** Mr. Garduno
Thank you, Mr. Chairman. First of all let me tell you that I believe that technology for developing countries is a misleading title for this panel discussion. And what I think is that there is not such a thing as appropriate technology for developing countries. I think there is an appropriate approach to select a technology which might have a high probability of becoming part of a lasting solution for a particular problem in a given situation of a specific country; whether it be a developed country, a developing country, a hard technology or a soft technology.

Let me give you an example following my presentation of yesterday regarding the process to legalize water rights we are now undertaking in Mexico. We need to improve our information system in order to support the following activities: first we have to issue permits for 300,000 water users; secondly we have to monitor their compliance with the allowed abstraction volumes, the concession expiration dates, and the polluting limits of their effluents; thirdly we have to monitor these users' compliance with their fiscal obligation to pay abstraction and waste-water disposal levies - this is a rather complex problem because we have to cover all the country and each user must be monitored from the time he applies for a concession until the time we have to monitor the fact that he is complying with the requisites to keep that concession.

I think it is not enough to select the best available software technology. In order to assess the problem correctly, we must assess the available characteristics of the 200 or more computers involved in the process that we already have, the education of the people that will operate the system all over the country, and also of the managers who will make the decisions with the information they get. Each decision may involve many aspects - technical, legal, fiscal, social, political, even historical or psychological. Secondly, the existent, independent and imperfect information systems, which we are already using, and which we must continue using to support daily work. Thirdly, the existing procedures and managerial systems that we have. After we make the assessment, what will the next step be. We would have to design a process. First of all to change attitudes in order to create a user-orientated system permanently searching for total quality. Secondly, we can think of improving procedures and managerial systems. And only after we have done that, we can then, after designing and implementing a training programme, improve the existing independent training systems and integrate them without jeopardizing the daily operation. Only after we have done all this, we can think of the best available software technology that could evolve as institutional capacity also evolves hand in hand.

In conclusion I would like to say that an adaptive process must be created in order that our people develop the ability to identify the main bottlenecks in the organization, select the best available technology for a particular situation, for a particular moment in their development, and define its possible evolution within existing constitutional restrictions and bureaucracy. We have to be aware that it is very difficult to get approval to buy 100 new computers, so we have to cope with the computers we have, and still try to give better service to our users. In other words, transfer of technology is not a magical solution, it is only part of a permanent dialectic interaction between theory and practice, which must be constantly fed by capacity building of multi-disciplinary groups.

Let me just - to use my last minute - give you an example of an intent to transfer inappropriate technology. During the following days after a severe explosion in Guadalajara, the third largest city in Mexico, due to a gasoline seepage into the sewage system, where many people died. It was back in 1992. A consultant suggested to me to use a very sophisticated computer model to monitor the evolution of the gasoline in the sewer system and in the underlying aquifer. A computer model that needed to be constantly fed with non-existing information. The most sophisticated information system I needed at that moment was only a complete list of cellular telephone numbers in order to be permanently in touch and make timely decisions. Thank you very much.

***** Dr. Santiago

Well, that was a very neat example of how a decision maker, who is working in a government, finds himself sometimes in problems with regard to how to put in perspective the problem he is thinking for the management of water and specific areas. Also that somehow we are seeing in the planning process these type of situations which were not considered.

So on these line I would like to bring the panelists on, what do they see in similar situations, or what are the problems they feel need to have planning from the very beginning in order to avoid as much as possible this situation regarding the transfer of technology, the hard technology, the need to utilize what is in place already or to open the possibilities for a policy so that the system itself can change. Please, I would like to have some ideas from you. Walter? Your experience with dams.

***** Dr Rast
I was going to say, not yet, in answer to your question. But actually let me not offer any comments at the moment if I may.

***** Dr. Santiago
OK.

***** Dr Rast
It might be easier to go through the comments at the end.

***** Dr. Santiago
All right then, then the next panelist will be so kind to give us some example of your situation.

***** Dr. Unver
I come from practice so I will be very practical and give you the views of a practitioner. I will make one general statement and give you seven examples of the Turkish project I am in charge of. So it should take all together less than eight minutes, one minute per statement.

The general statement is that I agree with the previous speaker in that technology transfer or Technology for Developing Countries is probably not the proper name for this session because technology is not the end or the objective, it is not even a means, it is a tool. The more important issue is the process that leads to the use of technology, or improving a technology, transferring a technology if applicable. What the more important issues in this process are, are items such as awareness, commitment, involving the society, including users, beneficiaries, and stakeholders. Then we will have criteria such as cost-added value acceptability, whether or not a problem does actually exist, or a potential is there, there is will, or whether or not we will be dependent on imports in use of technology. That was the general statement.

Item number one from the project I am in charge of. The approach that we adopted for the overall, holistic development of a large area, where six million people lived, was an integrated, socio-economic development. So water resources development was a part of it. I think this holistic approach is probably more important than the use of any technology in any of the sub-sectors. This is what I would call a policy-driven choice.

Second, which is less of a policy-driven choice, but it is an awareness-driven choice, which is the land use authority given to the administration in charge of this development project. It has allowed us not to do water and land integration but it has allowed us to protect the land use, the landscape, protect agricultural areas from invasion by urbanization, etc. And in doing that, we do a lot of town planning, zoning ordinances, etc. The more important issue here is to have the local people involved in the process, so we do it in a participatory manner. Then we come to the technology. We realize that doing this using GIS technology, Geographical Information System technology, would be an easier way to show the iterations we had to go through to the actual users, beneficiaries or stakeholders, including developers and environmentalists. So the technology we used is at the high end of the technology spectrum, but it is awareness-driven and a less important part of the overall process in this case.

The third example, which is a social- and demand-driven example, that is the involvement of women in development. We established multi-purpose community centres for women. On the one hand we give basic training, social services, and on the other hand we provide training for income-generating activities. This was demanded by local women as a result of our social investigations. And what we took as the approach to find the trainers and instructors was mobilize the existing training base within the governmental system and hire those that did not exist. It was fine at the beginning, but as the number of community centres increased, there was a shortage of instructors, and as we go further away from urban areas, there was difficulty reaching out; especially, as to providing advice for health, medical advice. We decided to use video conferencing for this purpose, and have a central location, where we would especially have the health personnel in an interactive manner talking with women. So this is, again, at the high end of technology. And in this case, it is quite important, because without it we would not be doing the job, not even efficiently, the job would be basically coming to an end.

The fourth example is what I call a naivety-driven example, it is a negative example, it is not a success, it is in a water-related area: irrigation technology. In a large area irrigated by ground water - this is 12, 13 years ago - we decided to establish magnetic card driven pumps. The farmer would put the magnetic card into the well, and the well would read it, or the micro-chip would read it, and it would either tell the farmer that it was not his turn in the rotation system to receive water or it would tell the water is coming. Of course, farmers, being much wiser than we were, did not appreciate this, and in less than a month we had most of the wells broken and the farmers were just getting water out of the wells - it did not work. So that was, again, with the standards of 12 years ago, at the high end of technology, but it was not useful at all. It had no added-value, and it actually caused the failure of the system.

The same thing when we introduced sprinkling systems, that was, again, 15 years ago. We thought, or the State side thought that if we installed pumped systems, sprinklers, lateral moving systems, as a gift to the farmers, they would adopt it, because it was wonderful technology, and we would be saving water. The farmers did not appreciate that either, because of a lack of a thorough understanding of how they would be using sprinklers instead of flooding the pastures. So, again, in a very short time, in less than a year, we had most of the sprinklers broken, and farmers were doing gravity irrigation. We are wiser now. We start with demonstration schemes and a large-scale training and extension programme. This was example four and five.

Number six, wastewater recycling, this is a problem-driven choice. We had a medium-sized reservoir in one city, near a city, and all the sewage was being dumped into the reservoir - raw sewage. So we had to tackle it. Local municipality, which was lawfully charged by doing it, did not have the technical capability or the financing to do it.

So we decided to take the charge. But instead of full and costly treatment, we decided to adapt a technology used in Israel, very largely, filtering the sewage. And we did exactly that. And we decided to use some of the water that came out of the filtering system for landscape irrigation. And now we use this as an example for other municipalities. This is very cost-effective, but for us problem-driven. There was a similar situation in two other towns near Syria. The raw sewage was being given into a stream that eventually ended up in Syria. And we had to take a politically-driven choice that was full treatment of sewage because we did not want to have additional problems with our neighbours.

That was number six. This is the last one. It is again irrigation. And this is benefit-driven. We decided to change our canal regulation in irrigation canals from upstream control to downstream control to save water and for easier operation. And what we did we selected a downstream French technology as our Egyptian friends did. But there was a problem with remote supervision and remote control of the gates because they had to be imported. So we adapted half of the technology and for the other half we went to the local military factory and asked them if they could produce the microprocessor for us. That dropped the cost from $100 to $10 a piece. So, again, we were able to go to the higher end of the spectrum with savings in costs.

So I have provided the basis in terms of the variability of needs and use of technology that would serve these needs. I think in the second round there will be more comments I might make.

***** Dr. Santiago
Thank you. Mr. Whiteside please.

***** Mr. Whiteside
Thank you. I do not have too much to add to what I said this morning. But just to reiterate Mr. Unver's point of the investment that is required in social analysis and training under what might start out as a highly advanced technology can be entirely appropriate if the human resource work is done properly.

The only other point I want to make really is to do with choice of technology and the way that donors in the north often promote certain types of technology and call it aid assistance when really it is export subsidy. And I think we need to be very clear to separate aid and trade and not to pull a magician's trick for public relation purposes of confusing the issue. But that is all I want to say.

***** Dr. Santiago
Thank you very much. Well, now as before it was open, please provide comments on these experiences presented here by our panelists. Mainly we have seen the problem that comes with the usage of technology, the adaptation of technology, implications on a social and cultural level, and the involvement of a community in order to be able to make any plan to be successful. Also we have seen other problems. At the higher level one needs to provide for short term answers and that will include strong decisions, tough decisions that might perhaps not be adequate for the long term but might have to be important for the short term political and economic reasons. So that please I would like to have some comments.

***** Professor Asano
Let me just give you some of my thinking on

this. My experience in developing countries is rather limited compared with others. I am usually involved with rich developing countries such as the Gulf states and the Mediterranean African countries. So those are my background. Therefore, predominately Asia and Indian continent problems I presume would be different. But I would like to give you some dilemma, I encounter. What we are facing when we try to transfer technology from a developed country to a developing country, with respect to health risks. That the countries where you are dealing with have a lot of long-term incidences of typhoid fever, cholera, dysentery, and in some cases more serious diseases. Our tendency is, of course, to introduce very stringent, let us say, water-quality requirements, but, yet, there is no hope of attaining them. In the meantime, as you can see in the California case I presented, we are virtually living in a virus-free environment - no immunities to enteric viruses. So what do we do there? Are we talking about one person dying per 100 people per year or are we talking about one per 100,000 people infected by some sought of disease? We are talking about, let us say, 15 years of chronic exposures. Then, we developed a cancer; let us say, one out of one million. That is where our acceptance of health risks seems to be in the United States. This is a dilemma that I think I would like to address to you - where do you put, for example, water quality standard in this context? Are we accepting the one out of 1,000 people dying? If you swim in the Lake Biwa, southern end of it, I assume that you would be getting several gastoentiritus cases per 1,000 people. Now this is true about swimming in the Santa Monica Bay, California. After major storm event, you are getting about this range of gastoentiritus cases, but maybe not dying. So this is a dilemma, where do we put ourselves for those countries who are suffering badly and they need help desperately.

***** Dr. Santiago

Yes, in that sense, what we saw today about the use of 20 litres per head per day, we are talking about short term survival, not long term, we are talking about basic need of water on a daily basis. And that, I think, is a very good point. And I will ask the panelists to provide some ideas on this, some comments. Yes, Dr. Rast, please.

***** Dr. Rast

Thank you, Vicente. I was, to my surprise, drafted last night to be here today, so I must admit I have not had a chance to give this particular topic a lot of thought. And I may defer your question as well, shortly. Because I also, of course, want to make a comment on this matter, which I think is of value to us to consider. And I give it to you from a perhaps slightly different perspective. I am from a UN agency, which automatically means I am a man without a country to worry about, or maybe I should say, the world is my beat, as it were. And also I am from a United Nations agency that has a catalytic role and an implementing role so we try to get things going and done not necessarily to do them ourselves. So, again, you are going to get some of my experiences and hopefully some of the perspectives that may have come from some of these things.

One thing that I had noted in all my travels is that except for death and taxes there are still a few other human constants all over the world. Everywhere I go, people seem to want to drink and eat and go to the toilet and have babies. Although they are doing a better job not having the babies, they still want to drink, eat and go to the toilet. This is a function that has to be satisfied. I have also noted that, as I said yesterday, everybody wants economic development and all the material wealth it brings, the material comforts. These things always cause environmental change of some kind. And as was mentioned by someone this morning, I think, nature is forgiving to some degree. It can take care of some of the waste products and stuff and some of the damage we do. It is just up to a point and then it becomes a real problem.

My colleague here to my right said we should not talk about technology transfers to developing countries and I completely agree. We should focus on problem solving as the goal. Now if that is the case, then I can be liberal about what I say a technology is. I think almost everybody in this room, when they think of technology, think about equipment or structures. And I would be surprised to hear if it was different. But if we are focusing on problem solving, I think we need to consider such things as behaviour patterns and management practices, which themselves can be done at little or no cost to provide enormous benefits. Our role is typically to run out, particularly from the western development perspective - and note we do not really have anybody here from a developing country that is at the lower end of the developing countries, I mean, there is a long list UNDP has put together, and they have number 174 and so forth that are in very poor shape compared to countries 100, so we do not have these people here, so all we can talk about is what we think is important.

So, we are state of the art. We tend to run to these places and want countries to spend a lot of money and so on and so on. Well, we also talk about indigenous and traditional technologies. And I think these are very important. And I think also that this is another way of saying this is how we do things around here. That is why it is indigenous. So you could ask the question, why do we want to change these things. Is it because suddenly our needs are so much that we are being swamped or our technologies are starting to fail us or what?

I like what Greg Whiteside said, that we should structure technologies to a country's structural, institutional capabilities. This makes sense. You do not just go in and say this is what you are going to do without saying can you support it. I think this is a very logical approach to use and I really like it.

So I suppose the fundamental question from my perspective is, what is the best way to transfer information about technologies, including behaviour practices and things like that, to the users, including their strengths, weaknesses and past experiences. I certainly think there is an important role for the general public and public awareness. They are usually the cause and the cure of the problems. And, typically, governments will only ask them to pay the bills for the problems rather than explaining why the problems need to be solved.

In forms of technology for developing countries, and this is becoming apparent in the Secretary General's special initiative on Africa, there is an urgent need for technology transfer, whatever that means to reach the poor majorities. We tend to focus on large projects that are directed often to urban dwellers. This is not an all-inclusive statement but that is particularly one of the realities - urban dwellers that are already connected to some kind of infraservice structure. The periurban areas, the rural areas are often left out in this technology transfer business unless you can get on the very community level of what some people have. I also think that we must pay attention to future issues when we are talking about technology.

Emerging conditions in the cities - if everyone is going to move into the cities, as is predicted, then we are going to have to start thinking about urban technologies and what that means. We also have to pay greater attention in regarding irrigation in water use. This is by far the biggest water use all over the world so there must be some efficiency that we are going to have to start addressing.

And then the rural poor - I always thought in some cases actually the big conferences we have on these things might be useful. I was thinking the other day, we had just had a big food summit in Rome, and I suspect that these discussions all day long on the needs of the poor and the hungry were completed, and everybody went out and had a nice meal - at the end of the day, not really thinking what this all meant. And I always think that it might be interesting to have a water summit where we tried to get everybody to get along with a litre of water a day just to see what it felt like. And then talk about technologies.

I guess in concluding I also might want to continue.... well, capacity building and sustainability - they are very important issues, and they are certainly part of it. I also can never say enough about the role of the media in terms of bringing this to everyone's attention. Most people seem to read the newspaper and listen to the radio, and I think we should probably make more use of that.

And one last remark - a sought of interesting one to me, because I have seen it in several slides in this meeting itself - is the golf courses that we are always talking about for wastewater reuse. And we use this example so often, I have often wondered if maybe we should stop considering golf as a sport or leisure activity and start thinking of it as a remedial measure to help us think of water problems.

And in the same way, I have to make another observation if you will forgive me, because this is one I have heard a lot in Texas in terms of technology - in this case, food. Sewage treatment plants seem to be a good technology because people always tell me that the catfish tastes better below the sewage treatment plant and maybe that is the case. But I thank you for letting me talk about this. I have thrown some ideas out and perhaps we can bring them into the discussion by way of perspective. But what I really think we have to talk a little bit about how select appropriate technology and even why sometimes rather than go in like a freight train and say this is the best for you without saying, would you mind telling us what you could use. Thank you.

***** Dr. Santiago

Yes, thank you very much. I totally agree with you. We have heard what Professor Asano has said, and the way he sees the support of some developing countries, (although they may not be economically defined as developing countries.) On one side you see the statistical numbers with regard the people that could die depending on the water quality. On the other their needs in different terms. Let's consider why the need for transfer of technology in the first place. Why is it that in many countries technologies have been the for years using natural resources and cannot be better utilized or further developed. Where have we failed in this perspective. I would like to have some comments. Is it that we only see the high-tech or side support for developing countries? Why?

***** Dr. Unver

Yes, yes. First of all we have failed if the large majority of the world's population is basically hungry. And like in very basic amenities of life, we have failed, obviously. That is not necessarily so because of the lack of technology or the use of improper technology. In many cases it is because of other reasons.

I would like to support Dr. Whiteside's opinion in that in many cases, aid agencies, large donors are probably less interested in learning thoroughly the problems, the needs so they could find the technological solutions that they could help with. In many cases, a lot of those affected, in addition to the rationales, standard criteria by fads and fashions in their own countries, to their constituencies, to be politically correct or to provide something that would seem more right in their respective countries, that are not necessarily that right in developing or under-developed countries for that management. An example, nowadays it is much easier to find assistance, health assistance, for AIDS than for cystosimyosis or malaria, because AIDS is so much "popular", it is a fact. Likewise it is relatively easy to find assistance for women's programmes, which is a good thing, but, of course, we have to be very careful with criteria used for that.

There is another drawback on the part of the donor's attitude from my personal experience, which is the post-assessment criteria they use, in order to determine the use of the money or assistance which they provided. In the typical case, they are more interested in having the money fully spent for the purpose determined at the very beginning rather than looking at the results, such as increased living standards, even if it applies at all. And, again, from my limited experience, minimal attention is given to monitoring and evaluation of an implemented project; so, once the money is spent, the assistance ends, and whether or not it sustains itself, continues into the future, is not the problem of the donor but the problem of the nation that used that assistance. It is, gladly, I see, including the World Bank, donors and international agencies are beginning to change this attitude. But this has become, to my knowledge, a big problem. I was once offered a very good deal - a soft loan with very low interest rates and large grace period - for establishing a ground satellite receiving station. And the need I assumedly had according to the donors' or the financiers' idea was the fact that I would be able to follow more closely, monitor more closely, the expansion of cities, which I was already doing with very standard methods, I did not need very sophisticated satellite technology, and even if I did, I could probably pay a $1000 per tape, and get the tapes from either the States or from France. Thank you.

***** Dr. Santiago

Thank you. So it seems that somehow the blame is on the agencies on the banks, or is it on those that make the decisions and are also requested to solve the problems? Is it that decision makers need also to consider what is coming into fashion, might not be precisely what is needed for the country. Is it that developing countries should suggest how aid should be put in place? Is that what we are talking about?

***** Professor Asano
May I just expand this discussion - not only donors and acceptors and so forth. But I would like to ask you all the experts here that, what happened to those educated people in a country where you are aiding, where are they? We are educating many, many people from those developing countries in the United States, U.K., Japan, Germany, France, and the Scandinavian countries. They are highly educated, well-trained people from those developing countries. But what happened to those people? Are we utilizing those or are they hiding somewhere - disappeared. I would like to ask you that question to my colleagues from distinguished career.

***** Mr. Garduno
Some are doing good work in their home countries. Others keep solving their Ph.D. thesis when they come back.

***** Professor Asano
That happened to me....

***** Dr. Rast
I might also add, I have seen this happen in some of the African experiences. When people do go off and become trained, they become highly skilled and desirable, and usually they are promoted into another job, and someone else takes over what they should have been doing, so you are left with a person that needs to be trained all over again.

***** Professor Asano
It is a major problem.

***** Dr. Rast
It is a major problem. And I have heard it often enough to think it must be real. So training may be fighting technology transfer.

***** Dr. Santiago
This is a reality in many countries. Having been in the Caribbean for five years, I also found that as soon as trained people came back, they were just a waiting for the right opportunity to go somewhere else, and they just disappeared. Thus somebody from the local areas have to do the job and maintenance with almost no knowledge at all.

***** Mr. Whiteside
I just want to make the point that it is actually worse than that - people are actually not coming back, not going back to their homes. There is a brain drain from the south to the north, because very highly qualified people can earn a lot more money in the north, and we would all make that same decision. I think we need to look at training facilities in the south and how they can be improved. How we can make training specific to job performance and not as some erudite exercise in collecting diplomas and Ph.Ds. The need is too great to turn it into that sort of exercise.

***** Dr. Santiago
I agree.

***** Dr. Unver
Let me be the devil's advocate and take a different approach. In the developing world I probably represent an upper class of the developing world. We probably do not need many more Ph.Ds. In my country, in my

project, the biggest need that I have is middle class technicians, good technicians that know what they are doing. As you go upwards, you have a larger availability of very, very skilled specialized people, towards the middle end, towards the middle you have a lack of good people with a thorough understanding of the thing, the specific thing he is doing. A second problem with the highly educated people, including the Ph.Ds., is the fact that the more highly educated, the more specialized you are, and probably you have a less chance of having a multi-disciplinary understanding of the problem you are dealing with, especially if it involves people. Us engineers do train ourselves in technical issues more than we learn about the social issues. We are more civil and technical engineers than social engineers. And in multi-disciplinary environments, if they do exist, there is a lack of coordination between different disciplines for various reasons. In the ideal setting each individual who is at a decision making level or at a level that directs other people to have a basic understanding of all of the interdisciplinary issues should not commit himself to the particular area where he got his Ph.D. Thank you.

***** Dr. Santiago
Thank you. Fortunately, now days I see quotas have been very tight with regard to some of the trainees going back home and staying there. It has been one of the good achievements of various institutions. The other part is when some of the students, go to developed countries in order to undertake a Ph.D. or masters degree, it seems also that they forget what are the specific needs from where they come from. So when they go back, they try to continue on the same lines without realizing that their needs are different. So far, we have found the problems of training of capacity building as one of human resources, second: most important, the views on how the agencies and developing agencies are looking at developing countries regarding what to look for and can be utilized for the management of the resources, particularly in the case of water. Following my previous comment, are developing countries the ones to be blamed for accepting or for this type of attitude? Is what we call the best available technology, the answer without meaning that perhaps the best available technology is not precisely in terms of discharge of so many parts per million but for the reality of what we can actually provide? Is that what we are talking about?

***** Dr. Chitale
Let me respond to two separate issues at one time. The first is the question of looking at society in a proper perspective. The developing societies by the very fact of being in a development stage are more multi-layered than the developed societies. You get a very high, sophisticated level in the upper class of society - technologically, socially, and administratively well advanced and a very lagging, poor section of the society. When we talk of development technology or technology transfer, we have to be clear as to which part of the society we are targeting. There are some technologies, like the one explained by our friend, like computerization in the water management. There we are not targeting the farmer's but, we are targeting the automated, regulatory system and the people who are going to handle and address that system. They should have the adequate know-how and knowledge of how to handle a computer. Take, for example, the Indian railway system, one of the very largest

networks that is fully computerized. There is no problem running that computerized network even though it is difficult to say that India as a whole has come to the computer age. So there is a multi-layered society where the technological needs are different. And the classic paradoxical example is that of the Ethiopian Airline - forget the hijacking and the accident that took place - but on the African continent this is one of the countries that does not have a railway network but runs an airline reasonably efficiently compared to African standards. That highlights the difference that are necessarily to be kept in view when we think about the technology, the needs of the society, and the type of transfer that ought to take place.

Coming to the objectives of the management - I am only giving one example to cut time. We want the rivers to be clean - but of what standard? It is wrong to believe that human effort in industrialization and urbanization is the only polluter. That is not true. Nature itself is a polluter. In acute dry areas you have the problem of fluoride content and salinity without man's intervention. One of the problems of water supply in India and Pakistan is how to supply drinking water to the fluoride and chloride affected villages, because the groundwater itself contains more than 7000 ppm of the mineral content. How to make that water portable and drinkable? At the other end, in the northeastern part of Bangladesh or India, because of the hot humid climate, even for a large river where industrialization has not taken place and urbanization has not taken place, if you go and look at the natural quality of water, you will shudder. Because of the degeneration of the leaves and the decay of the leaves that takes place in the hot humid climate, the natural lakes, the natural rivers are not of the standard which people in the temperate climate imagine. Therefore, a man trained in public health engineering abroad, when he comes to India, he is at a loss to know how to proceed, because being psychologically trained to a certain level of purity, he tries to pursue the idea of completely cleaning the entire river. Now this is how the relevance of the background is very important when it comes to water and land related issues. In our training programmes we will have to take great care to see that this relevance of the background is not lost anytime. Thank you.

***** Dr. Santiago

Thank you very much. Yes. we have seen what the problem is about and how we should be focused perhaps on the training component capacity building on situations and also based on how to address specific problems. Also, as you say, perhaps nature is the one making problems. I think that nature in itself when it works, cannot be considered as polluter, but that is another point of view.

***** Dr. Rast

Maybe we have to transfer some technology to nature or something but that is another question. Largely, nature can be very stupid sometimes, this is particularly the case in modeling. We go to great lengths of trouble to make wonderful models of the ecosystem, and we know that they are good, we put the right coefficients, and we run them, and we get some nice predictions like this, and then we go and measure nature, and it did this. So I can only conclude that nature does not understand models at all.

But the point I am trying to make is, I asked the question initially, how do we select appropriate technology for a given problem? And if one stands back, you have to ask yourself, it does not matter what type of governmental unit you have - I have some people in this area under these conditions with some kind of a water problem, for example. What can I do to help them solve? They have addressed it up to a certain point, but they must not be able to address it beyond that point, because suddenly the indigenous technologies are no longer enough. So what does a person do at that point. Do you run to the Internet and look up problems and all of a sudden there are all of these solutions. Is there something like a Sears robot catalogue of technologies that you can go to. You have to ask yourself. And certainly I do not want to go to an industrial company. The company will insure me that whatever my problem is, that is the absolute best technology, I should just simply pay for it, please. So where do we go. There is no single source on this earth that I am aware of that one can go to as a sought of shopping centre of technologies; particularly, to find out the experiences, the cost, how relevant it is for your situation - I do not know any particular centre, except the individual retailers, if you will. This is something we should think of as well that we need to talk about - how we can let knowledge of technologies and experiences be known to a wide section of the world. I do not see it, yet.

***** Dr. Santiago
Yes, with regard to that within UNEP and IETC, we are just starting to do something on this line. Specifically we are preparing a series of source books on water augmentation and technology considering five regions of the world where traditional technologies (as well as high-tech). Also, we are going to prepare a database to include technologies with their descriptions, the use, and the problems they present, so that also decision makers could use and not say "sorry, I did not know that this technology was not culturally acceptable" for example. One of the examples - I think it is in India, or Bangladesh - I read that there was a need to install water pipes for houses, but it appeared not to be the right thing to do, because the women used to go to the well, and sought it as leisure time to be able to speak with the rest of the community. Sometimes what we see as a right and logical approach culturally speaking it might just be wrong.

***** Mr. Whiteside
May I make a point that Walter's comment about the Internet. And can we go to that to find out some of these transfer technology issues, the answer is, yes, we can. I think in the last couple of years there are a number of mail-based systems set up where you can get a discussion going on the Internet. And we in Nepal have one going on about low-cost latrine pit linings using clay with the problem of high water table. And there have been six or seven respondents from around the world who have produced ideas and given some of their experience. So I think the Internet does hold much promise, but it is still very much a tool in the south that is in the urban centres. But we should use it. It is a great hope, I think, for some of these information-transfer issues.

***** Dr. Garduno
Well, I think that the Internet and all these shopping lists for technology are no doubt very valuable. But we have been trying to blame different groups, we have been trying to blame donors, we have been trying to blame decision makers. I think we should also blame universities. And the reason is very simple. I think that universities try to promote, they think very highly of publishing

papers. And when peers get together, they like to be more and more all the time sophisticated, in many cases, I am not talking about 100 percent. We have seen that in Mexico, that recently a researcher gets lots of good points if he publishes abroad, no points if publishes in the country. And the problems that should be addressed are in the country, they are not abroad.

In my particular field in water management, I have been talking about a lot of this with Asit Biswas, talking about water-use management in the country. We have been trying to look for books on water-use management. There are no such books. There are some books on some tools, like those ill-behaved models that do not understand - I mean that nature does not understand them. And of course there are some models that are useful. We can use them to allocate water, we can use them simulate complex water resources, surface and ground water problems. But when we have to address situations where political, legal, fiscal, even historical or psychological problems are important regarding water conflicts on one people, then we only have to rely on our own experience, and we have to invent a solution everytime. For some reason we have not been able to attract the attention of the universities, of academia, to look into these real-world problems, that are probably going to be the problems in water management in the very near future - not building more infrastructures but solving conflicts among users, among users, among countries, among regions.

***** Dr. Santiago

OK, thank you. So it comes to the point now that the presentation of Maureen O'Neill, this excellent presentation, has given some framework about how to deal with the transfer of technology. What should be considered in the transfer of technology. It is talking about all these different issues from the finance point of view, economic, social, academic, if you want to say. So, it is a very complex issue the transfer of technology, (if we call it transfer). It is something that needs strong revision from both sides. Institutions, donors, as well as those that have the capacity to take decisions, in order to see what exactly are the needs not basically on an economic basis of the short term but also on the long term and for the benefit of the country as a whole. So far we have been talking about different issues ranging from how you see it as one of donor consensus and assistance to one of the developing countries. We have seen problems about the structural assistance in the country to be able to utilize better purposes and for water management. All the problems raised from decision makers, existing technologies, the views of those that provide the technologies, etc. Sometimes transfer is just for profitable purposes more than for the developing, in the true sense of the word.

And now I would like to open the discussion to people in here, our distinguished audience, to provide some ideas, some comments about what you have heard with the regard of the different perspectives. You have seen the problems, and the needs. Do you have any comments?

2nd Panel Discussion

Soft Options or Hard Choice

Chair Professor Saburo Matsui
Panel Professor Malin Falkenmark
Professor Genady Golubev
Professor Sven Jorgensen
Ms. Maureen O'Neill
Professor Yutaka Takahashi

***** Interpreter for unidentified speaker
Thank you for waiting. We would like to start the next Panel Discussion on "Soft Options or Hard Choices". The chairman is Professor Matsui of Kyoto University. The panelists Professor Malin Falkenmark, Professor Genady Golubev, Professor Sven Jorgensen, Ms. Maureen O'Neill and Professor Takahashi.

***** Interpreter for Professor Matsui
Thank you. This is going to be the last panel discussion and as chairman I will be speaking in Japanese.

I would like to invite all the audience, to participate towards the second half of this panel discussion.

Among the panelists, we have the pleasure of having Professor Golubev with us. Professor Golubev is a professor at Moscow University, and currently he is a visiting professor at Nagoya University. His specialist area is hydrology and his is the vice president of International Hydrological Society (IAHS) he has also served as the Assistant Director General at the IUCN and he was the Assistant Executive Director at UNEP. He has had a long relationship with ILEC and has considerable experience in the areas of hydrology natural conservation.

Now we would like to start the discussion. The theme of our discussion is "Soft Options or Hard Choices". It is very difficult to give a Japanese translation for these words, especially when it comes to "Soft Options". So in Japanese we use the words "available methodology" or "possible methodology", but the true meaning maybe somewhat different. "Soft Options" has a much wider meaning than "possible methodology". So during the coming discussions I would like to ask you to keep in mind a wide meaning for "Soft Options". For example, we have hard choices vis a vis the "Soft Options", and concerning the "Hard Choices", we can have hard choices and soft choices. So there can be many different ways to understand these terms. So in the coming discussion we want to try to keep our definition wide, and we want to have a wide exchange of ideas.

Now, I would like to ask each of the panelists to speak and I would like to ask Professor Malin Falkenmark to speak first.

***** Professor Malin Falkenmark
Thank you. I think that given the upcoming global water crisis, my particular perspective is related to how to cope with the challenges

in the different parts of the world. And in finding out how to cope there are a number of compromises which have to be struck, and we have to change our perspectives in order to be able to go forward because we are so tied up with our own way of thinking.

The strong driving forces of this upcoming global water crisis is the rapid population growth. I think that not many people have really been able to understand on a deep level how large this population growth is. It is 85 million added to the world population every single year, and these 85 million people have to get water and they have to get food. So world food supply is starting to be a first rate issue.

But at the same time we have rising expectations all over the world for water based services and goods. So the challenge is how to avert the crisis following from the increasing water scarcity. When we have increasing demand for a resource which is finite it gets more and more tricky, and this is the particular challenge in Africa.

Since food is produced with water, water scarcity leads to a problem of food scarcity. But then if we look at the situation in Japan and in Europe and in the United States, the issue is water pollution. I think it is necessary to change perspective in order to be able to cope with both of these different problems. And I think that this Shiga Forum has been very helpful because we have spoken so much about the landscape, and I think that the key is not just to look at water as such, we have also to look at land, because land productivity is driven with water in the root zone.

So I think that we have to put the focus on man's interaction with the landscape, because the landscape is the life support provider. It provides food, it provides water and it provides energy, but in this landscape water plays fundamental roles. As we heard yesterday water is the bloodstream of the biosphere and helps to balance the situation in the landscape - in a physical sense as a temperature moderator by precipitation and condensation; in a chemical sense as a carrier of chemical substances through dissolution and re-precipitation of these substances; and in a biological sense as a raw material in photosynthesis by cleavage of the water molecule and by its later reassembly in the respiration process. But at the same time if we go to the human society, water is an engine of regional growth. So it is water in the landscape in all these different functions that we have to put in our focus.

So then the problem is how do we address these future challenges. Basically what it is all about in my understanding is finding ways to cope with the environmental pre-conditions in every particular place while satisfying the societal demands in that region.

Now, the perspective used is of course crucial for our ability to solve the problems, and we have to have two perspectives in parallel. We have to have a short term perspective to solve the immediate problems. We have to a long term perspective in order to avoid long term threats that we can already see. We have to have a small scale perspective for the local problems, while having a large scale perspective for the regional and global problems.

Now, the technology that we have been discussing in the first panel discussion, has the aim to solve a particular problem like reduced flood risks, or get water to a city, or purify the wastewater after use. But if we take the long term perspective, the large scale perspective, then the overriding problem is the human predicament. In particular man's interaction with these landscape phenomena that are driven by water. And here many compromises are necessary as I discussed in my introductory lecture because we need compromises. We are forced to interact with the landscape, since that's where the resources are, but at the same time we have to cope with the landscape's responses to the unwanted side effects.

In addition many landscapes are bleeding nutrients. This is what we have spoken about earlier as non-point pollutants, but it is a leeching of nutrients from the landscape and these nutrients go to the lakes and in the lakes they produce eutrophication. It is an extremely slow process to remedy that phenomena. So it has to be met far in advance.

These landscape responses, they also produce a bio-diversity reduction as soon as the water which moves through the landscape is polluted. So, as I understand it, looking at these enormous driving forces with a population growth of 85 million people every year - that is a new India every ten years - we are standing of a crossroad. Either we continue with our present thinking with small changes, we mend here and we mend there and we proceed with incremental changes with conventional technology and so on, and we allow the economies to continue to play the roles they are playing today and we listen to their mantras. Or we could take the opposite approach, that is to take a new fresh look on the challenge in front of humanity, by taking an so called broadcasting approach. What do we want the landscape where we live to be for the next generation, for our children and grandchildren? Do we want the landscape to continue to bleed, or should we try to do something about it?

So that's the first question. What do we want the landscape to be? The next question is what is needed to get where we want to be? Then we have different measures that we have to take. We have to stop the outflow of pollutants from human activities. We also need ethical rules, as we heard yesterday, in order to find out how to share the water in rivers which pass from one country to another. And we also need ways to be able to achieve a land productivity conservation so the land remains productive also for the next generation, so that they also get food. And once we have defined what is needed to get to this desired future then we can find out how to get there. How do we develop the coping capability which is needed? And how do we develop the diagnostic ability which is needed in order to find out what is specific for the problems of each particular region.

Thank you.

***** Interpreter for Professor Matsui
Thank you very much for summarising all of the points that we have to consider. Two days ago Professor Falkenmark gave us a keynote speech and she again clarified the points that we have to consider. If Professor Falkenmark had a keyword, I think it is "landscape". The landscape is not a very familiar term among water specialists, so it is also difficult to find a Japanese counterpart for the English term of "landscape". This is not about the physical appearance of the land itself, it is more than that. So using the

keyword of "landscape", we hope to deepen the discussion.

I would like to ask Professor Golubev for his comments. If possible would you please use the keyword "landscape" in your comment.

***** Professor Golubev

I shall try, but I think I shall begin with something different. Today and yesterday, the discussion was always about technology, but in almost all cases it was finished not with technology, but with the people. So that what in fact we are talking about in many, many cases here is not technology and technological issues, but people's attitude to water, to water resources, to water use. And what we are facing, all of us, we know it pretty well, that there are various points of view concerning water. We worship very much a certain lake, a certain river or a certain spring and that has nothing to do with the commercial value of it. It is just a matter which is very deeply ingrained in our hearts. That is on the one hand. But immediately we treat this particular water body as a source of resources for us, and in this case, in most cases, we misuse it.

So it is very complex and I think all the discussions of today and what I am saying now leads to me say that what has to be managed? Not technology, but people. And that leads me to the very, very soft options in all this because managing people, or transforming people's minds, making them more educated means, in my mind, soft options, to water management and to the future of water use.

Here I would like to raise just a few points, a few questions. One is the price of water used by human society. There is no price at all to the water bodies which are worshipped. They are just respected. On the other hand if we go through all the water users, at the other hand, at the highest end, you would see the urban water supply systems where we have the highest levels of technology normally. We know that the highest prices also for the urban water supply, but it makes me think that perhaps when we talk about the price of water resources in fact what we are dealing with is the price for the technology which is used, and the water resources are not charged for almost at all. And this is one of the issues which should be properly discussed more.

Then I wonder, and I would like to throw this question open to everybody because I don't have an answer for this, is why in spite of all limitations of water resources, why in spite of all difficulties with the water quality, water is not a limiting factor in economic growth? Why water is not a limiting factor in spatial growth? Why water is not a limiting factor in growth of cities in California? What is this there?

I wish to treat water very widely not only as a resource, but also as a component of the environment, as a component of landscapes, as one of the principal tools through which one can manage sustainable development altogether. And that leads me to Professor Falkenmark's point about the limitations of water and food supply now and in the future. Well, one of the very clear cases is that the massive amount of food, which exists in the world, is in fact very, very long water transfers materialised in the food which is transported from the place of production to the place of consumption, and they should also be treated this way.

Now, I would like to come more close to the management of people, and in this particular case I would like to discuss more, if I may say so, the environmental education of engineers. Well, probably more than half the people in this room are engineers, so please excuse me if I may touch upon your feelings. But you know yourselves probably that in many cases engineers do not respect water, do not respect the nature of water. They are very pragmatic people and they think in terms of cubic meters of concrete, the number of concrete tubes, tonnes of metallic constructions and so on in many cases, and they forget that they are working with Nature. There is a very deep belief, which I suspect comes from generation to generation of engineers, that Nature makes mistakes and I the engineer have to correct the mistakes of Nature. And in this particular case what happens in many, many cases is that Nature becomes to correct the mistakes of those engineers.

We know very well the case of the Aral Sea, all of us. One of the Russian scientists at the beginning of the century said, "the Aral Sea is a mistake of Nature". Following this belief and this statement, it was decided 50 years after that statement that it was the right time to develop irrigation there. The result we know. It was a very deep mistake based on the purely technological approach without any consideration to be given to the natural aspects of water resources management, of natural resources management in general.

So the belief that nature should be commanded is wrong. I would like to remind you, probably most of you don't know this statement which was made by an English philosopher of the 16th century, Francis Bacon, he said, "Nature to be commanded must be obeyed". In other words, you have to first learn the laws of the Nature and then to be successful you should follow these laws of Nature. That means that the education of engineers should continue, should go on, should be more developed.

And let me just as a finish, before I stop, just to say a few words about our Russian experience now. The experience is that the environmental situation in the country is not good. It is not good also with the water resources, but what I believe is quite good is that the last five years we have seen a quantum leap, I would say, in the preparation of engineers and all other experts at universities. Everybody, all experts which are supposed to work later with nature, engineers of different types, agronomists of different type, they all have many courses in environment. Many subjects of environment are introduced in traditional courses. So that I think will produce a new generation. It is not a high secret that it's not only in my country, but in many countries over the world that the ruling generations, those who rule the country do not have environmental education at all, so that perhaps the next generation will be more successful with this, and that would be also for the success of the water resources use.

***** Interpreter for Professor Matsui
Thank you for your very informative views. Professor Golubev mentioned that the during the discussion we have had over three days, unfortunately we have had several points that we have been unable to discuss fully, for example the economics of water. Unfortunately, we were unable to invite economic experts to this Forum, but Professor Golubev has rightly emphasised the importance of the economics of water.

People used to think that water was cheap and this line of thinking is still prevailing in the world. We have to change that thinking, otherwise we will abuse water in the future. So in that particular context, Professor Golubev pointed out some very important aspects of the issue.

I feel that Russia is now in a major transition period in terms of its economic system and from what I understand it appears as if in that transition process Russia has actually recognised the importance of this issue.

We shall return to the topic of the Aral Sea later if we have time, but Professor Golubev also referred to educational reform. Well, the same thing is happening in Japanese universities. For example, in the Department of Engineering of Kyoto University, where I am working, how environmental education is incorporated in traditional courses is being considered in the reform of our educational program.

I would now like to invite Professor Jorgensen to make his presentation.

***** Professor Jorgensen
Thank you very much Mr. Chairman. We are going to discuss how we can solve the world's water problem? We having been confronted with "Soft Options or Hard Choices". In my opinion this is "Soft Options and Hard Choices", because we are dealing with extremely complex problems. Complex problems and complex systems would require complex solutions. So it is not surprising that we need a wide spectrum of solutions. We need many ingredients of what we have heard during the past day to be able to overcome this enormous problems we are facing in water management.

I would like discuss four items which have been brought up during this conference and which I think is very important among the many, many issues we have touched on. Two of my issues will be about water quantity and two about water quality.

When we look into water quantity, it is obvious that the amount of water we need is a multiple of the population and the water consumption per capita. So if we have to solve the problem, we have either to reduce the population or we have to reduce the cubic meter per capita or, even better, with this enormous problem we are facing, we have to look on both factors at the same time. I think it has been touched a few times, but I would like to emphasise again that I think population control is a very important ingredient and we should not forget about it, that this is one of the two factors determining the total water consumption.

But I would also, of course, like to discuss the other factor - how many cubic meters we are using per capita. I think they were more or less all mentioned in the Blue Revolution, but just to repeat we need recycling, reduction of water use, demand management and first of all maybe we need, and that has also been touched upon by Professor Golubev, we need green taxes. We need, to a much higher extent, to put tax on resources. Resources are a limiting factor in our possible growth in prosperity. So we have to control, of course, this factor. So I would strongly recommend the use of the green tax system to a much higher extent than we are doing today.

The two other factors or issues I would like to mention are concerned with water quality.

In my opinion today you have to play on environmental technology, eco-technology, cleaner technology, environmental legislation to be able to cope with the problem. You have to deal with the entire spectrum of possibility and even within this four mentioned factors, we have many possibilities. There are many environmental technologies available today and you can make very sophisticated, complex solutions to any water problem.

And that leads me to the last issue where I again agree very much with Professor Golubev, namely that this is a human factor. We have the technologies there; we could control population growth, to mention the first factor, we could recycle much more, but can we agree on this? This is maybe necessary, that we change our attitude to nature as it was also mentioned previously in this discussion. I like very much the expression by Professor Falkenmark, the landscape is bleeding. What can we do about that? We need a much more ecological and social approach. Water management has, up to now, been very much dominated by civil engineering and concrete, and canalisation, but we need to use the ecological principle I presented previously today. We need to think ecological. We cannot cheat Nature and if we want to fight against Nature, Nature will win. We have to fight with Nature to solve the problem. That is the key.

We also should not forget in this context that we need social planning. We saw this morning excellent slides illustrating how water is precious for the developing countries. We should not forget that there are tens of thousands of villages in Africa which have no water at all, where they have to carry the water kilometers away to be able to make a decent living. So water is in many parts of Africa, and I'm sure also in Asia, the limiting factor, and it is a limiting factor to growth in spite of what Professor Golubev asked, is water a limiting factor? Yes it is. In some regions it is a limiting factor. There is no doubt about it.

So I would strongly recommend that coming out of this workshop we should try to synthesise the many good ideas and I tried to make this synthesis in four points. I hope that this will be a part of the proceedings, that we have this wide spectrum of choices and that we should go for both "Soft Options and Hard Choices".

Thank you very much.

***** Interpreter for Professor Matsui
Thank you very much. In Professor Jorgensen's discussion the importance of human factor was re-emphasised. This point I believe we need to discuss later on, so I shan't comment right now.

He also mentioned a green tax. I think a green tax is particularly important for Japan. The point is because Japanese society is trying to reform the tax system. The national fiscal system is facing a major deficit. In order to overcome this deficit, in addition to administrative reform, tax reform is also on the table. Therefore, currently the current tax system is based on the wage or the salary system, so how about a new tax system based on the amount of consumption. That is the discussion taking place.

The landscape issue is another point. Yes, I hope to discuss about landscape as well during this session. How to deal with Nature. How to associate ourselves with Nature was one focus. What we are discussing in Japan is we have a key word, it is the co-existence of human beings and Nature. The word "kyozon" in Japanese is co-existence, we are using this word co-existence already when we discuss about the relation of human beings and Nature. We hope to discuss this with the audience later on.

So now may I call upon Ms. O'Neill for her comment.

***** Ms. O'Neill
Thank you. What I would like to do is emphasize a few points and then I would like to give an example that I hope will be of use to people.

We are looking at the future and that is what we need to keep in mind. We also need to keep in mind that technology is a very important issue, but it is a means to an end; it is not the end itself. The end itself is people. That's what we have to keep in mind. And we have to keep in mind that we are talking about a decent standard of living for the world. Not just for a portion of the world, but for the whole world.

With that, I think that I want to re-emphasise there are millions of people at risk. We really need to understand this, and we probably will be repeating it quite a bit, but it's important that it is stated over and over again. This is everyone's problem. You will be affected. You may just be affected by the price of your food rising. That might be the least that you feel with this, but there could be more. People in desperate situations may do desperate things.
This always leads back to issues of resources to do what is necessary. It is commonly believed that even if we do things differently, we are going to have huge price tags. That may be true, but in times of crisis we always seem to find money for defence budgets. Preventing desperate situations so that millions of people are not at risk would be a wise use for some of these funds.

I would also like to comment on your point about an economist not being present. Yes, I agree that that's not ideal, but on the other hand it's not bad either. There are some positive things to that. In water resources, we need many viewpoints from varied professions. And I think we are mature enough to understand that there is no one right profession. There is no one right viewpoint. The issue of money, financing must be broadened. It cannot just be left to one profession. Economists deserve much respect, and I think it is very, very important that all of us who are not economists listen very carefully to what they have to say and work together on this issue. But many people in this room also need to be involved in that decision and those discussions, so that there are what I call 'reality checks' on this issue.

So, with that I would like to give an example of something that happened in the United States, and what came out of it. Actually it's a hopeful example. There is a saying "money doesn't always buy happiness". Money doesn't always buy solutions either. Approximately 30 years ago there was a river in the United States that caught on fire. It was quite dramatic, to see this river burning. Because of that image, there was a great deal of money poured into water resources. What happened was grants were given out. Money was given away and government was told to "fix it". This came from the top down. Government said, "We've got your solutions. We've got the technology. We've got what you need to do. No problem". I happened to be on the receiving end of this great cycle. It was very interesting because the big cities were targeted first. The treatment plant that was built was not the best for the community due to time constraints of narrow ideas about technology. This was a huge, major investment of money. We had a breakdown in that plant. There was a sand filtration system and nobody had thought to check to see if we could get the special replacement sand easily. Keep in mind, this is the United States. We could not get the material we needed. The company that had the sand that was the right particle size had gone out of business and it turned out that they were the only one in the United States that had this product available. So while this was going on there were numerous bypasses and a lot of messy incidents. This was fixed, there was another problem, and we went on this way. There was one problem after another. The plant was eventually retrofitted into working, but it was a very expensive way to do business.

When the big city problems were basically addressed, we then turned to the small city problems. And lo and behold by that time we started running out of money. The money just wasn't there and the grants just weren't there in the same way that they had been before, and yet the problems were still there. So going into the small communities, what we discovered is that we didn't have the skilled labour there to run these sophisticated plants. We didn't have any place to take the waste from these plants. The prescribed top down solution just didn't work.

One of the positive things from not having enough money, (and I'm not advocating not having enough,) was a lot of innovation occurred. There were some new ways of looking at infrastructure. Usually, with wastewater treatment it is not the treatment system itself that costs nearly as much as the pipes that are needed to go to the treatment plant beyond. There were a lot of innovative things that came about with this. There were new pipes that were designed. You didn't have to do as much construction. You didn't have to dig down as deep. The slopes didn't have to be the same. This is technology that came out of a situation because of not having enough. It was not just throwing money at a problem. Not throwing money at a problem, and doing things thoughtfully produced the best solution. It caused innovation. What we need to do is constantly look for innovation, and keep open minds. We also need to understand the dialogue has to be broadened to the various professions and the public and understand that there isn't one right solution for everybody.

***** Interpreter for Professor Matsui

Thank you very much. So the discussion was about the past 10 or 20 years. That was one example of an incident in the US. Even the country with the largest budget has had difficulties in the area of water resources management. They have also had their trial and errors. That is what we have heard. The sewage treatment systems in smaller cities is facing major difficulties, even in cities in the USA. In comparison to European cities the sewerage service ratio is lower in the USA and much lower even in Japan.

Closing Session

Conclusions and Recommendations

Chair Professor Asit K. Biswas

***** Interpreter for unidentified speaker
We would like to start the final session. We would like to ask Professor Biswas to announce recommendations to conclude the Forum.

***** Professor Biswas
It has been two and three quarters very long days. We have had many presentations from different countries, different backgrounds and many very interesting ideas. So time has come now for us to put together what we think should be the conclusions and recommendations of this two and three quarter days discussion that is almost complete now.

I have a personal suggestion to make but of course the decision has to be collective. We have attended among us many, many meetings like this. Some meetings produce many conclusions, many recommendations, but my personal view has been that, if we produce too many conclusions, to many recommendations, nobody will read them. So it is better to have two or three important conclusions and two or three important recommendations whatever we decide them to be the best. And try to see if those conclusions and recommendations can be implemented. If we have a long list of recommendations, which is very easy to produce, then very few of them will have any possibility of implementation or even people taking them seriously. With this philosophy - and we are at your disposal to decide what you wish best - if we should decide to go for a fewer recommendations.... very few recommendations and very few conclusions, perhaps two to three each.

Looking back over the last few days two or three facts come down very, very strongly. And let me say from my own personal perspective what I see is the common thread during the last three days of discussion. In terms of conclusions I would like to suggest two main ones. The first one from the beginning of Monday to now, the last panel discussion, it comes out loud and clear that everybody agrees that there is now a global water crisis. And that this crisis is likely to become more serious during the next 20 to 50 years. We do not see in the present scientific analysis of the future - and no one can predict the future - we do not see any possibility, at least not on the horizon, that the situation could be significantly improved unless many things are changed. So one of the possible conclusions could be that the world is already facing a serious global water crisis and the problem is likely to become more serious in the future unless right from now we try to take some very important steps including changing mind sets, attitudes and behaviour. That could be one possible conclusion.

The second possible conclusion is a correlation of that. While in the water profession in this room and elsewhere, almost all of us are convinced that there is a global water crisis already out there. And as Professor Malin Falkenmark has graphically said, for the last ten years that there has been a water blindness among the public and the decision makers in terms of the crisis. So my suggestion for the second conclusion would be, even though we strongly believe there is a crisis and it is going to get worse in the future, public at large, decision makers in general and the media still have not accepted the fact that there is a global water crisis or the magnitude of that crisis.

So my suggestion would be to have conclusions of this nature, two or three, you may wish to add one or two more, but no more than three to four at best.

Now, if you accept this type of suggestion of macro suggestion, what could be the type of recommendations we could consider? Again, I would like to suggest we have two to three recommendations only instead of thirty or forty detailed recommendations. So from these two conclusions we would like to suggest three possible recommendations for your consideration.

First, we believe this Shiga International Forum on Water, that is about to be completed very soon, has been really a fascinating event, which managed to bring scientists from all over the world and Japan's top scientists together, people from the universities, people from the governments, general public, and all of us are very pleased to see a significant media presence hear. So we would like to propose that in future, every two to three years, we try to organize - by "we" we mean all the collaborators of this forum, and we have at least the collaborators in the forum in our programme and virtually all major water institutions in Japan and the rest of the world included - that this group consider the possibility of convening a World Water Forum, perhaps every two to three years, at least initially. But on more focused subject, the subjects, again, can be decided upon by the collaborators, but during this meeting, for example, we heard many suggestions for areas where such a forum could focus on. One possibility could be, what are the economic instruments that are available for water management. And how have these economic instruments are at work in different parts of the world - we have some success stories, we have some failures, of course, as well. It could also focus on public participation, not on its desirability, but how to do it properly in terms of a large-scale integrated basis in management. Here, also, we have had mixed results from all over the world.

We could also talk about education, training and public awareness. But we leave this up to the organizers. If they accept such a recommendation, first to decide that such a forum is intellectually financially possible, because without money we cannot do anything, so economics has to play a very important role in this area. And second, if that is desirable and economically feasible, what should be the process by which some forums could be organized, what should be the topics.

So that could be one of our recommendations that we should consider - a World Water Forum of a mixed nature, interdisciplinary nature with various stakeholders from scientists to government civil servants to international organizations to public decision makers and the media all working together and trying to identify some problems and even more offer some solutions for the world.

The second possible recommendation could be - and, again, it has come throughout the last three days - all of us believe that water is not high enough in the national as well as international political agenda. So one of the recommendations could be to try our best to put water higher up in the national and international political agenda. This could be done in a variety of ways but we cannot discuss it today in the short time available. But one possibility could be that all the co-sponsors and collaborators of the symposium could perhaps even put together a small task force that could work in this area and see what might be possible in terms of process to put water in the national and international agenda. So this could be a second recommendation from this Forum.

The third recommendation could be how to foster better international collaboration in the water field. And here, by international collaboration, we are taking a very broad definition, and we would make it clear that this would include some of the discussions that took place yesterday, for example, bilateral and multilateral arrangements on international rivers, lakes and aquifers, how to work together between the various institutions and countries more effectively. It could also consider the desirability of international treaties, international conventions whatever terminology framework convention. It could also by international collaborations do that also. It could also include, as the first panel discussion came out today, that better collaborations between many of the donor or the external support agencies and some of the countries where they are working is desirable. How do we do a better collaboration between the three?

So these are some personal suggestions. And what we would like to suggest to you is what do you think of conclusions, recommendations like this - would you like to delete some, would you like to add some, would you like to amend some of these? And the process we suggest, because we have limited time available, that all your comments and views we will listen very carefully, and then the organizers will then put together a small group to finalize the conclusions and recommendations after our discussions today.

So with those remarks, I would like to open the floor for your views, comments and suggestions.

ORGANIZATION

1.Organizer

Shiga Prefecture

UNEP International Environmental Technology Centre (UNEP-IETC)

2.Co-organizers

Japanese Environment Agency

Internaitonal Lake Environment Committee Foundation (ILEC)

3.Cooperation

Aeon Group Environment Foudation

4.Co-sponsors

Japanese National Land Agency

Japanese Ministry of Foreign Affairs

Japanese Ministry of Agriculture, Forestry and Fisheries

Japanese Ministry of Construction

Japanese Ministry of Home Affairs

Water Resources Development Public Corporation (Japan)

Japan International Cooperation Agency (JICA)

Overseas Economic Cooperation Fund (OECF)

Lake Biwa - Yodo River Water Quality Preservation Organization (Japan)

United Nations University (UNU)

UN Centre for Regional Development (UNCRD)

UN Development Programme (UNDP)

International Association on Water Quality (IAWQ)

International Water Resources Association (IWRA)

Society of International Limnologist (SIL)

World Water Council (WWC)

Japan Society on Water Environment

Japan Society of Civil Engineers

5.Financial Contribution

The Japan Trust for Global Environment

Council of Local Authorities for International Relations

SCHEDULE
OPEN FORUM

DAY ONE Monday 25 November (Otsu Prince Hotel)

9:30	Registration
10:00	Opening Ceremony
11:30	Keynote Speeches (Falkenmark and, Biswas and Tortajada)
13:00	Lunch
13:45	Session I 'Water Management in Japan'
15:45	Special session 'Future of Basin Management of Lake Biwa and Yodo River'
- 17:45	

DAY TWO Tuesday 26 November (Lake Biwa Museum)

9:30	Session II 'Water Management of National Contexts'
13:00	Lunch
14:00	Special Lecture (H. Kawanabe)
14:30	Session III 'International Cooperation'
- 18:00	

DAY THREE Wednesday 27 November 1996 (Lake Biwa Museum)

9:30	Session IV 'Technology for Water Management'
12:00	Lunch
13:00	1st Panel Discussion 'Technology for Developing Countries'
15:00	2nd Panel Discussion 'Soft Options or Hard Choices'
18:00	Closing Session 'Conclusion and Recommendations'
- 18:15	

DAY ONE Monday 25 November 1996 (Otsu Prince Hotel)

10:00	Opening Ceremony	
	Addresses	Governor M. Inaba, Shiga Prefecture Executive Director, UNEP Government of Japan Environment Agency Ministry of Construction
	Guidance to participants	S. Matsui (coordinator)
11:00	Break	
11:30	Keynote Speeches (chair: M. Watanabe)	
		M. Falkenmark (Sweden) "Global Water Crisis: Differences in Regional Predicaments"
12:15		A.K. Biswas (Canada) and C. Tortajada (Mexico) "Absence of Water in the International Political Agenda"
13:00	Lunch	
13:45	Session I "Water Management in Japan" (chair: A. Morishima)	
		Y. Takahashi (Japan) "One Hundred Years of River Modernization - Water Quantity Management in Japan"
		N. Tambo (Japan)"Water Quality Management in Japan"
15:15	Break	
15:45	Special Session "Future of basin management of Lake Biwa and Yodo River" (chair: H. Imamoto)	
		M. Okano (Japan) "History of Lake Biwa & Yodo River's water issues and the new trend"
		M. Nakamura (Japan) "The emerging Lake Biwa issues"
		M. Otsuki (Japan) "Promotion of regional water quality improvement programmes at Lake Biwa and Yodo River"
		X. Jin (China) "Water quality status of Lake Taihu"
17:45	Break	
18:00	Reception and Special Lecture	
		T. Kira (ILEC) "ILEC's first 10 years"
-20:00		

DAY TWO Tuesday 26 November 1996 (Lake Biwa Museum Conference Room)

9:30	Session II "Water Management in National Contexts" (Chair: M. Falkenmark)	
		O. Ünver (Turkey) "Water Resources-Based Socioeconomic Development Euphrates-Tigris Basin in Southeast Turkey"
		H. Garduño (Mexico) "Water Use Management in Mexico"
		B. Braga (Brazil) "Integrated Water Resources Management in the Metropolitan Region of São Paulo"
11:00	Break	
11:30	(Chair:H. Garduño)	
		M. Chitale (India) "Management of Irrigation and Drainage in India"
		F. El-Shibini (Egypt) "Water Management in Egypt"
		Y. Yagi (Japan)"Water Quality Monitoring of Lakes, Rivers and Coastal Waters, and Framework Conservation Policy in Japan"
13:00	Lunch	
14:00	Special lecture (Chair: M. Nakamura)	
		H. Kawanabe "Our Expectations of the Lake Biwa Museum"
14:30	Session III "International Cooperation" (Chair: M. Chitale)	
		W. Ripl (Germany) "Dissolved Matter Transport to the Sea Limiting Ecological Sustainability"
		Y. Matoba (Mekong River Comm) "Mekong River Basin and Multinational Coordination "
		S. Bjork (Sweden) "River Basins as Ecological Units"
16:00	Break	
16:20	(Chair: S. Jørgensen)	
- 18:00		A. Milburn (UK) "A Global Freshwater Convention"
		W. Rast (UNEP) "International Cooperation for Global Water Problems"
		A. Morishima (Japan) "International Cooperation for Global Water Environment Conservation"

DAY THREE Wednesday 27 November 1996 (Lake Biwa Museum Conference Room)

9:30	Session IV "Technology for Water Management" (chair: M. Hashimoto)	
		S. Jørgensen (Denmark) "Application of Eco-technology in Water Management"
		T. Asano (USA) "Reclamated Wastewater as a Water Resource"
10:30	Break	
11:00	(Chair: T. Asano)	
		M. O'Neill (UNDP) "Successful Approaches to Creating and Maintaining Sustainable Water Technologies"
		G. Whiteside (Nepal) "Community Water Supplies in Developing Countries"
12:00	Lunch	
13:00	1st Panel Discussion	"Technology for Developing Countries"
		Chair: V. Santiago (UNEP-IETC)
		Panel: W. Rast (UNEP) T. Asano (USA)
		M. Chitale (India)
		H. Garduño (Mexico)
		O. Ünver (Turkey)
		G. Whiteside (Nepal)
14:45	Break	
15:00	2nd Panel Discussion	"Soft Options or Hard Choices"
		Chair: S. Matsui (Japan)
		Panel:
		M. Falkenmark (Sweden)
		G. Golubev (Russia)
		S. Jørgensen (Denmark)
		M. O'Neill (UNDP)
		Y. Takahashi (Japan)
16:45	Break	
17:00	Closing session "Conclusions and Recommendations"	
		Chair: A. K. Biswas (Canada)
18:00 -18:15	Closing address:	K. Yamazaki, ILEC Director General

Profiles

Ms. Elizabeth Dowdeswell
Executive Director
United Nations Environment
Programme

Prof. Norihito Tambo
President
Hokkaido University
Japan

Prof. Malin Falkenmark
Swedish Natural Resources
Research Council
Rapporteur-General, UN
World Water Conference
Sweden

Mr. Masahisa Okano
Director
River Department, Kinki Construction
Bureau
Ministry of Construction
Japan

Prof. Asit K. Biswas
President, International Society of
Ecological Modelling
Past President, International Water
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Senior Adviser to 17 governments and
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Vice-Chairman, Committee on
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Profiles

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Prof. Dr. Wilhelm Ripl
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Dr. Madhav A. Chitale
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International Commission
on Irrigation and Drainage
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Mr. Yasunobu Matoba
Chief Executive Officer
Mekong River Commission Secretariat

Prof. Fouad El-Shibini
National Water Research Centre
Egypt

Prof. Sven Bjork
Department of Limnology
University of Lund
Sweden

Profiles

Dr. Anthony Milburn
Executive Director
International Association on Water Quality
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Ms. Maureen O'Neill
Senior Water Policy Adviser
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United Nations Development Programme
USA

Dr. Walter Rast
Deputy Director
Water Branch
UNEP

Mr. Greg Whiteside
Country Representative to Nepal
WaterAid
Nepal

Prof. Akio Morishima
Sophia University
Japan

Prof. Genady N. Golubev
Moscow State University
Russia

Prof. Sven Jorgensen
Department of Environmental Chemistry
Royal Danish School of Pharmacy
Denmark

Dr. Vicente Santiago
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Prof. Takashi Asano
Adjunct Professor
Department of Civil and Environmental Engineering
University of California, Davis
USA

Prof. Saburo Matusi
University of Kyoto
ILEC Scientific Committee Member
Japan

Shiga Prefecture

Efforts made for the conservation of the environment and the promotion of ecology

Shiga cradles Lake Biwa in its bosom and the residents lived for centuries keeping harmonious relations with the nature, above all with aquatic environment in and around the lake. In response to emerging environmental problems including the degradation of water quality in Lake Biwa in the 1960s and 1970s, the prefectural government has taken various measures for conserving aquatic environments such as the enforcement of the "Prefectural Ordinance Concerning Prevention of Eutrophication of Lake Biwa". Moreover, in 1984, the prefectural government instituted and held the World Lake Conference (LECS'84), and in 1989, the international symposium "Ecology for Tomorrow" to mark the tenth anniversary of the promulgation of the Ordinance. Furthermore, with the growing world's concern over global environmental problems, the government and citizens of Shiga are now coping with these problems on the basis of their accumulated experience, with emphasis on the role of natural ecosystems.

Conserving the Water Quality of Lake Biwa

In an attempt to restore the beauty of Lake Biwa, the "Ordinance Concerning the Prevention of Eutrophication of Lake Biwa" of 1979 was enacted by the prefectural government, with great support from the prefectural residents. Water quality conservation efforts are continuing through various structural and nonstructural measures. Urban sewerage and rural wastewater management systems are examples of the former, and the public education and promotion activities involving a large number of citizen groups are examples of the latter.

Conserving Lakeshore Ecosystems

A new prefecural ordinance specifically aiming at the protection and restoration of reed beds around Lake Biwa was enacted in 1992. The lake area was also designated as a wetland of international importance within the framework of the Ramsar Convension in 1993.

Environment Agency, Government of Japan

Introduction of the Water Environment Management Policy

During the over 25 years after the foundation of the Environmental Agency in 1971, the environmental situation at both the national and global level has changed drastically.

In Japan, the Environment Administration was initially implemented under the Basic Law for Environmental Pollution Control and the Nature Conservation Law, and achieved considerable results in that context. However today our current socioeconomic systems and lifestyles based on huge amount of production, consumption, and disposal cause serious environmental problems both domestically and globally. In order to cope with these problems, conventional methods which focus on regulation have not always been sufficient. For the sake of it, the Basic Environment Law, which was enacted in November 1993, lays down basic principles and policy directions and provides the foundation upon which to implement a comprehensive environment policy.

Under the Basic Environment Law, the Basic Environment Plan which clarifies the long-term and comprehensive environment policy direction was decided by cabinet in December 1994. The plan sets four long-term objectives; building a socioeconomic system which fosters a sound material cycle; harmonious coexistence between human-kind and nature; participation by all sectors of society; and the promotion of international activities. The plan spells out not only policies to be taken by the government but also the role and activities expected of local governments, corporations, the public, and private organizations for achieving those objectives.

The Basic Environment Plan places "Conserving the Water Environment" among the policies under which we build a socioeconomic system which fosters a sound material cycle. The policy is being developed which is aimed at integrated conservation of water quality, quantity, aquatic biota, and near shore areas to maintain and enhance sound water circulation.
An Extract from Conservation of the Water Environment, the Basic Environment Plan is below.

Restricting the burden on aquatic environments to within nature's capacity for purification is important. Burdens on aquatic environments through the atmosphere and soil and the effects of deterioration of aquatic environments on the atmospheric and ecosystems must also be considered. To address these problems we must take an integrated view of conserving water quality, quantity, aquatic biota, and near shore areas. In this regard, policies shall be promoted to reduce burdens on aquatic environments at every stage of water utilization, to protect aquatic ecosystems, and to secure environmental safety.

The long-term objectives set by the Plan

【 Sound Material Cycle 】

The Plan aims at building a socioeconomic system fostering a sound material cycle with the maximum possible reduction of environmental loads, through promotion of recycling and increased efficiency in the use of resources and energy at all stages of socioeconomic activities from production and distribution to consumption and disposal, and through reduction and proper control of discharges to the environment.

【 Harmonious Coexistence 】

The plan aims at maintaining and restoring a healthy ecosystem and ensuring coexistence between humankind and nature through wise use of the environment-conserving outstanding natural environments, maintaining and restoring accessible natural environments, and managing wildlife, as well as promoting rich contact between people and nature.

【 Participation 】

In order to achieve a sound material cycle and harmonious coexistence, the Plan aims at building a society in which all parties participate actively and voluntarily in environmental conservation activities, cooperating with each other and sharing burdens fairly according to each party's impact on the environment, environmental benefits enjoyed, and ability to contribute to the protection of the environment.

【 International Activities 】

Aiming to only build a sustainable society generating little environmental load within Japan, the Plan will promote international activities through global cooperation, making use of our abilities, technology and experience, as deemed appropriate to Japan's presence in the global community.

International Lake Environment Committee Foundation (ILEC)

Today, the quality of water in a number of lakes around the world has degenerated to an extent unrecoverable by natural means of purification. Local industrial developments and population increase have affected the ecosystem of lakes, and therefore, their water quality. Lakes are now in danger of losing their long-standing natural functions. Unable to remain indifferent to such conditions, ILEC was formed in 1986 as an international NGO, and given legal status in 1987 by Environment Agency and the Ministry of Foreign Affairs, Japan. The Committee was organized with an aim to promote environmentally sound management of natural and man-made lakes and their environments consistent with sustainable development policies by promoting international research and investigation and by facilitating the exchange of findings and knowledge among the experts throughout the world. In addition, ILEC has been contributing since 1992 as a supporting foundation for the UNEP International Environmental Technology Centre.

Major Activities

(1) Collection and organization of data on the conditions of lakes throughout the world.
(2) Organization of training seminars on regional developing and lake environment conservation in developing countries.
(3) Preparation of guidelines for lake environment management.
(4) Assistance in planning and organization of conferences on lakes and their environments.
(5) Promotion of lake environmental education.
(6) Support for UNEP International Environmental Technology Centre.
(7) Publication of newsletters and journal.

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The UNEP International Environmental Technology Centre

The International Environmental Technology Centre (IETC) was established by the United Nations Environment Programme (UNEP) in April 1994. It has offices at two locations in Japan - Osaka City and Kusatsu, Shiga Prefecture.

The Centre's main function is to promote the application of Environmentally Sound Technologies (ESTs) in developing countries and countries with economies in transition. IETC pays specific attention to urban problems, such as sewage, air pollution, solid waste, noise, and to the management of freshwater basins.

IETC is supported in its operations by two Japanese foundations: The Global Environment Centre Foundation (GEC), which is based in Osaka and handles urban environmental problems; and the International Lake Environment Committee Foundation (ILEC), which is located in Shiga Prefecture and contributes accumulated knowledge on sustainable management of freshwater resources.

IETC's mandate is based on Agenda 21, which came out of the UNCED process. Consequently IETC pursues a result-oriented work plan revolving around three issues, namely: (1) Improving access to information on ESTs; (2) Fostering technology cooperation, partnerships, adoption and use of ESTs; and (3) Building endogenous capacity.

IETC has secured specific results that have established it as a Centre of Excellence in its areas of speciality. Its products include: an overview on existing information sources for ESTs; a database of information on ESTs; a regular newsletter, a technical publication series and other media materials creating public awareness and disseminating information on ESTs; Local Agenda 21 documents developed for selected cities in collaboration with the UNCHS (Habitat)/UNEP Sustainable Cities Programme (SCP); advisory services; Action Plans for sustainable management of selected lake/reservoir basins; training
needs assessment surveys in the field of decision-making on technology transfer and management of ESTs; design and implementation of pilot training programmes for adoption, application and operation of ESTs; training materials for technology management of large cities and freshwater basins; and others.

The Centre coordinates its activities with substantive organisations within the UN system. IETC also seeks partnerships with international and bilateral finance institutions, technical assistance organisations, the private, academic and non-governmental sectors, foundations and corporations.

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For Life on Earth

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