Lakes and Reservoirs as International Water Systems

Towards World Lake Vision

Edited by
Libor Jansky,
Mikiyasu Nakayama
and **Juha I. Uitto**

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Contributions from the UNU Workshop: Lakes and Reservoirs as Important Elements of International Water Systems held during the 9th International Conference on the Conservation and Management of Lakes, 14 November 2001, Otsu, Japan

Edited by Libor Jansky, Mikiyasu Nakayama and Juha I. Uitto

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Foreword

Water systems are sensitive barometers of the health of our planet. While water covers most of the earth's surface, not more than two percent of the water body consists of freshwater – and most of that is bound in polar icecaps. Freshwater in a liquid state is, indeed, very scarce. By UN estimates, some two-thirds of the world population will face water shortages by 2025, a situation aggravated both by the still-rapid growth of population and by a decrease in available freshwater supply. Entering the twenty-first century, the average per capita water supply is about one-third lower than that of 1970.

Greatly aggravating the problem is the fact that a great part of the world's available freshwater is concentrated in a relatively few large lake systems, many of which are shared by two or more countries. Yet, while the management of international river systems is a major concern to scientists and legal authorities, little attention has been paid to the nature of lakes as international water bodies.

Lakes are of great value to humankind. Systematically, three main categories of values can be distinguished: direct, indirect and symbolic values. The most obvious (direct) use of lakes is as a source for drinking water, irrigation, transportation, fishing and the water supply for households and industry. Additionally, water bodies are breeding grounds for migratory waterfowl and home to myriad species of flora and fauna. Indirect values imply water-retention mechanisms during flooding, impacts on local climate and sinks for wastewater discharges. Symbolic values include religious and spiritual purposes, and the references to water in the expressions of art.

Until recently, the menacing ecological, economic and social consequences of depleted water resources have been insufficiently understood. Oceans appeared too vast, rivers seemed too mighty, and fish occurred too plentifully to be at risk of being destroyed permanently. And despite their crucial importance, lakes have often been undervalued by scientists, ecologists, policy makers and the public as they focus mainly on water quality, wetland ecosystems, flora, fauna and catchment management.

However, growing population pressure implicates both enormous direct water use and collateral impacts (i.e., through construction activities, pollution transactions and the degrading of adjacent ecosystems). The intense human land use leads to increasing stress on lakes and, consequently, decreases their values to their flora and fauna as well as to humans. Decreased freshwater supply has resulted in destroyed precious aquatic habitats, threatened biodiversity and reduced food production. Therefore, water protection has become an increasingly vital task, often also to be addressed by geopolitical strategies where these water resources are shared by various countries. In 1997, the UN General Assembly called for the highest priority in regard to the demanding freshwater problems facing many regions, but especially the developing world.

Despite immense efforts made by the International Lake Environment Committee (ILEC) in organizing World Lake Conferences, designing guidelines on lake management and conducting training courses for young lake managers, the majority of the world's lakes remain unsustainably managed. This is due, in part, to an inappropriate communication of the principles to top-level decision makers.

To avert a major ecological and human tragedy, a strong political will and active collaboration between North and South, and East and West, must be promoted. Solutions to the most pressing transboundary threats must combine the use of sound sciences, technical innovations as well as managerial and policy solutions. Taking the marginalization of lakes into account, an adequate guide to master the complexities of international lake issues is urgently needed. Not only in this context, cooperation between the industrialized and developing regions needs to be enhanced. Industrialized countries need to adapt their official assistance programmes to the new challenges in the water sector.

Promoting the development of a comprehensive vision such as the World Lake Vision (WLV) will be an effective milestone towards the sustainable management of the world's lakes and reservoirs. I am, in this regard, very much pleased that the UNU has been collaborating with ILEC and other organizations in formulating the WLV, which is to be a major input for the Third World Water Forum, to be held in Japan in March 2003.

Prof. Dr. Hans van Ginkel
Rector
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Introduction

With the World Lake Vision towards the 3rd World Water Forum

The magnitude of stresses impairing the values of lakes around the world has led to various management responses. In addition to pollution control and restoration measures, several strategies to deal with water problems relating to the health and safety of human civilizations have been implemented on a global scale. Of special importance are the efforts undertaken by the World Water Council (WWC), which promotes international collaboration on water management and established the World Water Forum (WWF) as an effective means to promote relevant information dissemination and communication.

At the 2nd WWF in March 2000, the WWC presented the World Water Vision (Cosgrove and Rijsberman, 2000), providing a framework for global freshwater management for international agencies and national governments. Being a direct response to the freshwater crisis, it mainly deals with water shortages due to over-population, urbanization and industrialization along with sanitation problems. Thus, the World Water Vision does not supply appropriate guidelines for sustainable lake management. Therefore, a World Lake Vision (WLV) that reinforces the shortcomings of current management approaches is strongly needed.

A “vision” depicts an extensive set of targets and implementation strategies. Concerning lakes, two different scopes can be distinguished: individual lake and global-scale visions. While an individual lake vision (e.g., Lake Biwa’s “Mother Lake 21”) embodies long-term measures for a single lake, the World Lake Vision will outline principles for the future management of international lakes. The WLV, therefore, relates to the priority research areas cited in Chapter 18 of Agenda 21, “Protection of the Quality and Supply of Freshwater Resources: Application of Integrated Approaches to the Development, Management and Use of Water Resources.” By establishing a close interrelation between the two scopes, the over-arching WLV will provide guidelines for the creation of individual lake visions that, at the same time, will contribute principles and cases to global management strategies.

The aim of the WLV is to promote environmental conservation as well as the welfare and security of human civilizations. In this regard, national policy environments have to be improved to facilitate efficient lake management in a holistic manner. The WLV will primarily target decision makers, at local as well as national levels. These decision makers should better appreciate the sensitivity of dealing with international lakes so that sectoral policies and activities can meet the challenge of transboundary issues. Secondary targets are the general public as well as researchers who may not be fully aware of the implications arising from the transnational nature of large lake systems. The way in which the WLV's contents are mirrored in public considerations, transdisciplinary research activities and decision-making processes may indicate the benefits of the new concept.

The WLV should draw attention, at least, to the following points of view (Ballatore and Muhandiki, in press):

1. Visionary statement,
2. Values of lakes,
3. Stress on lakes,
4. Principles for lake management,
5. Cases of implementation of principles, and
6. Guidelines for implementation of principles.

The creation of a shared vision should raise awareness among all stakeholders concerned with lake issues, including national and international organizations as well as the general public and bureaucrats. The vision will bridge the gap between sciences and policy-making processes requiring a coordinated effort to implement current scientific knowledge into the management. The problem is not a lack of understanding the nature and environment of lakes, but rather the limited exertions to implement this knowledge into practice.

Furthermore, conflicts are inherent in the use of water resources. The WLV, therefore, will call for increased efforts on conflict resolution. In order to ensure a progressing development and an effective implementation of the WLV, the meaningful participation of all stakeholders within a collaborative surrounding is an essential prerequisite. By integrating all responses into one common task, the currently existing overlap and fragmentation of management measures should be alleviated.

The development of the WLV requires a pronounced perception regarding the need to balance scientific issues along with political concerns and public demands within a demanding environment of interacting interests. The United Nations University (UNU), as an independent academic institution, is well placed to deal with the sensitive political and legal issues and may, thus, considerably contribute to the new concept of the WLV.

Academic activities should enhance and ferment operational tools, which range from theory development to application to specific cases of appropriate lake management strategies. Especially during recent years, UNU's research has addressed several transboundary issues with special emphasis on advancing collaboration on international water bodies. The regional focus includes southern Africa and the Ganges-Brahmaputra-Meghna river basin as well as Central Eurasia. The UNU International Network on Water, Environment and Health (UNU/INWEH) has helped to address these concerns through improved training on freshwater management, on-the-ground water projects and integrated watershed management. As with other components of the UNU, the INWEH facility aims to build institutional capacities and networks in developing regions which are flexible enough to assemble teams from different disciplines and nations with precise skills and expertise on international waters. By offering these great advantages, the UNU system may act as a locomotive to promote research activities on the new vision concept.

A special focus should be the synthesis of past findings and lessons, since many case studies have been presented in a variety of symposia, workshops and conferences, but very limited attention has been paid to future requirements on transboundary lake management. A synthesis may include various viewpoints, while security issues – based on the challenging political and socio-economic changes in developing regions – should be given high priority.

As an initial step towards the goal to take responsibility for international lake systems, the UNU organized a workshop focusing on international aspects of integrated lake management conducted within the 9th International Conference on the Conservation and Management of Lakes in November 2001 in Otsu, Japan. In this workshop, experts on the management of international water systems devoted their speeches to a range of regional aspects.

The innovative examples identify models for potential replication based on findings of the workshop. The principles of sustainable lake management are illustrated by selected case studies in the following chapters, with special emphasis given to five developing regions: Africa, South America, the former Soviet Union, Eastern Europe and South Asia.

The Caspian Sea is an excellent example of problem solution through transboundary collaboration on international lake issues. As a result of a sharp and unexpected rise of the water level, serious concern evolved during the 1980s through the 1990s regarding the ecological, economic and social impacts. A solution was sought in regulating the water consumption patterns within the Volga river basin of Russia. Managing the lake within the focus of a large national river system was a crucial diplomatic challenge. The complex political situation in Russia and the other basin countries – Kazakhstan, Turkmenistan, Iran and Azerbaijan – stresses the urgent need for international cooperation.

The situation of the Mekong River basin further accentuates the call for collaborative mechanisms. Cooperation and information disclosure were highly promoted by the Mekong Committee (now the Mekong River Commission). However, although applauded as the “Mekong Spirit,” it has not always proved to be an effective instrument for resolving major conflicts among riparian countries. Also, while environmental concerns about international lakes in Africa have been addressed by the Global Environmental Facility (GEF) for the past several years, these lakes still need further efforts both nationally and internationally.

The strategies towards sustainable lake management on a global scale as outlined in the World Lake Vision will strongly support the world community’s exertions to preserve the natural environment and sources of life. The International Lake Environment Committee (ILEC) coordinates the vision development process, which is expected to culminate at the 3rd WWF, heralding the “century of water” in 2003 in Kyoto, Japan.

Prof. Dr. Motoyuki Suzuki
Vice Rector
United Nations University

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Emerging Issues in Sustainable Water Resources Management in Africa

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Introduction

The world as a whole is facing increasing stringencies in freshwater availability. Africa, in particular, is emerging as a potentially water-stressed continent of the future. Apart from the equatorial humid areas, most of Africa can be described as sub-humid to arid. A combination of weak economies and dependence on primary natural resources for daily subsistence has led to high levels of environmental deterioration, including the most extensive human-induced desertification process in modern times. Now superimposed on these trends are global warming concerns. Major rivers of Africa either already show trends of run-off reduction or are expected to do so. In southern Africa, the mean annual run-off of some major rivers is estimated to decline by as much as 20 to 45 per cent within the next 50 years (Arnell, 1999).

The perceived water stress – and, in particular, the seasonality of hydrological processes – has led to massive reservoir constructions, particularly in southern Africa. Initially designed to guarantee adequate supply even in drought periods, these water storage facilities now experience episodic failures to meet demand. Urban drift, meanwhile, has resulted in most African cities being overwhelmed by problems of waste management, leading to large export of eutrophication waste and other industrial pollutants. Consequently, an increasing number lakes and reservoirs are now eutrophic or on the threshold of eutrophication.

The mean summer temperatures of tropical African lakes exceed 25°C, and global warming could raise this mean temperature to over 30°C – thus creating extended periods of stratification, which has yet little understood consequences for biodiversity. These developments are taking place against a background of weak environmental management institutions. Six scenarios on the future development path of Africa reviewed by the United Nations Environment Programme (1999a) indicate poor governance at least for the next quarter-century. Yet good environmental stewardship cannot wait for that length of time, as degraded water resources can be itself a cause for further national and regional conflict.

Water and population

Although in the past decade-and-a-half the growth rate of African populations has fallen below three per cent per annum, many African states still display relatively high growth rates, taking into account their economic development. Table 1 (World Bank, 1999) shows the wide range of development stages in the Nile basin states. Seventy percent of these states have growth rates of 2.5 per cent per annum or more, in comparison to most developed countries which have growth rates generally below 1 per cent per annum. As the table shows, on average the population doubles about every quarter century, ranging from less than 5 years in Rwanda to nearly 40 years in Egypt. The median period is about 26 years.

Table 1. Population growth in the Nile basin states

State	Total population (million)	Population growth (%)	Doubling period (yrs)	Urban population growth (%)	Urban doubling (yrs)	Safe water population (%)	GDP per capita (US$)
Burundi	6	2.2	31.5	6.0	11.6	58	140
DRC	47	3.2	21.7	4.3	16.1	N/A	110
Egypt	60	1.8	38.5	2.4	28.9	84	1200
Eritrea	4	2.8	24.8	4.6	15.1	7	230
Ethiopia	60	2.6	26.7	5.3	13.1	26	110
Kenya	29	2.5	27.7	5.5	12.6	45	340
Rwanda	8	16.0	4.3	17.7	3.9	N/A	210
Sudan	28	2.1	33.0	5.0	13.9	60	290
Tanzania	31	2.7	25.7	5.5	12.6	49	210
Uganda	20	2.9	23.9	5.5	12.6	N/A	330
Average		3.9	25.8	6.2	14.0	47	317

Source: Adapted from World Bank, 1999.

In the urban environment, the rate of population growth is even greater. Here, the median doubling period is just over a decade, with a mean growth rate of 6.2 per cent per annum. The implication of these data is that the planning scenario for water resources management (water supply, wastewater treatment, pollution control, etc.) has to be revisited every twenty years or so at national level, but as often as every 10 years at municipal level.

In contrast to increasing demand on water, the past 40 years have seen declining run-off from Africa's major rivers. Figure 1 shows the time series of five-year moving average precipitation anomalies in West Africa. These data show sustained diminution in the precipitation hydrological income for the region.

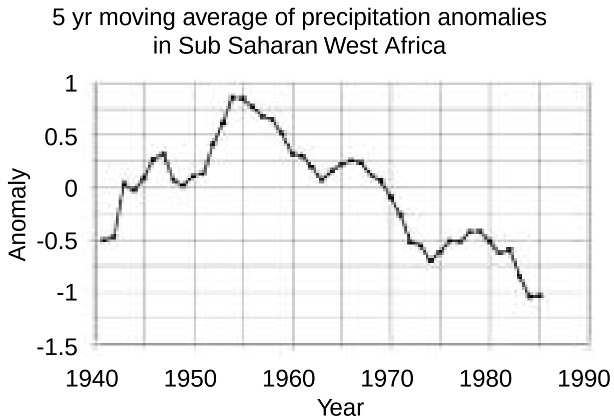


Figure 1. Declining precipitation in West Africa

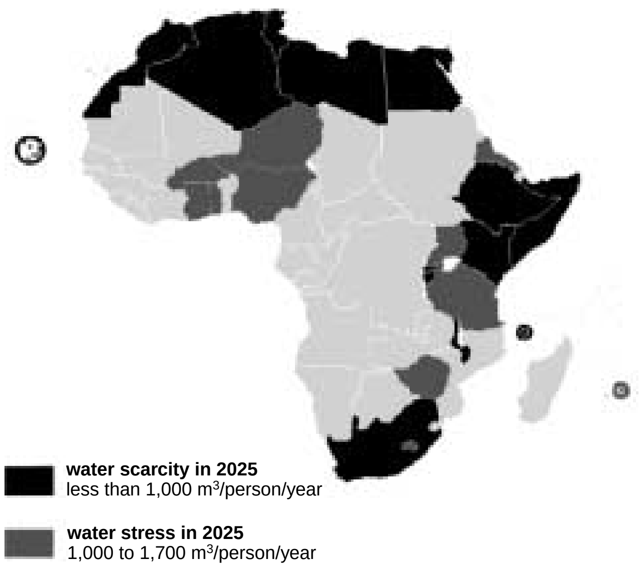


Figure 2. Projected water scarcity and water stress on the African continent

Consequently, a large part of the African continent is now experiencing or will soon experience water supply stress (figure 2). This is especially evident in North Africa, East Africa and southern Africa. This water supply stress situation is a result of growing demand with, in several basins, diminishing supply.

A combination of poor infrastructural development and declining water availability appears to be associated with declining food production (UNEP, 1999c). While the index of food production for the world for the period 1960 to 1995 rose by just over 20 index points, that of Africa fell by about 10 points in the same period. This decline was especially evident in the period subsequent to 1975, when (as shown in figure 3) precipitation anomalies fell below the long-term mean. This decline in food production has resulted in chronic undernourishment, especially in drought-prone areas (table 2). Thus, Africa has been a persistent recipient of food aid for most of the last quarter of the last century.

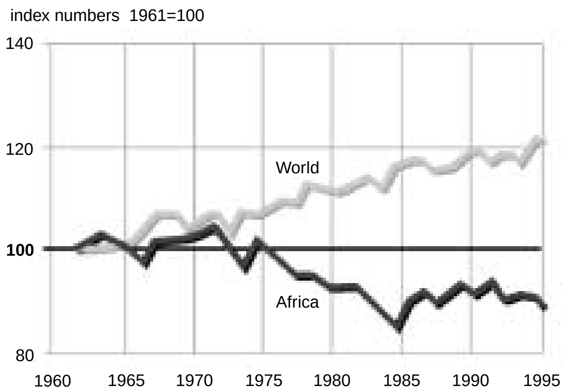


Figure 3. Trends in food production in Africa and the world

Table 2. Undernourishment in Africa

	No. of people (million)	% of population	
Region	1996/7	1979/81	1995/97
Central Africa	35.6	36	48
East and Southern Africa	112.9	33.5	43
West Africa	31.1	40	16
North Africa	5.4	8	4

Source: Adapted from IPCC 2001.

Future issues

Against this background, let us surmise what the future holds for Africa in respect to water resources-related issues. What are the major emerging issues?

Climate change

Climate change is a global phenomenon that will impact on all continents and nations. Africa's uniqueness in the climate change scenarios is that the IPCC Third Assessment ranked it as the continent most vulnerable to climate change. One of the causes of the future vulnerability of Africa arises from projected impacts on its water resources. Indeed, this may be said to be the underpinning driver to Africa's vulnerability.

Water availability – Table 3, from the IPCC 2001 Third Assessment (Desanker and Magadza, 2001), shows projected changes in hydrological performance of Africa's major river basins. Apart from the River Zaire, most basins show a wide range of scenario outcomes, most pointedly the southern African basins of the Ruvuma, Zambezi and Limpopo rivers. These data suggest further future stresses in the water supply of Africa due to global warming, exacerbated by land use practices that cause desertification. Projected water availability estimates (Gleick, 1993) are indicated in table 4.

In sub-humid areas, current adaptation to river flow variability is the

Table 3. Projected changes in hydrological performance of Africa's major river basins

Basin	% change in precipitation	% change in potential evaporation	% change in run-off
Nile	10	10	0
Niger	10	10	10
Volta	0	4 to -5	0 to -15
Schebeli	-5 to 18	10 to 15	-10 to 40
Zaire	10	10 to 18	10 to 15
Ogooue	-2 to 20	10	-20 to 25
Rufiji	-10 to 10	20	-10 to 10
Zambezi	-10 to -20	10 to 25	-26 to -40
Ruvuma	-10 to 5	25	-30 to-40
Limpopo	-5 to -15	5 to 20	-25 to -35
Orange	-5 to 5	4 to 10	-10 to 10

Source: IPCC 2001, Table 10-1.

Note: Estimates of ranges constructed from Arnell (1999, Figure 3). In some basins, estimates given by the HadCM3 simulation have been excluded where they appear to be outliers.

Table 4. Likely changes in water availability for some African countries

Country	Per capita water availability 1990	Per capita water availability 2025
Algeria	750	380
Burundi	660	280
Cape Verde	500	220
Comoros	2040	790
Djiboute	750	270
Egypt	1070	620
Ethiopia	2360	980
Kenya	590	190
Lesotho	2220	930
Libya	160	60
Morocco	1200	680
Nigeria	2660	1000
Rwanda	880	350
Somalia	1510	610
S, Africa	1420	790
Tanzania	2780	900
Tunisia	530	330

construction of reservoirs for water storage for irrigation, urban supply and hydroelectric generation. Practically all the major reservoirs of Africa, however, were designed using hydrological records of the first half of the twentieth century. As the data shown in figure 4 (Magadza, 1996) suggest, these reservoirs may no longer be able to satisfy their design performance due to a combination of increased water demand as well as altered hydrology. The figure shows that in a one-season drought cycle, the storage

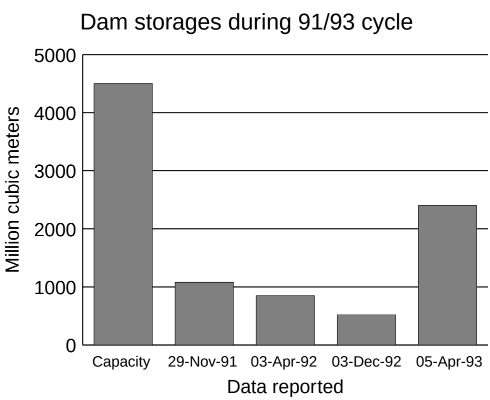
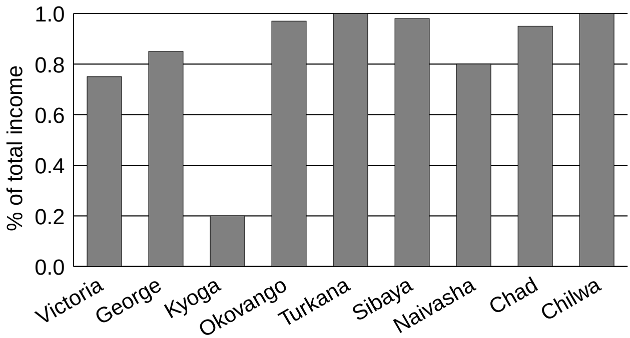


Figure 4. Changes in storage of Zimbabwe reservoirs following the 1991-92 drought

capacity of Zimbabwe reservoirs declined to less than 10 per cent of full capacity.

Recent water balance studies have shown that some of the major lakes have a very delicate balance between hydrological income and outflow (figure 5). In the majority of lakes, over 80 per cent of the run-off from the lakes' catchments is lost through evaporation. Consequently, only a small fraction appears as outflow. Increased evaporation due to global warming could drastically reduce outflow from the lakes, threatening the economic and environmental services offered by the rivers that emanate from these lakes. Indeed, paleontological evidence has revealed that only 14,000 years ago, Lake Victoria was pastureland, while very recent history has seen both Lake Malawi and Lake Tanganyika become closed-basin lakes with no outflows (Calder et al., 1995).

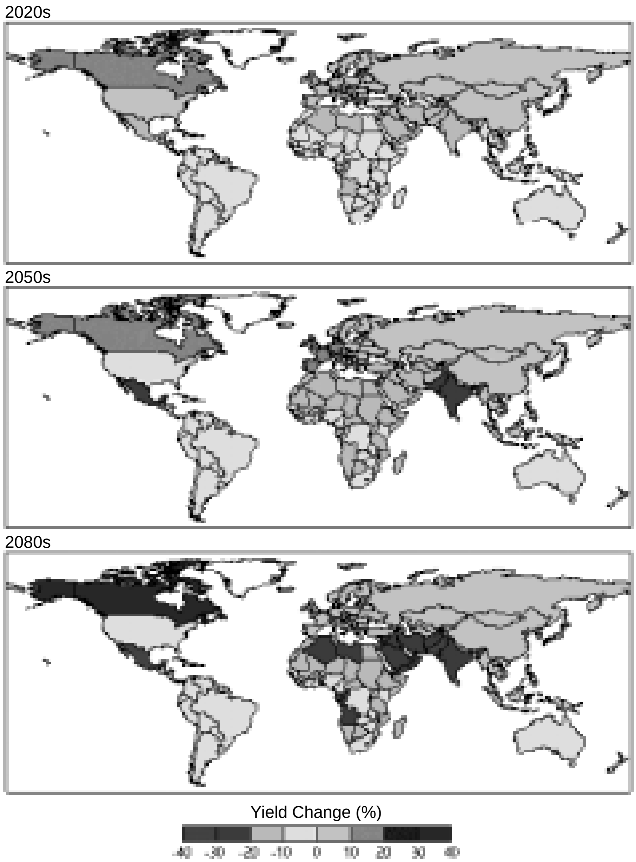


(Constructed from Talling and Lemoalle, 1998.)

Figure 5. Evapotranspiration losses as percentages of total hydrological income in selected African lakes

Impact on food production – This deterioration in water supply has social, economic, health and ecological consequences. Historical data on the food production status of Africa have shown declining yields for most of the last half of the twentieth century, and crop models indicate a further decline in yields attributable to global warming. Thus, the impacts of global warming, in the absence of significant economic development and agricultural technology, are likely to exacerbate the already precarious economic and nutritional conditions in large areas of Africa.

Compare table 2, which gives an indication of the level of malnutrition in Africa, with figure 6, which shows projected changes in food production deduced from climate change scenarios. This figure shows projected crop yields for wheat, rice and maize, with the effects of carbon dioxide fertilization taken into account. The data suggests that for the African continent, there will be significant declines for all three crops for the modelled period. Unless there is a fundamental change in the development pathway of Africa, the likely impacts of climate change will be a further deterioration of the quality of life in Africa. The emerging issue here is the contrast between urgency of the developing water crisis and the apparent ill-adapted status of many African states to address these threats.



Source: Jackson Institute, University College London/Goddard Institute for Space Studies/International Institute for Applied Systems Analysis

Figure 6. Projected changes in food production due to global warming

Economic impacts – The few studies that have been made to assess the impact of climate change, using current drought episodes as proxies, indicate significant economic costs. In the last half-century, Africa has invested heavily in its water resources for irrigation and hydroelectricity. Where the economies are weak, however, the impacts of global warming, through the curtailment of water resources services, can constitute major economic setbacks.[1]

The projected changes in runoff due to global warming are particularly important for future reservoir management. Because, as has been mentioned, Africa's major reservoirs were designed based on hydrological records of the first half of the twentieth century, increases in water demand, drought frequencies, and evaporative losses may render many of them inadequate for the purposes for which they were designed. As figure 4 shows, by end of the 1991–92 drought cycle, Zimbabwe's water reserves had diminished to about 10 per cent of installed capacity, and large irrigation estates in the southeast of the country lost large proportions of their annual production. Other reports of energy supply disruption due to drought have come from Ghana, Nigeria, Kenya, Tanzania and Namibia. It is clear that unless alternate energy sources are developed, the development fabrics of several African states dependent on hydropower are threatened at a basic level.

Impacts on biodiversity – Besides open-basin lakes, Africa has many closed-basin lakes, which are an important component of local economies. In Malawi, for example, as much as 40 per cent of fish (the main protein supply for that country) comes from Lake Chilwa. But this lake, in the past four decades, has dried up three times, each time placing in jeopardy thousands of fisher folk whose livelihood depends on the fishery industry of the lake. Similarly, in East Africa the rift valley lakes of Naivasha and Nakuru have shown disturbing water level declines during recent droughts. The horticulture industry associated with Lake Naivasha is a major contributor to the economy of the area and to the nation in foreign currency earnings.

These shallow lakes, often home to endemic species, also play an important role in biodiversity conservation. The saline lakes, such as Lake

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1 The economic impact due to curtailment of the hydropower generation from Lake Kariba, resulting from the 1991/92 drought, for example, was estimated to be some US$102 million dollars loss in GDP, US$36 million loss in export earnings and loss of 3000 jobs (Benson and Clay, 1998).

Nakuru, Crate Lake in Kenya and Lake Abiata in Ethiopia, are invaluable habitats for the flamingos, which do not occur in any other habitat.

Shallow wetlands, such as the Okovango in Botswana, Lake Bangweulu in Zambia, the Nile Sud in Sudan, the internal Niger delta and Lake Chad, are particularly sensitive to changes in water balance. The gradual drying up of the Chobe wetlands due to reduced flooding of the Zambezi, for example, resulted in drastic reduction of wetland vertebrate populations.

The human impact

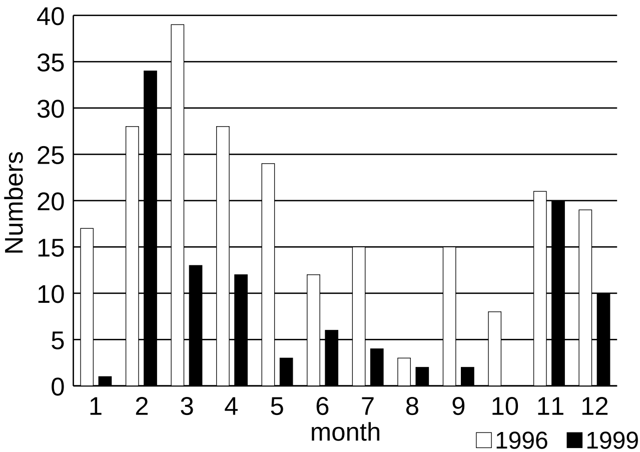
Land use – In 1994, Africa consumed 0.4 billion cubic meters of fuel wood. Overall, the African loss of forest area is between 2 and 5 per cent per annum. Poor agricultural practices, especially in sub-humid southern Africa, necessitate the clearing of additional land for cropping as soils become infertile. This continual loss of forest cover results in desertification.

Of particular relevance to water resources management is the increase in silt loads. The life expectancy of most medium-size reservoirs in Zimbabwe, for example, has decreased to under 15 years (Magadza, 1984). The hydroelectricity generation capacity of Tana River cascade in Kenya has also been greatly compromised by siltation, and the system's response to even mild drought is a severe shortage of electricity supply. This combination of increasing urbanization (with a doubling period of less than twenty years), diminishing reservoir storage capacities and global warming impacts is potentially ruinous to development prospects of sub-humid Africa, especially East and southern Africa.

Pollution – The pace of urbanization has often outpaced the institutional capacity to provide civic services such as waste management. Consequently, many urban populations suffer from inadequate wastewater treatment facilities and solid waste management. Table 5 (Magadza and Mukwashi, in prep.) shows phosphorus and nitrogen export in surface run-off from Harare suburbs, while figure 7 shows the incidence of bloody diarrhoea in the urban environs of Harare due to contact with polluted street run-off. This surface run-off ends up in the local reservoirs, causing severe eutrophication that invariably leads to the use of herbicides when aquatic weeds, such as *Eichhornia*, invade lakes and reservoirs.

Table 5. Phosphorus and nitrogen export in surface run-off from Harare suburbs

Suburb	Residential type	P export (metric tons)	N export (metric tons)
Umswindale	Low density	0.02	0.25
Gwebi	Low density	0.12	1.00
Kuwadzana ext	Low density	0.52	2.87
Marimba	Mixed/Indust.	0.38	3.55
Mukuvisi	Mixed/Indust.	15.03	50.36
Budiriro	High density	1.39	8.48
Epworth	High density	17.45	52.92
Glenview	High density	43.55	143.81



This bloody diarrhoea is associated with contact with contaminated surface water run-off. The lower incidences in 1999 reflect lower attendance at state clinics due to a rise in the cost of accessing medical services.

Figure 7. Incidence of bloody diarrhoea in 5-year-old children in a Harare high-density suburb

In addition, the inability of urban settlements to absorb the employment needs of inmigrants results in what is euphemistically called the “infromal sector”: various homestead levels of industry that normally are not supervised by environmental hygiene state institutions. This results in an unspecified range of pollutants entring the water system.

An example is the spillage of BCB oils into waterways of Zimbawe by scrap metal dealers. Table 6 shows the level of PCB and DDT and their derivatives in mother’s milk in three urban centres of Zimbabwe. While it may not be possible to conclusively attribute this PCB to the spillages, it can be noted that in the urban centres of Kadoma and Esigodini there were high spillages of the contaminant, while the remote town of Kariba would have received the contaminant through its inflows (which orginate in urban areas).

Table 6. Comparative amounts of DDT, DDT derivatives and PCB in mother's milk

Area	Characteristics of land use	Mean Age of mothers	Sum_PCB	pp-DDE	Pp-DDT	Sum DDT	Ratio DDT/DDE
Kariba	DDT for vector control	23	2.78	13606	9080	25259	0.6
Kadoma	Cotton	22	59.55	5049	1254	7047	0.2
Esigodini	Subsistence farming	25	13.27	1176	250	1607	0.22

Source: Adapted from Chikuni et al. 1997.

Note: Concentration in ng g-1 milk fat

While the eutrophication of medium-sized resorvoirs has been known for some time in Africa , as exmplified by the accounts of Lake Chivero and the Hartebeesteport Dam in South Africa, the emerging issue is that eutrophication and water pollution may now be affecting large lakes and reservoirs. For the past five years, the water hyacinth problem in Lake Victoria has been on the increase. On Lake Kariba, data indicates that the total phosphorus level in that reservoir may have reached the eutrophic threshold. This has also been accompanied by outbreaks of water hyacinth, which has had to be controlled by the herbicide 2.4-D.

The important issue here is that while technologies exist for restoration of medium-size reservoirs (vide Lake Chivero, circa 1980; Magadza, 1994), the mangement of water pollution and eutrophication on large shared-water bodies in the current technological and institutional capacity setting of Africa is likely to be problematic.

No shared lake or reservoir in Africa is administed under an international treaty that has legal force, *ipso facto;* the exisiting understandings, such as the new Lake Victoria Fisheries Authority and the SADC Protocol on Shared Waters, are more operational frameworks rather than legal treaties. Further, it should be noted that current protocols, although supported by participating parties, have been historically inaugurated at the instigation of some third party, such as UNEP or other donor agencies. The crucial step of transiting to legal treaties, with well-stated obligations, liabilities and priveleges, is an initiative made by the participating states themselves. Even then, however, the will to adhere to such treaties will need a level of political accountability that yet has to evolve in most of Africa. This is a critical transition that UNEP (2001) has identfied as a necessary step.

Conclusion

As we have noted in this brief discussion, in Africa there is a mismatch between population growth (and, in particular, urbanization) and the water resources. In addition, climate change is likely to impose an additional constraint on economic and social development options, due to diminished water resources availability in most of sub-humid Africa.

We have also noted the already inadequate provisions for safe water in most African rural and urban communities and, in particular, the disproportionate rate of urbanization to water supply infrastructure facilities in urban areas. Water pollution, especially eutrophication, and detrimental land use practices will increasingly denigrate the economic value of water.

These trends occur in the context of institutional and administrative inadequacies and, in particular, weak protocols on shared waters. The projected trajectory of the evolution of appropriate governance from a number of scenarios is circa 2025 to 2050 (Achebe et al., 1990). This is also the IPCC projection of when climate change impacts will become increasingly manifest. Africa has been cited as having the lowest adaptive capacity to climate change, and therefore is the most vulnerable to such change. The emerging picture is, thus, of a continent with discernible water supply and water quality shortfalls that are likely to worsen in the foreseeable future unless there is a radical change in governance and economic development to create the necessary background for adaptive measures to these imminent threats.

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Sustainable Water Resources in South America: The Amazon and La Plata Basins

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Introduction

Most of the tropical and sub-tropical regions of South America are dominated by large rivers and associated floodplains, wetlands and shallow lakes. Of the six most important South American river basins (Magdalena, Orinoco, Amazon, S. Francisco, Paraná and Uruguay – the last two part of the River Plate Basin; see figure 1), the Amazon and La Plata basins are shared by the largest number of countries: the Amazon basin by nine countries (Brazil, Colombia, Venezuela, Ecuador, Bolivia, Peru, Guyana, French Guiana and Suriname), and the La Plata basin by five countries (Argentina, Brazil, Bolivia, Paraguay and Uruguay).

The size, volume and complexity of the natural hydrographic network of South America undoubtedly influences the use of water resources, the rational exploitation of which will be closely related to the economic development of the continent (Tundisi, 1994). This enormous fluvial network, integrated into regional ecology, is vital for future development of the continent, and its preservation, recovery and integrated management is a matter of concern to scientists, decision makers, managers and administrators throughout South America. The Amazon watershed, in addition to its enormous importance for the South American continent, has also global implications (Bonetto, 1994).

Several research papers and analyses for both regions have been published. Recent books, such as Sternberg (1998), Padoch et al. (1999)

Source: Tundisi, 1994

Figure 1. The five hydrographic basins of South America; the Amazon and La Plata are the two largest international watersheds

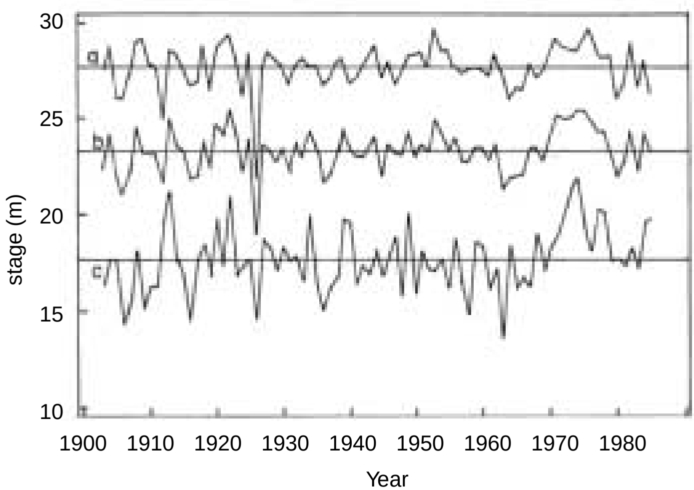
and Junk et al. (2000), describe and discuss the basic features and functioning of the Amazon basin and highlight the initiatives for conservation. Bonetto (1994) wrote an extensive review for the La Plata basin, and a summary of La Plata basin management issues was published by UNCRD (1994).

This paper summarizes management problems of the water resources for these two watersheds, and discusses some perspectives for the integration of research and management with a predictive perspective, in a watershed approach.

The Amazon basin: development strategies

The Amazon basin, the largest on earth, is dominated by the Amazon River, its tributaries and a very large floodplain system, consisting of a complex of channels, rivers, lakes and islands. Since the river and its tributaries transport a large amount of suspended material, the river dynamics are fundamental in the successional patterns of the forest and in shaping the morphometry of channels and shallow lakes.

The variations in water level are a very important forcing function (as shown in figure 2), with an average of 10 meters near Manaus and 5-6 meters in the lower Amazon. The magnitude of the floodplain interactions in this watershed are of prime importance for maintenance of the functioning of the terrestrial and aquatic ecosystems, with an exchange of biomass and nutrients between these two subsystems during periods of high water and low water.



(a) annual maximum for each year, (b) mean of all values for each year, (c) annual minimum for each year. Because of the insignificant slope of the water surface in the Amazon River, lower courses and tributaries, the readings at Manaus are presumably valid for the main stem and confluence. Horizontal lines give the mean level of each series for the period of 83 years. Source: Sternberg, 1998.

Figure 2. Water level fluctuation measured from the river stages at the Manaus gauge, about 18 km up the River Negro, for the period 1903-1985

Plants and animals have developed several strategies for the periods of water stress (low water) and high water level. These strategies include migration of fishes, physiological adaptations in herbaceous plants (the production of resting stages) and the migration of terrestrial invertebrates to the canopy (Tundisi, 1994; Junk & et al., 2000). A characteristic feature of the Amazon watershed is the interaction between terrestrial and aquatic ecosystems, and the extensive floodplains and flooded forest, which by extension and size are the most important of the South America continent.

The "varzea" (floodplains) have been exploited since prehistoric times (Roosevelt, 1999). The high heterogeneity of the habitat, represented by climate, vegetation, fauna, geology and soils, was used extensively in a dynamic long-term occupation of the environment and its diverse components of floodplain ecosystems. According to Roosevelt, "floodplain and nearby interfluvial resources were certainly adequate to support nomadic paleo-Indian foragers for several thousands of years." Later on, the food of the settlers along the shores and estuaries of the Amazon was based on fish and shellfish.

Along the Solimoes-Amazon river, "varzeas" extend over 3,000 km, and the several types of floodplains produce socio-economic mechanisms of exploitation and interaction between man and these ecosystems (Sternberg, 1998; Kohlhepp, 2000). The management of floodplain requires management of the terrestrial and aquatic resources because of the uses during dry periods and inundation periods. Junk et al. (2000) describe four major economic activities in the "varzea": fishery, forestry, agriculture and animal husbandry, all of which are competitive activities. Conflicts of interest, thus, are common in the exploitation of this floodplain.

The several impacts in the floodplains are a result of mining, farming, crop raising, and the build-up of human settlements (small towns and villages). Some initiatives for adapting new legislation for the multiple uses of the "varzea" were discussed recently by Vieira (2000). This legislation, related to sustainable development, addresses issues such as land tenure, fishery, forest exploitation and pollution.

Reservoirs in new developing regions in the Amazon

The three Amazon reservoirs built up in the tropical rainforest produced many impacts (Junk and Melo, 1987; Matvienko and Tundisi, 1996). Now, new developments in reservoir construction are planned for the pre-Amazonia, in the tributaries in regions of "cerrado" (savannah) vegetation.

In the Tocantins River, located in the central-north region of Brazil, the situation differs completely from the other extensive urbanized regions of Brazil. Here, the water quality is excellent, urban regions are limited to a few localities, and the vegetation ("cerrado") remains. A series of seven reservoirs for hydroelectric power will be constructed, providing the region with a cascade of artificial ecosystems that will entirely modify the economic, social and ecological components of this region. The strategy for management of these ecosystems will consider the following components and actions:

- control of eutrophication by waste water treatment and control of non-point sources,
- control of activities on the reservoir shore to avoid direct impacts,
- regulation of retention time to avoid phosphorus retention in the reservoir,
- deforestation of future areas of inundation to avoid oxygen depletion,
- control of fisheries and aquaculture, and avoiding the introduction of exotic species of fishes, and
- sanitary and environmental education for the local population.

A watershed approach is being adopted from the beginning of the project, and a reforestation programme is fully underway (Tundisi et al., 1999).

In these new developing regions, preventive actions will be implemented, thereby lowering costs of recovery in the future and anticipating measures for eutrophication and toxicity control. Public resources in the future can thus be directed to other programmes and objectives, such as education and health instead of pollution and contamination abatement (Tundisi, 2001).

A model of management will be implemented considering the following aspects of the problem:

- eutrophication prevention,
- sediment transport and erosion potential,
- hydrodynamics and water flux,
- watershed management with sustainable agriculture,
- soil irrigation and adequate plant crop to avoid erosion, and
- soil susceptibility to erosion.

Adequate modelling will be based on the establishment of a data bank and an information system that encompass biogeophysical, social and economic components. The models, in fact, will address the integrated and predictive watershed management. (See figure 3.) The models will be applied to the management and optimization of multiple uses.

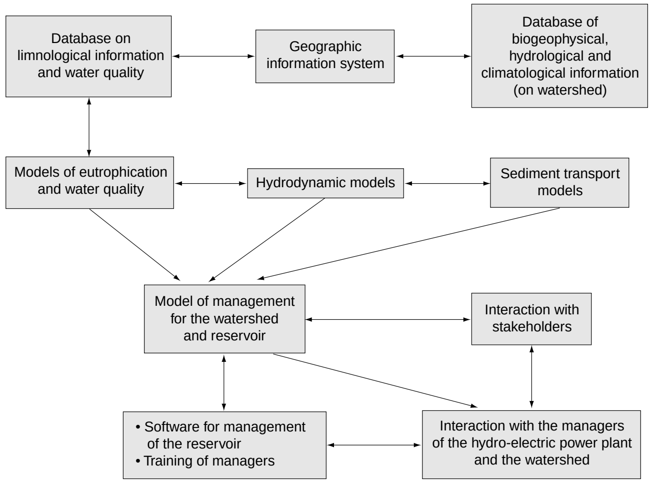


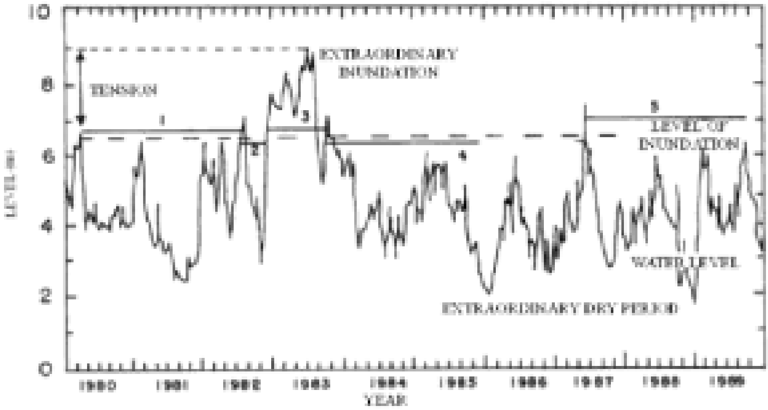
Figure 3. The organization of the management plan of the reservoir Luiz Eduardo Magalhaes, Tocantins river; this is an adaptive, integrated and predictive model of management

The La Plata basin

Figure 4 shows the water-level fluctuation of the Paraná River. As in the Amazon basin, the rivers of the La Plata also depend strongly on the water-level fluctuation for their hydrological and ecological functioning. In the floodplain, a hydrosocial cycle is coupled to these variations of volume, water level and inundation.

This river basin (3,000,000 km^2) comprises the Paraná, Uruguay and Paraguay river watersheds. With a population of 120 million, this is the most industrialized area of South America, with extensive metropolitan areas and a large conurbation in the northern region (Middle Tietê watershed, S. Paulo state).

One of the main problems pointed out as critical for the La Plata basin is the range of disparities regarding the state of sanitation in the basin. While some urban areas have reasonably good sanitary conditions, other areas at the periphery of urban centres are ill-equipped. A global approach to basin sanitary conditions is necessary to promote better access to wastewater treatment and prevent impacts on the health of the human population (Ronderos, 1994). New public investments in wastewater treatment and protection of headwaters for municipalities are needed to improve quality of life.



Neiff (1994)

Figure 4. Water level fluctuations in the Paraná River

A very important characteristic of this basin is its cultural identity. Another important general feature of great impact is the construction of large reservoirs, initially for hydroelectric power generation but later used for such activities as tourism, navigation, recreation and fisheries. These dams have greatly changed the basin's natural systems, interfering with human activities but also producing several alternatives of development within the basin (Bonetto, 1994; Tundisi, 1994).

Dams in the La Plata watershed have produced several impacts, both positive and negative, such as the following (Agostinho et al., 1994, 1997, 1999; Tundisi et al., 1993; Straskraba and Tundisi, 1999; Barbosa et al., 1999; Guntzel, 2000; Henry, 1993):

Negative impacts
- Changes in the hydrological cycle
- Changes in biodiversity of the rivers
- Relocation of population
- Loss of agricultural land (fertile soil)
- Loss of wetlands
- Changes in the regional local economy
- Social impacts due to relocation
- Changes in water quality

- Barriers to fish migration
- New alternatives for local and regional businesses
- Changes in the hydrosocial cycle
- Loss of riparian forests along tributaries
- Increase of potential for water-borne diseases

Positive impacts
- Generation of hydroelectricity
- Promotion of multiple uses, such as navigation, irrigation and tourism
- Enhancement of fisheries and aquaculture
- New supply of energy
- Promotion of agricultural businesses
- Development of irrigation technology and new opportunies in agrobusiness
- Increase of food supply from agricultural crops
- River regulation and flood control
- Water purifiers
- Water reservation
- New opportunities for aquaculture

The integration of research, planning and management is a fundamental concern. The continuity of the planning and management process has to be maintained by a permanent flow of data from research results gained through the monitoring system, which in turn is developed using an integrated methodology. It is important, for example, to follow-up on the biogeophysical changes in the watershed as a consequence of long-term economic and social alterations produced by reservoir construction.

Since the La Plata River basin is an international watershed shared by Argentina, Bolivia, Brazil, Paraguay and Uruguay, this transboundary system needs integrated management with participation by the five countries that share this vital resource. Therefore, the need for regional integration, management of sub-basins, monitoring and preparation of qualified human resources is very urgent. Since the reservoirs are a common feature of the basin, they could be used, as well as their watershed, as a focal point of research, management and training. This will require a systematic and integrated approach to water management and development in the sub-basins.

Urban reservoirs in the La Plata basin

A prominent feature of the water resources in the La Plata basin is the urban reservoirs for water supply of large populations. An outstanding example is the reservoir system for the S. Paulo Metropolitan region (although many other urban areas, from large to small towns, have the same pattern of water supply). The S. Paulo Metropolitan region has 26 large reservoirs, constructed in the last quarter of the nineteenth century and the twentieth century. These reservoirs, today located amidst a heavily populated and industrialized urban system, supply drinking water for 21 million inhabitants. The costs of treatment have increased in the last 10 years due to the many problems of eutrophication, toxicity and deforestation that affect the water quality and produce loss of biodiversity.

Many reservoirs are used for recreation, tourism and fisheries as well as for water supply. These activities were developed by the local communities over the years; the reservoirs are located in other municipalities, not in the S. Paulo town, and therefore there are problems of an institutional and political nature that interfere with their management. Despite efforts to introduce the watershed approach as a concept for management, the institutional and legal constraints are difficulties for implementation (Braga et al., 1998). The strategy for management of these reservoirs is focused on the following actions (Tundisi, 1990a, 1990b):

- control of non-point sources of phosphorus and nitrogen (reforestation of watersheds, sanitary education of population),
- treatment of wastewater to control eutrophication,
- organization of a data bank, and
- implementation of corrective and remediation actions at the watershed level, and technology for reservoir recovery (in-lake management), aeration, sediment isolation and phosphorus inactivation.

The cost of these actions is very high. For example, the estimated cost for the pollution abatement of Pinheiros River in S. Paulo town is US$100 million. It also requires an extensive period of preparation for institutional integration (federal, state and municipal institutions), involving negotiation at several levels. A great effort will be made for environmental and sanitary education, especially for populations near the reservoir, on the lake shore (Tundisi, 1993a, 1993b).

The economy and water resources in the Amazon and La Plata basins

Since in both basins the water supply and availability are the basis for economic development, it is fundamental to analyse briefly some economic consequences of the relationship between supply and demand of water, water quality and water availability. In the Amazon basin, the hydrological cycle is very much tied to the hydrosocial cycle (Merret, 1997; Ayres et al., 1999), and the economic development of this region (especially the floodplain) is dependent upon adequate exploitation of the water resources.

Conservation of the biodiversity in the floodplain has enormous economic importance, since this is the reserve of natural resources for the future. The management of the floodplain by local communities, and their approach to conservation and sustainable fisheries, will have a positive economic impact, as was demonstrated in the Mamirauá project and all other projects where conservation of biodiversity was the basis for economic development, as alternatives for large-scale development plans at federal and state levels (Goulding, 1999).

For example, in the whole of Amazonia, “artisanal” fisheries accounts for an annual revenue of US$ 100–200 million, employing 70,000 persons and, thus, maintaining 250,000 persons (Petrere, 1992; Barthem, 1999).

On the other hand, the harnessing of the hydroelectric potential in the Amazon basin, especially the tributaries, has an important economic impact, since it will provide new alternatives for the agricultural exploitation of the “cerrado” in the pré-Amazonia and promotes tourism, recreation, fisheries and irrigation on a larger scale. The whole economic development of Tocantins state, for example, will be based on the construction of 45 reservoirs through 2020 for water supply, hydroelectricity, navigation, fisheries and irrigation. A total of US$10 billion will be invested in the development of this hydroelectric potential. Besides the build-up of the infrastructure, the exploitation of this potential will promote new possibilities for economic development based on water resources and will stimulate several new activities in the economy. However, in both regions of the Amazon basin, conservation of water quality, sanitation and the use of water for subsistence and alternatives for development are fundamental.

In the La Plata basin, further economic development and improvement of quality of life, employment and alternatives for development depend on water resources, especially the recovery of eutrophic systems, the optimization of multiple uses and the adequate balance between several activities that impact surface and underground water resources. The "services" provided by the aquatic ecosystems are becoming costly. The treatment of water to produce potable water is attaining a high price, about US$20 per 1,000 m^3. The recovery will need a large amount of public or private resources (an estimated of US$40–50 billion for the next 10 years) for investment in wastewater treatment control of eutrophication and watershed management. Figure 5 shows the extensive network of major rivers and tributaries both in the Amazon and La Plata basins.

Figure 5. Network of main rivers and tributaries in the Amazon and La Plata basins

Conclusion

Both the Amazon and La Plata basins are dependent on the vast volume of surface water resources for development. In the Amazon basin, sustainable development is mainly related to the exploitation of the floodplain, conservation of biodiversity and small-scale farming for cattle exploitation and food production (Junk et al., 2000).

The floodplains have considerable ecological, biological and economic significance. They are very productive and have become a focus of economic exploitation. Ayres et al. (1999) estimated that 80 to 90 per cent of the population in the Amazon basin is living near the flooded areas, mostly on the margins of large rivers.

Integrating conservation and exploitation of the fertile floodplains is not an easy task. But recent advances in conservation approaches, such as the one developed in Mamirauá, Central Amazon, show the usefulness of a conservation project based on a broad definition and new approach to nature exploitation integrated with processes of social development, as pointed out by Lima-Ayres (1994).

The people living in settlements in the Mamiraua Reserve have adapted to the flood season; therefore, their activities are dependent on the flooding for food production and economic development. Fisheries for food supply and as a basis for commercial exploitation is one of the main resources of the human population in this reserve area. (Goulding, 1999)

It is important to develop pilot projects, such as the Mamirauá Project, in other regions of the Central Amazon floodplains where the forms of community participation are defined by the community members on the basis of their local and regional experiences. The creation of a large group of sustainable Development Reserves in other areas of the Amazon seems to be the key for the conservation of water resources and biodiversity.

On the other hand, the use of the large hydroelectric potential in the Amazon basin, and mainly in its tributaries such as the Tocantins River, has to be integrated with local development plans. Conservation of water quality and optimization of multiple uses is a priority in these new economic activities centred on the utilization of the hydroelectric potential of the basin.

In the La Plata basin, the exploitation of hydroelectricity is almost exhausted, especially in the upper Paraná basin. In this region, more than 100 large and small reservoirs (from 22 million m^3 to more than 20 billion m^3) have produced very large charges in the river systems and had many impacts on the water resources. In this basin, optimization of multiple uses, water conservation and recovery of eutrophic and hypereutrophic aquatic ecosystems are of prime importance. Water quality and availability are now fundamental factors for sustaining economic activities and multiple uses of reservoirs. The supply of water for small municipalities is also an important factor for sustainable development and quality of life. The use of underground water is increasing in this basin, placing other stresses on the water reserves – particularly, stresses of quantity and quality, since many activities, such as industrial discharges, agricultural development and extensive urbanization, are factors of pollution of these water resources.

For both basins, efforts have to be directed to the integration of national and international policies for water conservation, supply and demand. Countries of the La Plata basin recently organized a watershed agency (RIGA – Rede Integrada de Gerenciamento de Águas – Integrated Network of Water Management) with the participation of private and public organizations of the five countries. This agency will help in the transfers of technology among the countries, promotes seminars and training activities, and will prepare projects of conservation and restoration.

A similar project for the Amazon Region is being organized in the new Tocantins state in Brazil, with the aim to develop new opportunities for multiple uses of water and conservation as a basis for sustainable development.

For both basins, the sanitary and environmental education of the population can help the strengthening of the sustainable development based on water resources management.

International efforts should also be directed to promote a new institutional organization in order to enhance the conservation and optimization of multiple uses. Within this new organizational development, the watershed as a unit for research, management, and sustainable development in several scales, from small watersheds (< 200 km^2) to large ones (>2000 km^2), is a new and consistent improvement.

Therefore, integrated water resources management should consider the watershed on a global, regional and local level (i.e., the watershed as a basic unit for planning and management). Local and regional approaches to water management are key issues to be considered. On the other hand, a strong link among the data bank, research and management has to be developed. Without the basis given by such actions at the sub-basin and basin levels, it will be impossible to provide adequate planning and management.

The problem for both watersheds is to change the management from a reactive, sectorial and local approach to a predictive, integrated and watershed one. The international efforts directed to this conceptual change can help in this process (Straskraba et al., 1993; Straskraba and Tundisi, 1999).

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The Caspian as an International Water System

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Introduction

The Caspian – the largest lake and biggest closed river basin in the world, an unusual ecosystem with very specific oscillations of the water level, and home to rare and valuable species of fish, including those that produce caviar – was, until recent times, a relatively remote region. In spite of its relative remoteness, however, the Caspian (the lake and the basin) has always been an international system. Situated mostly along the frontiers of Europe and Asia, it is the realm of the border area between two great civilizations, Christian and Muslim – a zone of not only cultural interface, but also occasional and vigorous conflicts.

During the past 100 to 150 years, a number of oilfields have been found and developed in the region, beginning from the area near the city of Baku. This region was once the most important oil producer in the world, and it was from here that the first pipeline towards Western Europe was built. Many well-known names, including Nobel and Rothschild, made fortunes in Baku. Nevertheless, the region remained relatively remote and isolated. And because the shores of the lake and most of the basin were within the borders of only two countries, the Soviet Union and Iran, the Caspian political system was relatively simple and uneventful.

About 10 years ago, however, the situation changed. Political developments associated with the collapse of the Soviet Union have created possibilities for the evolution of a new system for the Caspian lake and its basin. Currently, the Caspian shores extend through five countries rather than just two: the Russian Federation, Kazakhstan, Turkmenistan, Iran, and Azerbaijan. Within the Russian Federation, the Caspian extends through the Dagestan Autonomous Republic, Kalmyk Autonomous Republic and Astrakhan Oblast, each with different degrees of autonomy and legal status. Thus, the political system of the Caspian has become very complex.

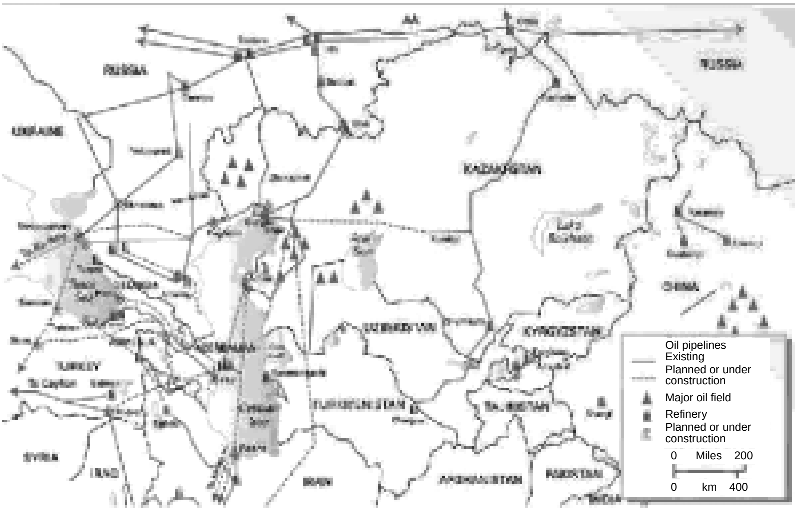

Figure 1. Oil fields, refineries and pipelines in the Caspian region

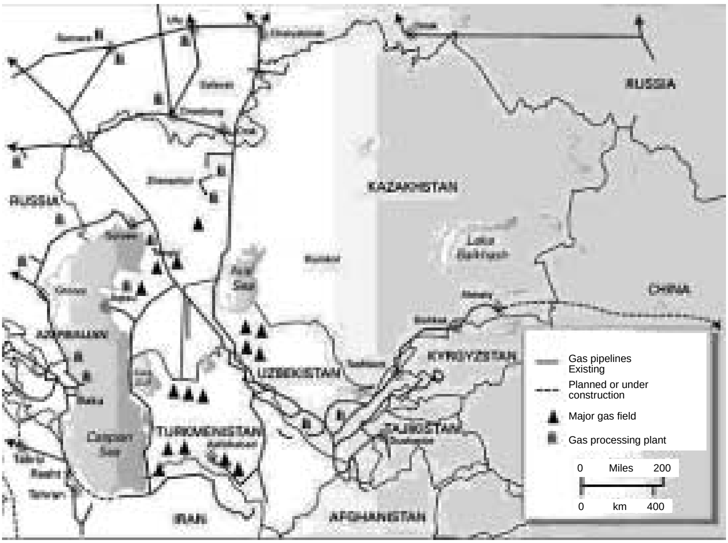

Figure 2. Gas fields, processing plants and pipelines in the Caspian region

Oil and gas fields abound in the region, and activities related to oil and gas (prospecting, extraction, transportation and processing) have become the main factors for changes in the region. (See figures 1 and 2.) These activities are the main priority for the Caspian countries (though relatively less so for Russia), with much greater importance than anything else, to the detriment of major environmental issues. The main thrust of national strategies for the region comes from the realization that possession of a piece of the lake's bottom, and with it a probability of access to oil and gas reserves, is a key priority. All of the major transnational oil companies and oil-importing countries, even those far from the Caspian, have an interest, making the problem of the Caspian Sea legal status a very important, pragmatic, but still-unresolved issue.

As a result, the Caspian (both the land and the sea areas) has become a very complex international system, encompassing a web of closely interrelated economic, political and ecological issues. The objective of this paper is to clarify the main international problems of the Caspian system and their principal components. The globalization of geopolitics, economics, ecology, etc. is a fact of life there, and the question of whether or how to divide the sea into the five national pieces, and what to divide (the bottom, the water mass or both) is not a trivial one.

The wide strip of the Caspian basin and the Caspian Sea extends roughly north-south for about 2,700 km, representing a barrier for the great migrations of peoples moving generally from east to west. On the other hand, the general north-south orientation of the Volga River basin as well as of the Caspian Sea contributed to the development of navigation.

Because of its geographic location, the Caspian system has always been international. Historically, states have appeared and disappeared within this transportation network. The Russian expansion south and east commenced in the second half of the sixteenth century, during the rule of Ivan "the Terrible." The strategic geopolitical situation in most of the Caspian region remained relatively calm from the sixteenth to the twentieth centuries. During these five centuries, two countries dominated: Iran kept the south coast and a relatively small strip of land, while Russia possessed the rest of the coastline and extensive adjacent land to the north of the Caspian Sea.

Hydrology

The Caspian is the largest lake in the world, so large that it really deserves the name Caspian Sea. Its morphological parameters strongly depend on the water level, which has fluctuated over time. The area of the Caspian Sea is about 400,000 km^2 (all figures are approximate), the length and width are 1,200 and 170–450 km, respectively, and the length of shoreline (including islands) is 7,000 km. The water volume is some 80,000 km^3, and the average depth is 180 m (with a maximum of 1025 m).

The Caspian Sea consists of three main morphological parts, which are almost equal in area: a very shallow northern part with depth not exceeding 10 m, a middle part with an average depth of 170 m (and maximum depth of 790 m), and a deep southern part with an average depth of 325 m (and a maximum depth of 1025 m).

The Volga is the main tributary of the Caspian Sea. Its watershed area is 1,360 million km^2, and it has in its basin no fewer than 37 reservoirs with the total volume of 200 km^3. The inflow from the Volga River is the main positive component of the water balance of the Caspian Sea, while evaporation from the sea surface is the main negative component. The largest water flow of the Volga (253 km^3 per year) is not at its mouth, but at about 600 km north of the delta. At the upper border of the delta, the run-off of the Volga is 243 km^3 per year, or about 87 per cent of the total river inflow to the Caspian Sea (Voropaev et al., cit. from I. Zonn, 1999).

Water is a scarce resource in the arid part of the Caspian basin and will play a crucial role in further development of the region. Also, it is important to note that over 40 per cent of the whole of population of Russia lives in the Volga basin, and Moscow is situated there, making the Volga River and the Caspian Sea the traditional “backbone” of Russia. These facts are of very high geopolitical importance.

A distinctive feature of the Caspian Sea is the considerable and sharp oscillations of its water level, which are determined by the water balance of the Sea and the River. Typical oscillations are 1.5 m over 10 years, and 10 m over 1,000 years. Historically, during the past 2,500 years, the water level of the Sea has fluctuated within a range of 14 m, between 20 m and 34 m below the world ocean level (sea level). During the period of instrumental observations, that is since 1837, the water level has been between 25 m and 29 m below sea level, with the average level of –27 m. (See figure 3.)

From the beginning of the twentieth century until 1929, the Caspian water level was relatively stable, fluctuating at around –26.2 m. In 1930–1941, however, due to hydrometeorological factors (primarily the low flow of the Volga), the water level dropped by 1.8 m. Then, from 1942 to 1977, the water level dropped by an additional 1.3 m, to –29.3 m. Through the

Figure 3. Variations of the water level of the Caspian Sea

next 20 years, until 1997, however, the water level rose, reaching –26.5 m. The rise of water level has since slowed, and the current trend is not yet pronounced.

In the past, human settlements were, as a rule, constructed at relatively high locations in relation to the sea. Human life and economic activities were adjusted to the high-water level, and economic losses from fluctuations were minimal.

The prolonged fall of the Caspian water level in 1930–1977, however, led to the erroneous opinion that the water level would keep falling, due to human activities in the basin such as filling up the water reservoirs and using the water for irrigation. As a result, new projects during that time were geared to the low level of the Caspian Sea. Subsequent rising of the water level, therefore, has created constant or temporary inundations of human settlements, areas of oil and gas operations, roads, power supply lines, piers, etc., causing enormous economic losses in all the five Caspian countries.

Also, in many places around the Caspian, the shore is extremely flat. Storm surges are typical for this kind of shore under the influence of strong winds, with water levels rising by as much as 3 to 4.5 m and penetrating inland for up to 30 to 50 km. Human suffering and economic losses have been very high due to the superposition of these short-term, catastrophic oscillations on the long-term changes in the water level.

The long-term forecast of the Caspian water level, although very important from an economic point of view, remains an unsolved problem, and chances of solving it are presently remote. An arbitrary water level of –25 m has been chosen in Russia and Kazakhstan as the principal reference level below which the planning and design of new projects is not allowed. It was also decided that no new capital construction will be located below –23 m.

About 90 per cent of the fluctuations of the Caspian water level can be explained by natural factors; only 10 per cent are attributable to anthropogenic factors (Golitsin & Panin, 1988). Water withdrawals from the Volga basin for irrigation and other purposes are about 40 km^3 per year. The role of Russia in this process will keep growing because the Volga River is the main source of water in this arid part of the basin.

Oil and gas

In 1991, the political map of the Caspian Region changed, when the Russian Federation was proclaimed on 12 June 1991, and Azerbaijan, Kazakhstan and Turkmenistan became independent. On 21 December 1991, these four countries became members of the Commonwealth of Independent States (CIS).

To reach economic independence and prosperity, the Caspian states count on their large reserves of oil and gas. The results of assessments of oil and gas resources in the Caspian region vary greatly (by an order of magnitude or even more). A review of various data on Caspian oil and gas resources was published by Igor Zonn (1999), from whose book most of the information in this paper is taken. The oil resources of the Caspian Sea are estimated at between 2.3 and 34 billion tons, or between 17 and 250 billion barrels. This places the Caspian oil reserves at or near second place in the world (although still far behind the resources of the Gulf region).

In 1995, the Caspian region produced 44 million tons of oil. Drilling and oil production will increase, and it is expected that by 2010 the region may supply about 5 per cent of world oil production. The Caspian countries thus have already begun getting some golden trickles, but the demand needed for impovement of the standard of life still is much larger than the supply.

It should be noted that these data on oil are approximate; they are taken from different sources, and may be distorted to serve the political and economic interests of the states-owners of the oil (and gas) resources. As Zonn (1999) observes, "today, some leaders of the Caspian countries, in order to increase their personal political weight and the prestige of the states they are leading, and thereby to attract foreign capital, and also being led by the geopolitical ambitions, may knowingly set too-high figures of the hydrocarbon resources."

Natural gas is a promising source of energy and chemical industry. The main gas fields in the Caspian region are in Turkmenistan and Kazakhstan. At the beginning of 1997, the approximate proven reserves of natural gas were 3 trillion (10^{12}) m^3 in Turkmenistan, 2 trillion m^3 in Kazakhstan and 1 trillion m^3 in Azerbaijan. The forecast of gas reserves in Turkmenistan is between 8 and 23 trillion m^3, while that for Iran is 21–23 trillion m^3 – that is, over 14 per cent of the world reserves of natural gas. The total in Russia is over 50 trillion m^3, but only a part of it is in the Caspian region. (All the figures should be taken with caution.)

Russia, Iran and Turkmenistan are the leading countries in the gas reserves of the world. Together, they have over 50 per cent of gas resources. The Caspian region, therefore, is becoming a very important area globally, from a geopolitical point of view, due to the high environmental quality and enormous resources of gas as a source of clean energy supply.

The infrastructure

Oil and gas generally are not utilized at the place of extraction. The dispersed distribution of resources from the oil and gas fields in the Caspian region thus requires a sophisticated network of pipelines. This network becomes even more complicated because of such large and important obstacles as the Caspian and Black Seas, Volga and other major rivers, and other main features of topography.

No less important are political interests. It would be correct to say that the final decision on a new pipeline is based, first of all, on international political interests, and only then, to some extent, on economic and environmental considerations.

The three principal directions for the transport of Caspian oil (and gas) are to the west, south and east. The most important pipelines of the western route (in use or planned) take oil to the Black and Mediterranean Seas. The southern route envisages pipeline(s) from Turkmenistan through Iranian territory to Pakistan, with use of oil on the way, and possible extension to the Arabian Sea. Total length would be 1,700 km. Options for the eastern pipeline routes are mainly for China, with a main line of 2,600 km; getting oil to the main consumers inside China would require extensions with a total length of 8,000 km. There are many other suggestions and projects for pipelines, since great resources of oil and gas necessitate large pipelines and pipeline networks.

More comprehensive development of various transportation networks is on the agenda for the Caspian region. There are projects to develop existing segments of railways by connecting them, thus creating large and modern networks. The main directions would be east-west and north-south. The former is the TransAsian Railway (TAR). Connection portions have already been built, thus facilitating travel between Russia, China, Turkey, Pakistan and Western Europe. In total, the TAR uses a network of about 11,000 km of national railways. Its main trunk is Istanbul-Teheran-Meshkhed-Serahs-Chardjou-Tashkent-Almaty-Urumchi-Beijing.

The North-South routes, such as Kushka (Turkmenistan)-Gerat (Afghanistan)-Kandahar (Afghanistan)-Karachi (Pakistan) and Termez-Karachi are of about 1,100 km each. They are under a preliminary intergovernmental agreement for design and construction. About 60 per cent of the north-south portion can already be exploited for transcontinental use. The importance of the new railways system around the Caspian Sea, together with its connecting routes, cannot be overestimated.

The sea routes, together with ports, navigation facilities, etc., are other positive aspects of transportation networks developments. It is planned to build a TransCaspian ferry system to connect the main ports of the Caspian Sea. Some additional ports are being built, such as Olia (near Astrakhan), Lagan, Aktau, etc. – one step in economic development causes more steps.

The infrastructure of the Volga-Caspian system is becoming ever-more complex. Moreover, the natural and man-made parts of the system have a growing number of the crosscutting nods. The state of the system is the result of human activities on the Caspian Sea and its shores, and on the watersheds of its tributaries. The interaction of all these factors and processes leads to a permanently changing (but deteriorating) environment.

Pollution

The main sources of pollution in the system are oil and its products. On average, oil losses in the process of its extraction, transportation and usage are up to 2 per cent of the total volume. One gram of oil and oil products can make 20 tons of water unusable.

Further, the Volga River can be regarded as the main conduit of the sewage waters of Russia. In 1998, the volume of polluted water in the Volga basin was 39 per cent of the total sewage run-off formed on the territory of Russia (State Report, 2000). In the Caspian basin, there are some 200 large cities with a total population of approximately 10 million people; these make considerable contribution to the pollution problem. The principal oil fields are also the spots of the highest pollution. On the coast, a number of industrial (mostly petrochemical) centers have been created, with pollutants from them being among the main factors of the critical state of the environment.

The water reservoirs in the Volga basin accumulate a good part of the pollutants. Pollution in the Northern Caspian is determined by run-off of the Volga and Ural Rivers, and the largest Kazakh oil fields. In the Southern Caspian, pollution is associated with the industrial area (mostly petrochemical) around Baku, oil extraction from the sea bottom, and polluted run-off of the Kura River. With further development of the oil industry, sooner or later the Caspian regions will suffer environmental catastrophe unless an agreement is reached on coordinated actions by the Caspian countries.

Unique fisheries

The Caspian ecological system is very rich and very specific; it is, in fact, a piece of world heritage. Unique among the components of the system are a few species of sturgeon, which account for up to 90 per cent of the total world catch of these fishes and produce most of the world's caviar.

Due to human activities in the basin and lake – such as hydraulic engineering projects, extraction of oil, development of the petrochemical industry, expansion of irrigation, growth of the water supply systems, etc. – degradation of the aquatic ecosystems has occurred in practically all parts of the Caspian system. Fishery resources are steadily falling. Between 1978 and 1994, for example, the estimated number of the adult sturgeons in the Caspian Sea decreased from 142 million to 43.5 million individuals.

Following the collapse of the Soviet Union, in addition to the factors mentioned above, numerous kinds of illegal fishing and poaching have developed. The annual legal sturgeon catch from the Caspian Sea shrunk from 10,620 tons in 1992 to 5,190 tons in 1994 (Zonn, 1999). Deterioration of the Caspian ecosystem is continuing, and at least four species of sturgeon (*Aktinopterigii*) are under the threat of extinction. This would be the great loss; in the long run, the loss of fisheries resources probably would be larger than losses due to the depletion of oil. Coordinated actions among the Caspian countries should be developed to cope with trade-offs among the different priorities for the system.

Legal status

The uniqueness of the Caspian Sea system and its basin necessitate a special approach to its legal status. The Caspian countries have spent considerable diplomatic efforts and administrative actions to achieve the most convenient solutions for themselves. De facto, the sea has been divided. However, there is need for an agreement that would fix the situation de jure. It may be a long process, but it would lay the foundation of the future cooperation among the Caspian countries to be based on a consensus approach.

Tragedy of the commons

The Caspian situation is typical of the "Tragedy of the Commons," according to the well-known definition of Garrett Hardin. A solution cannot be found that would be "best for everybody" as the sum of the available resources is less than the total of demand. On the other hand, if the system continues without proper control, it will eventually collapse.

The solution is to achieve trade-offs among the different parties, distinct sectors of the economy, and diverse environmental issues. Only by giving up something can one get something else in exchange. The problems of an intricate system will involve complicated solutions.

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River Danube: Needs for Integrated River Basin Management

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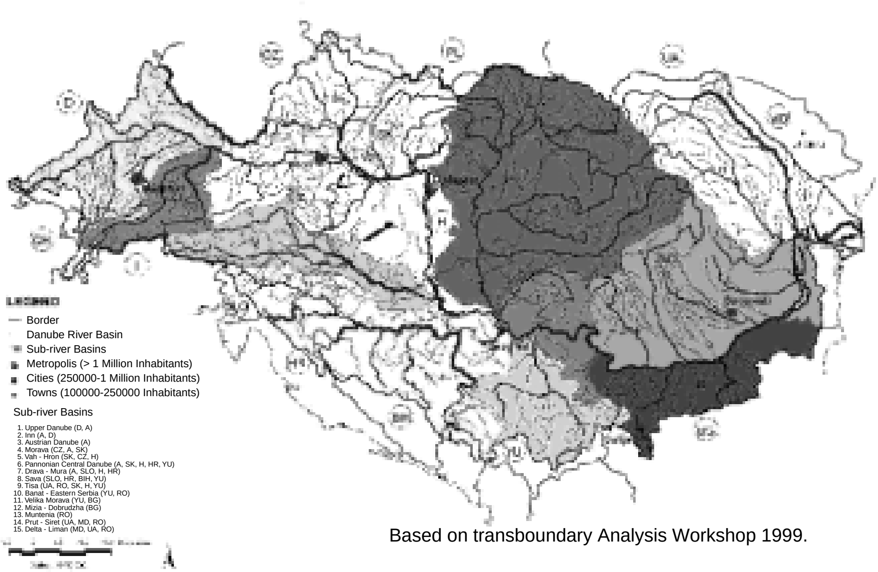
History and general situation of the Danube basin

The Danube River has been an important means of military transportation for nearly 2,000 years. In the third century, it was the northern border of the Roman Empire, and Roman soldiers no doubt used the river. Later, the Goths, Slavs, Huns and other Germanic tribes used the Danube to cross into the Roman Empire. The Danube was also used to gain access to Constantinople. The Crusaders used the Danube to travel faster on their quest to regain the "Holy Land," and towards the end of the Middle Ages, the Ottoman Turks used it for easier advancement into western and central Europe.

Both the commercial and military value of the Danube are still recognized today, and many treaties have been signed to try to keep any country from having too much control of it. In the early part of the 19th century, the Danube served as a link between the industrial area of Germany and the farmland of the Balkans. At this time, the Ottoman Empire was weakening, but the Russian Empire was near the height of its power. Austria and other powerful European nations recognized this threat to the area and acted to prevent Russia from gaining the Danube delta.

Running a length of 2,780 km, the Danube is the second-largest (after the Volga river in Russia) and most important European river. It flows along or through 10 countries (Germany, Austria, Slovakia, Hungary, Croatia, Federal Republic of Yugoslavia, Bulgaria, Romania, Moldova and Ukraine), making it the most international river in the world. (See figure 1.) Its entire catchment area of 817,000 km^2 includes large parts or the entire territory of 13 states (the 10 already mentioned as well as the Czech Republic, Slovenia and Bosnia-Herzegovina) and small portions of another 5 states (Switzerland, Italy, Poland, Albania and the Former Yugoslav Republic of Macedonia).



Danube Pollution Reduction Programme, United Nations Development Programme, Global Environmental Facility, ICPDR - Programme Coordination Unit (Vienna). Produced by Zinke Environment Consulting for Central and Eastern Europe, Vienna 1999 (cartography U. Schwarz).

Figure 1. Map of the Danube River basin

The Danube has some 300 tributaries, of which 30 are navigable, and some are of transboundary character. Most of the Danube and its tributaries have been developed by tens of thousands of reservoirs, locks and dams. These artificial lakes and other river works undertaken over the past several decades have significantly altered the natural flow and sedimentation regime of the Danube.

The first hydro dam in the Danube basin, built at Vilshofen in Germany, dates back to 1927. Today, the installed hydropower capacity in the basin is on the order of 29,000 MW. The upper reaches of the Danube illustrate the high density of dams in the basin: There are 58 dams, or an average of one dam every 17 km, in the first 1,000 km of the Danube River. Ecological problems resulting from these interventions have led, since the early 1980s, to a greater public opposition to the continuation of conventional river development, and conflicts have arisen. Some of these conflicts – such as Hainburg (in 1984) and Gabčíkovo-Nagymaros (in 1988) – have drawn international attention, but less publicized conflicts and controversies have surrounded many other projects in the basin in Germany, Austria, Croatia and elsewhere. All over the Danube basin, large dam and canalization projects face bigger public, political and legal constraints.

Transboundary river problems

In cases of a transboundary river, several problems in river management and water exploitation arise. As mentioned by Caponera (1996), using the example of the Mekong River, there has to exist some institutional framework that covers certain major principles: freedom of navigation, commercial establishments, joint programmes of development of river-based communication and relations, establishment of joint regulations for river or water utilization, respective fishing rights, etc.

In addition to the above, several local and regional river problems that frequently appear have not always been considered. These include (Jansky, 1998):

- division of fishing rights or rights on river beds,
- adjustment of boundaries when channels are diverted,
- tolls on navigation of and duties on crossing the river,
- the building of bridges and collection of tolls on bridges,
- escaped animals, prisoners or debtors,
- raising of the river for mills, and building weirs for these mills,
- rights regarding not lowering the water for navigation purposes,
- drawing of water for drinking or for non-riparian use (e.g., felling, panning for gold by machine, etc.),
- rights to game from the river banks, and
- the right not to have the water polluted by sewage or other effluents.

As for regional/national river problems, we can consider all of the above, on a larger scale, plus the rights of non-contiguous lands to use the river for navigation and for the passage of migrating fish, as well as to exploit the river and the bed sediments with or without damage to other users. Similarly, for pollution, the large-scale removal of water and diversion of river channels have to be considered. Rights of transit, refuge or repair in time of war must be taken into account as well.

Various combinations of influence can have different effects. Many river problems, such as flow control and conservation measures, influence downstream territories, while other problems, like migrating fish and navigation, operate in and affect upstream territories. Thus, disputes arise, more or less exacerbated by the superimposition of other, unrelated problems (including religion, politics, recent aggression, relative prosperity and expanding versus contracting economies). Different communities are more or less touchy about such matters, according to their traditions or their perception of unequal treatment on previous problems, and they have more or less successful ways of solving disputes. It would be interesting to see how disputes over water boundaries are solved within individual communities, between communities, or between villages or counties. There are several such questions to answer, but the subject needs careful consideration as a new chance for people and nature.

An integrated approach to land, water and natural resources management on a river basin level is very important. The concept of river basin management requires that decisions affecting the river should be taken within the context of the river basin as a whole. Key issues in this regard are water resources and the licensing of exploitation, water quality and the licensing of polluting discharges, flood control and flood protection, and the protection of ecosystems and habitats. It can also include the issuing of permits for (and controls on) land use – construction, agriculture, industry, solid waste disposal – where diffuse polluting inputs may affect ground and surface waters. This logically leads to integrated river basin management, i.e., the management of all environmental compartments on the geographical basis of the river basin.

Thirteen of twenty-five major river basins in Europe are basins of transboundary rivers, with the Danube being the largest of these. Unprecedented development of water and soil resources, and their exploitation and pollution, have taken place in most of the Danubian countries during recent decades. Some of the projects have been beneficial, but others are affecting the environment adversely. Most of the projects were planned and executed without proper consideration of the complex interrelationships and developments between people, water, land and the environment.

International cooperation

One special problem is the state of the Black Sea, where continuous polluting in past decades has set conditions for an ecological time bomb. It is said that the greatest polluters are the rivers mouthing to the Black Sea – and the greatest of these is the Danube. This problem, together with the question of water pollution in individual countries of the Danube basin, has become one of the main topics in discussions concerning the solution of environmental problems in countries of Central and Eastern Europe.

These countries have started to deal seriously with the efficient repair and improvement of the environment. Their first topic was the question of the water quality in the Black Sea, and then, recognizing the cause of this, in the Danube River. At the same time, Western countries sent their experts to assist in formulating tasks suitable for international cooperation, and in allocating technical and financial support for solving the environmental problems. These activities sometimes overlapped and resulted in a number of project proposals, not all of which were realistic, and some of which duplicated other efforts. Some were not even in accordance with the national priorities of individual Danubian countries.

Continued cooperative effort is badly needed – especially, tailor-made assessments to set priorities to protect rivers, to choose the best management practices, and to examine the effectiveness of measures taken under the Convention on Protection and Use of Transboundary Watercourses and International Lakes. It is not only pollution that poses a threat to human health and safety, and the ecological functioning of transboundary waters. The mitigation of adverse effects of floods on downstream populations and ecosystems remains a problem in many cases.

Cooperation on water problems has always been extremely important to European countries. At present, some 150 international agreements related to the protection and use of transboundary waters in Europe and North America are in force or have been signed. In addition, five environmental conventions and related protocols address the protection of transboundary waters, industrial accidents, air pollution control, environmental impact assessment, and public information and participation in decision making. The most recent agreements include:

- The Convention on the Protection and Use of Transboundary Watercourses and International Lakes, signed in Helsinki on 17 March 1992. This convention, intended to strengthen national measures for the protection and ecologically sound management of transboundary surface waters and groundwaters, obliges the parties to prevent, control and reduce water pollution from point and non-point sources. It also includes provisions for monitoring, research and development, consultations, warning and alarm systems, mutual assistance, institutional arrangements, and the exchange and protection of information, as well as for public access to information.

- The Agreement on Cooperation in the Field of Transboundary Water Management, signed by Romania and Ukraine on 30 September 1997.
- The Agreement on the Protection and Rational Use of Transboundary Waters, signed by Estonia and the Russian Federation on 20 August 1997, which entered into force on the same date.

Environmental Programme for the Danube River Basin

The Environmental Programme for the Danube River Basin (1994) was initiated in response to the increasing stress on the environmental quality of the river basin due to human influence. Problems arise from inadequate wastewater treatment and solid waste disposal facilities, the disposal of industrial wastes into the air and water and on land, and modernization and intensification of agricultural practices and livestock production. There is significant water, air and soil pollution at local, regional and transboundary levels, and serious deterioration of environmental conditions of the Black Sea that are significantly influenced by the Danube.

The long-term objective of the Environmental Programme for the Danube River Basin is to achieve sustainable use and development of the Danube basin's natural resources. The Regional Environmental Programme aims to establish an operational basis for strategic and integrated management of the Danube River Basin while focusing initially on priority environmental issues. A Strategic Action Plan focuses on areas of acute environmental concern and on the integration of environmental concerns into economic development policies.

Overall, the aim is to protect and enhance environmental values. The intent is to develop comprehensive inventories involving the systematic collection of information and its compilation in a form that facilitates study and analysis. Initially, inventories focus on areas of priority environmental concern and cover (a) existing data, infrastructure, and sources of pollution, (b) the accumulation of pollutants in soils, groundwater and sediments, and (c) biological resources.

A more strategic and comprehensive approach to data collection, processing and exchange is being followed. The aims are to develop tools and methodologies for high-level information processing; create the computerized infrastructure necessary for efficient data input, use and exchange; and promote the dissemination of the results. The top-level international information system will contain databases relating to bibliographic information, institutional frameworks and expert networks, synthesized environmental information (from national databases), standards and legislation, basin processes and human activities, and decision support systems.

New project for protection of the Danube River

The Regional Environmental Center (REC) Country Office of Slovakia is announcing a new project that will take advantage of the EU Water Framework Directive (EU WFD). This international project, called the NGO Participation in the Danube River Basin Management Plans, is supported by the UK Foreign and Commonwealth Office. The goal is to improve environmental awareness and encourage participation by NGOs in Danube River basin management plans at both the national and international levels (Muller, 2001).

International efforts to coordinate and manage the Danube basin have been active since 1991. Danube countries and the European Commission signed the Danube River Protection Convention in June 1994 in Sofia, Bulgaria. Although the level of Central and Eastern European NGO participation is currently limited due to insufficient effort into maintaining their participation and involvement, the EU Water Framework Directive presents a new opportunity to further improve the Danube's management.

Every EU accession candidate country must have all EU environmental legislation implemented at the date of accession (barring negotiated transition periods). The main tool of the EU WFD is the River Basin Management Plan (RBMP). The preparation of RBMPs is one of the most important venues of influence for NGOs. The information publicly available during the preparation of an RBMP allows NGOs to identify strategic weaknesses of the plan. In addition, the EU WFD allows for, and encourages, NGOs to demand more concrete, detailed sub-basin, watershed, and sector-based management plans. Hence, NGOs, supported by the general public, can have a highly significant, positive impact on future Danube River water management.

The aforementioned international project started on 1 September 2001 and runs through 20 December 2001. National NGO meetings will take place in Bosnia Herzegovina, Bulgaria, Croatia, Czech Republic, Hungary, Romania, Slovakia, Slovenia and Yugoslavia, with twenty participants from the NGO sector and relevant authorities invited to discuss their involvement in the National Danube RBMPs and select their representatives for the regional meeting.

REC Country Office Slovakia will hold a two-day regional meeting on 13 and 14 December 2001, where the 20 designated country representatives will discuss their roles and participation in the International Danube RBMP. The regional meeting will strengthen international cooperation and networking of NGOs involved in water management in Central and Eastern Europe. An additional result will be the creation of a project web page that will establish a new venue for further national and international cooperation and coordination

The EU Water Framework Directive[1]

Europe's citizens are increasingly demanding cleaner water:

- cleaner water for drinking;
- cleaner water for bathing;
- cleaner water as part of their environment, their local and regional heritage.

The increasing demand by citizens and environmental organizations for cleaner rivers and lakes, groundwater and coastal beaches is evident. This demand by citizens is one of the main reasons why the Commission has made water protection one of the priorities of its work. A new European Water Policy will have to get polluted waters clean again, and ensure that clean waters are kept clean. In achieving these objectives, the roles of citizens and citizens' groups will be crucial. This is why a new European Water Policy has to get citizens more involved. A thorough restructuring process concerning European Water Policy is on the way, and a new Water Framework Directive will be the operational tool, setting the objectives for water protection well into the next century. The following provides an overview on the development, present state and future of European Water Policy.

Addressing pollution from urban waste water and from agriculture

In 1988, the Frankfurt ministerial seminar on water reviewed existing legislation and identified a number of improvements that could be made and gaps that could be filled. This resulted in the second phase of water legislation, the first results of which were, in 1991, the adoption of:

• the Urban Waste Water Treatment Directive, providing for secondary

1 Transcript from the Official Journal of the European Communities, OJ No. L327.

(biological) waste water treatment, and even more stringent treatment where necessary, and
- the Nitrates Directive, addressing water pollution by nitrates from agriculture.

Other legislative results of these developments were Commission proposals for action on:
- a new Drinking Water Directive, reviewing the quality standards and, where necessary, tightening them (adopted November 1998), and
- a Directive for Integrated Pollution and Prevention Control (IPPC), adopted in 1996, addressing pollution from large industrial installations.

Consultation process

Pressure for a fundamental rethink of Community water policy came to a head in mid-1995. The Commission, which had already been considering the need for a more global approach to water policy, accepted requests from the European Parliament's environment committee and from the Council of environment ministers.

Whilst EU actions such as the Drinking Water Directive and the Urban Waste Water Directive can duly be considered milestones, European Water Policy has to address the increasing awareness of citizens and other involved parties regarding their water. At the same time, water policy and water management must address problems in a coherent way. This is why the new European Water Policy was developed in an open consultation process involving all interested parties.

The Communication was formally addressed to the Council and the European Parliament; but, at the same time, it invited comment from all interested parties, such as local and regional authorities, water users and non-governmental organizations. A score of organizations and individuals responded in writing, with most of the comments welcoming the broad outline given by the Commission.

The outcome of this consultation process was a widespread consensus that, while considerable progress had been made in tackling individual issues, the current water policy was fragmented, in terms both of objectives and of means. All parties agreed on the need for a single piece of framework legislation to resolve these problems. In response, the Commission presented a Proposal for a Water Framework Directive with the following key aims:

- expanding the scope of water protection to all waters – surface waters and groundwater,
- achieving “good status” for all waters by a set deadline,
- water management based on river basins,
- a “combined approach” of emission limit values and quality standards,
- getting the prices right,
- getting citizens involved more closely, and
- streamlining legislation.

European inland surface waters

European inland surface waters can be defined as all water on the surface of the land, including run-off moving across the land surface; streamflow in rivers, creeks or other natural channels; groundwater contributed through seeps or springs; and storage in lakes, ponds or reservoirs (man-made lakes). Groundwater and surface water are closely interconnected and need to be thought of as one hydrologic system; studies of their conjunctive use and management are also increasing. Interactions between surface waters and groundwater can be extremely important ecologically. Water resources in Europe have been profoundly influenced over the past century by human activities, including the construction of reservoirs and canals, large irrigation and drainage systems, changes of land cover in most watersheds, high inputs of chemicals from industry and agriculture into surface and groundwater, and depletion of aquifers.

Groundwater seepage into or out of stream channels can produce major changes in surface flow. Seepage from streams into adjacent alluvial banks maintains riparian vegetation in semiarid regions whose streams are fed by runoff from wetter, higher elevation source areas. Seepage into streams during the months following seasonal high flows helps to maintain base flow during periods of critical importance for many aquatic organisms. Short-term seepage into and from alluvial banks during floods (bank storage) can significantly attenuate flood peaks. Infiltration of polluted surface water into recharge areas can pollute groundwater, as has happened with nitrates in many agricultural regions of the Danube basin. The nature of surface-groundwater interactions must be understood in order to predict the potential consequences of reducing flow releases from dams or diversions, and of non-point source pollution on the surface.

Water quality in Europe's natural and man-made lakes appears to be improving, but water quality in many lakes is still poor and well below that in natural lakes in a good ecological state. Europe's groundwater is endangered in many ways. Significant pollution by nitrate, pesticides, heavy metals and hydrocarbons has been reported in various countries. Trends in nitrate pollution are unclear. Although smaller quantities of pesticides are being used, environmental impacts are not necessarily diminishing because the range of pesticides in use is also rather wide.

Integrated River Basin Management

Integrated River Basin Management (IRBM) is the coordinated planning and management of land, water and other natural resources based on natural river basins. Of particular importance is the need for integrated water and land management, as urbanization and the degradation of rural habitats can adversely affect the quality and quantity of water within streams, rivers and aquifers.

Integrated river basin management is not a new concept. This concept, which aims to establish a balanced approach to land, water and natural resources management on a basin scale, was developed more then 50 years ago. The concept of river basin management requires that decisions affecting the river be taken within the context of the river basin as a whole. The key issues are water resources and the licensing of exploitation, water quality and the licensing of polluting discharges, flood control and flood protection, and the protection of ecosystems and habitats. It can be extended to the issuing of permits for, and controls on, land use – such as construction, agriculture, industry, solid waste disposal – where diffuse polluting inputs may affect ground and surface waters. This leads logically to integrated river basin management: the management of all environmental compartments on the geographical basis of the river basin.

Unprecedented development of water and soil resources and their exploitation and pollution have taken place in most of the Danubian countries during the last few decades. Some of the projects have been beneficial, but others are affecting the environment adversely. Most of the projects were planned and executed without proper consideration of the complex interrelationships and developments between people, water, soil and the environment. It also should be considered that the idea of utilizing the enormous energy of the Danube dates back to the beginning of the twentieth century. However, it took nearly 50 years until progress in science and technology was ready for the implementation of such projects.

Five elements for effective integrated river basin planning

Five key cross-cutting issues need to be systematically considered for the different tasks to be performed during the river basin planning process – e.g., defining river basin districts, identifying key water management issues, assessing the most cost-effective set of measures for achieving objectives or developing monitoring programmes.

1. Integration between organizations, economic sectors and disciplines dealing with water management issues is required for ensuring efficient and cost-effective river basin planning. This is especially relevant for international river basins. Also, other EU legislation, policy and financial instruments are to be integrated with water policy to remove or minimize obstacles to sustainable water management.
2. The river basin is to be clearly recognized as the basic planning scale for water management measures. The great diversity in river basin sizes, however, means that approaches suitable to one location are not automatically transferable elsewhere (although the same basic planning principles must apply). Coherence is required between the processes developed at different spatial scales – i.e., reconciling top-down and bottom-up approaches to ensure environmental objectives are effectively met.
3. Timing of implementation is considered as critical. Deadlines for achieving the objectives of the WFD are extremely challenging. However, they must not be seen as a step-by-step timetable for implementation, as many tasks will effectively be required before such deadlines. A general lesson on timing? It is better to start implementing early but imperfectly.
4. Information, consultation and participation of the public and stakeholders are key elements of the process that will lead to successful river basin planning. Provision of transparent and accessible information, together with genuine opportunities for participation in planning and decision-making, should be prioritized from the start. Participation needs to be adapted to the appropriate scale, target groups and activities, and managed carefully to ensure expectations by all sides are clear and can be fulfilled.
5. Capacity among all relevant actors needs to be maximized.

> Capacity building, starting with awareness raising, is required for officials, planners and administrators, but also for economic sectors, local authorities and NGOs. Allocating adequate financial and human resources to capacity building and the participation process will be key to implementing the WFD, in particular for countries of Central and Eastern Europe that are future members of the EU. But will we be successful?

Conclusion

Much progress has been made in water protection in Europe – in individual member states, but also in tackling significant problems at the European level. But Europe's waters are still in need of increased efforts to get them clean or to keep them clean. After 25 years of European water legislation, this demand is expressed not only by the scientific community and other experts, but to an ever increasing extent by citizens and environmental organizations. We should take up the challenge of water protection as one of the great challenges for the European Union as it approaches the new millennium. Let us seize the initiative generated by the present political process on the Water Framework Directive for the benefit of all Europe's citizens and waters:

- getting Europe's waters cleaner, and
- getting the citizens involved.

The WFD represents a fundamental reform of EU water legislation in both environmental and administrative terms. Indeed, if fully implemented, the Directive will be a significant step towards implementation of Sustainable Development within the EU.

The environmental management of the Danube River basin should be promoted within the framework of the WFD. Materializing integrated water management is clearly the way to go for any international water system, yet it has hardly been put into practice in the past. The Danube River basin can be considered to be a harbinger in this regard.

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Institutional Aspects of International Water Management: Lessons from the Mekong River Basin

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Introduction

Water resources in international water systems are a multi-national issue, for which the establishment of issue-specific intergovernmental organizations is supposed to be instrumental for conflict abatement and resolution. It should be asked, however, what kinds of roles are to be played by such organizations. Among existing institutional mechanisms for international water systems, the Mekong Committee has often been mentioned as a model to be followed for other international river systems. Indeed, although it has not always functioned to meet expectations, the Mekong Committee has many reasons to be applauded. This paper describes the functions that a river basin organization (RBO) can be reasonably expected to perform, in particular by reviewing what happened in the Mekong Committee.

Mekong River basin

The Mekong River is an international river extending through six riparian countries: Cambodia, China, Lao People's Democratic Republic, Myanmar, Thailand and Viet Nam. It has a total length 4,200 km, making it the 12th-longest river of the world, with 795,000 km^2 of catchment area and 4,750 million m^3 of average annual runoff. It is the largest international river within South-East Asia (Kuniyasu, 1992).

The river rises in Tibet and flows for about 2,000 km through high mountain ranges and valleys in the Yunnan Province of China and northeastern part of Myanmar. It then enters into the lower Mekong basin at the Lao PDR, and then forms the border between the Lao PDR and Thailand for a distance of 900 km. It flows through Cambodia and Viet

Nam before discharging into the South China Sea. In Viet Nam, it has a large delta named “nine dragons.”

Four riparian countries (Cambodia, Lao PDR, Thailand and Viet Nam) of the six basin countries constitute the lower Mekong river basin. The lower Mekong basin covers 609,000 km^2 (about 77 per cent of the Mekong’s total catchment); it includes almost all of the Lao PRD and Cambodia, one-third of Thailand, and two-thirds of Vietnam (OECF, 1974). The Mekong’s potential for hydropower, irrigation, flood control, navigation and fishery development is immense. It is the only large river in the world, other than the Amazon, that remains virtually unexploited (Kirmani and Le Moigne, 1997).

In 1952, the Bureau of Flood Control of the Economic Commission for Asia and the Far East (ECAFE) of the United Nations published the initial report about flood control and water resources development of the Mekong river basin. Further study was carried out by ECAFE in 1956 regarding the basin’s potentialities in hydropower, irrigation and flood control. The report of the study, published in 1957, provided a conceptual framework for developing the Mekong River basin as an integrated system by having close collaboration of the riparian countries. The report pointed out that irrigation was then practiced on only 3 per cent of the entire farmland (57,000 km^2) of the four riparian states, and that water resources could be developed to irrigate as much as 90,000 km^2 of farmland. It also suggested that 13.7 GW of hydropower could be generated by constructing five dams within the catchment. The report also called for (a) establishment of an international channel, or clearing house, for the exchange of information and coordination of projects, and (b) signing of a convention and establishment of a permanent body for the development of the basin (Mekong Secretariat, 1989).

It was envisaged that development and management of water resources in the Mekong River basin, for hydropower generation, irrigation and flood control, would spur socio-economic development of the basin countries and help lift the region out of poverty (Jacobs, 1995). The prevailing poverty of the region was then regarded as the major driving force of the communist movements in the riparian countries, and the US Government gave full support for the development scheme of the Mekong river basin.

The representatives of four countries (Cambodia, Lao PRD, Thailand and Viet Nam) met in May 1957 to follow up on the report by ECAFE, and recommended the creation of a “coordination committee.” Another meeting by these four countries was held in September 1957, and the “Statutes” was unanimously adopted by the representatives of the four basin countries. The “Mekong Committee” thus came into being. It was the first attempt by the United Nations in terms of its direct involvement in continuing support for the planning and development of an international river basin (Mekong Secretariat, 1989). The Mekong Committee was established to promote, coordinate, supervise and control the planning and investigation of water resources development projects in the lower Mekong basin. The Committee has an Executive Agent, as the head of the Secretariat, whose main functions are to implement the Committee’s decision (Caponera, 1966).

Leading industrialized countries supported the idea of comprehensive international development of the Mekong River basin. Various studies were launched on hydropower, irrigation, navigation, fishery and flood control within the framework of the Mekong Committee (Hori, 1993), which thus served as the focal point of donors in the region.

Two countries in the upstream of the Mekong River basin – China and Myanmar – did not join the movement due to political reasons. China was then not a member of the United Nations, and Myanmar (then Burma) was not willing to participate in such an international effort.

Roles of river basin organizations

Inter-governmental institutes have been established in many international water systems as RBOs. While some of these now function satisfactorily, others are practically defunct. The vital question to be asked is: What kind of roles should be played by such organizations under prevailing circumstances in the real world? Experience has shown that a river basin organization may play one or more of following roles for the sake of basin countries.

Provision of a common arena for member states to regularly meet and discuss issues related to their shared water resources. – In cases where no river basin organization exists, riparian countries must deal with any issue related to their shared water resources (in an international river basin, lake basin or aquifer) through usual diplomatic channels on a case-by-case basis. Providing riparian countries with a common and regular arena should be instrumental in giving chances for each basin country to (a) meet periodically with their counterparts in other riparian states, (b) make representatives familiar with the ways of thinking of other representatives, and (c) promote mutual understanding and trust among participating parties. Most RBOs thus have periodic meetings among member states.

Having a river basin organization, however, does not automatically promote such movements. In one particular existing river basin organization in South Asia, for example, the only agenda item of any regular meeting for more than a decade in the past was determining the date and venue of the next meeting. The reason was that one of the member states was unwilling to discuss anything substantive at the meetings and, in practice, executed a veto against any substantial agenda. Not surprisingly, the RBO existed for years without producing any visible result in terms of sharing the common water resources. In another river basin organization in Asia, member states typically criticize the behaviour of other basin countries, mostly about inequitable use of the shared water resources, while practically no attempt has been made to resolve conflicts by the countries involved. Efforts by all member states are needed to prevent an RBO from becoming defunct.

Promoting information sharing among various countries and agencies. – It can be noted that a basin country often has insufficient knowledge about other riparian states, particularly regarding such fundamental knowledge as meteorological and hydrological data. In fact, basin countries are sometimes suspicious of any data offered by other riparian states. Resolution of the dispute between India and Pakistan in the 1950s over sharing of water resources in the Indus River basin, for example, experienced many years of delay due to the fact that one party did not trust the meteorological and hydrological data provided by the other, and kept insisting on more and more data. Having a common data and knowledge base among basin countries, which should also be shared with donor countries and aid agencies as well as general public, ought to be instrumental in avoiding or alleviating distrust among basin countries about the reliability of the data on which the development and management scheme of a catchment should be based.

The impacts of information disclosure may be examined by comparing the Mekong River with the Ganges River. In the former, the Mekong Committee (now Mekong River Commission) has been instrumental as a focal point for disseminating information about the basin for the past four decades. It collects and makes available meteorological and hydrological data in the basin, various studies carried out in the past for development and management of the basin, minutes and notes of discussions held in the Committee (Commission), and articles that have appeared in journals and newspapers. This de facto information disclosure policy in the Mekong basin has successfully promoted support from donor countries and organizations for the sake of economic development of the basin countries, and has also resulted in many academic research activities in and for the basin by researchers throughout the world.

In the Ganges River basin, on the other hand, the hydrological data in India has been classified, and no organization functions as a focal point for information disclosure. Thus, not surprisingly, much less support has been offered by donors for management of the Ganges River system simply because “outsiders” are unable to obtain sufficient information about the Ganges River system for developing their own project ideas. It is remarkable that graduates of the Asian Institute of Technology (in Bangkok, Thailand) have developed many theses about the Mekong River basin, but few theses have been developed about the Ganges River system. This suggests that the intellectual resources of this highly advanced engineering college in Asia have not been used for the sake of the Ganges River basin, while the Mekong River basin has enjoyed the benefits of these resources.

Developing a coordinated water resources development and management scheme is often the major aim of harnessing riparian states, as in many cases in the past. A realistic basin-wide management scheme may be developed only through collaboration of riparian states. Having such a scheme serves as a proof for other countries (in particular, donor countries) and aid agencies that riparian countries are on good terms – at least to the extent that they have developed the scheme through collaboration and are ready to implement the scheme in a coordinated manner.

The development scheme of the Mekong River basin in Southeast Asia is a good example. The Mekong Committee was established in 1957 by four riparian countries (Cambodia, Laos, Thailand and Viet Nam) to promote, coordinate, supervise and control the planning and investigation of a water resources development project in the lower Mekong basin (Caponera, 1966). It was then envisaged that development and management of water resources in the Mekong river basin, for hydropower generation, irrigation and flood control, would spur socio-economic development of the basin countries and help lift the region out of poverty (Jacobs, 1995). Leading industrialized countries supported the idea of comprehensive international development of the Mekong River basin. Various studies were launched on hydropower, irrigation, navigation, fishery, and flood control within the framework of the Mekong Committee (Hori, 1993).

In 1970, the Mekong Committee published a detailed report about the "Indicative Basin Plan." This showed the framework for the development of the basin over the next three decades, with emphasis on integrated development of water resources for the sake of improving the quality of life of the growing population in the basin countries (Mekong Secretariat, 1989). The Indicative Basin Plan identified 180 possible projects in the basin.

Of these, the idea of constructing seven cascades of dams in the main stream was the major component. The aims of constructing these dams were mainly for power generation and irrigation. With seven dams, the total effective storage was to be 140,550,000 m^3, with power generation capacity of 18,900 MW. About 40,500 km^2 of farmland was supposed to be irrigated (Kawai, 1984). The large-scale development scheme envisaged in 1970s was not materialized, however, due to changeover of political regimes in three of the member states as well as increased environmental concern over the huge development plan. The Mekong Committee nevertheless functioned as the coordinating mechanism of the basin countries for more than 30 years. The continuing collaboration among basin countries has led to many economic development activities in the region, and the Mekong Committee has been instrumental in formulating the development scheme of the basin – not according to the "huge development scheme" as envisaged in the 1970s, but as the collective effects of small to medium-sized projects in various fields.

Securing assistance from donor countries and development aid agencies. – Having a basin-wide development or management scheme may motivate donor countries and aid agencies so that more financial and other sort of assistance is given to the basin countries, for the sake of materializing such a scheme. In many cases, obtaining resources from outside is the only foreseeable and realistic way of moving a scheme from paper to reality. A development or management scheme therefore should be very solid and "doable." In the real world, however, elaborating a realistic scheme, as a team effort of all the basin countries, tends to be much more difficult than developing an unrealistic scheme. This is because interests of each riparian state may not be fully reflected in a realistic scheme, while each country may put whatever it wants in an illusionary scheme. The latter is much easier to be agreed upon than the former.

Resolution of conflicts among member states. – A river basin organization is supposed to be instrumental towards resolution of conflicts among member states. However, RBOs have not always been useful in this context. A notable example was failure of the Mekong Committee in resolving conflicts between two member states, Thailand and Viet Nam, in the early 1990s. Representatives of Cambodia, Lao PDR, Thailand and Viet Nam signed the "Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin" in April 1995. This Agreement provides principles for sustainable development, utilization, management and conservation of the water and related resources of the Mekong River basin, as well as institutional, financial and management issues relating to the mechanism of coordination between the member countries (MRC, 1996). The negotiation process among riparian countries towards the Agreement was unique in that the United Nations Development Programme (UNDP) played a mediatory role as a third party.

Disputes between Thailand and Viet Nam effectively impaired the functioning of the Interim Mekong Committee, however. The Committee had been faced with an impasse since January 1992. The UNDP was worried about the possible "disappearance" of the Interim Mekong Committee, in which it had invested a lot of money during the "dark period" of 1975 to the early 1990s.

The UNDP, therefore, organized informal meetings among the four riparian countries, with the aim of finding out whether the riparian countries were still willing to maintain the (Interim) Mekong Committee as a mechanism for collaboration. The riparian countries showed their willingness, through these informal consultations, to maintain the mechanism for collaboration. It was also agreed that a Working Group should be established with representatives of the four riparian countries under UNDP's chairmanship to look into the future framework for cooperation. Through five Working Group meetings held in 1993 and 1994, the draft "Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin" was developed, and subsequently signed by representatives of the four riparian countries in April 1995. Thus, the

UNDP successfully played a role of mediator.

Sharing of costs and benefits in water resources development/management. – Basin countries tend to feel the needs of “costs and benefits sharing” when a particular international water system has attained a certain degree of development. This was the case in international water systems shared between Mexico and the United States, as well as between Canada and the United States.

The Mekong River basin has not yet reached the point where the basin countries feel the need for a “costs and benefits sharing” mechanism. Even the dispute between Viet Nam and Thailand in the early 1990s did not lead to such a mechanism, nor have the possible implications of dam and reservoir construction in China driven other basin countries into the need for such a mechanism.

It should be noted , however, that once a river basin has reached a certain degree of development, riparian states are obliged to develop some sort of “costs and benefits sharing” mechanism. The Mekong Committee (now the Mekong River Commission) was supposed to be an arena for the member states to raise this particular issue and develop a mutually agreeable solution.

Conclusion

It goes without saying that establishing an inter-governmental organization by participation of all basin countries should be useful in the context of having a common arena for member states to regularly meet and discuss issues related to their shared water resources. The Mekong Committee (now Mekong River Commission) was, in this context, a model to be followed by other international water systems. It has consistently provided member states with chances to meet and discuss issues, even when some member states experienced hard times in the late 1970s to early 1990s.

A river basin organization should be instrumental in promoting information sharing among basin countries as well as other parties, including donor countries, international agencies, non-governmental organizations, research institutes and private firms. This may take place, however, only if member states believe in the concept of information disclosure and the assumption that transparency of information is a most effective tool in promoting rational management of international water systems.

The Mekong Committee has maintained meteorological and hydrological monitoring since the 1960s through the collaboration of member states (because a reliable monitoring scheme did not exist in the basin back in the 1950s, when the Mekong Committee commenced its work towards basin-wide development of water resources). The fact that the Mekong Committee has maintained the monitoring system, through assistance from the basin countries, has materialized transparency in data gathering and distribution. These data are in fact available to anybody at reproduction cost. The transparency in these data has apparently motivated many researchers to work on the hydrological regime of the basin, and was also instrumental in fostering various project ideas about use of water resources, both at national as well as regional levels. It seems evident that the transparency of hydrological and meteorological data is far advanced in the Mekong River basin, as compared with other international water systems, and that this has led to the development of many project ideas both by riparian countries and donors.

Developing a coordinated water resources development and management scheme has in many basins the highest priority of the coordinated efforts by basin countries. Securing assistance from donor countries and development aid agencies may materialize it. Basin countries should make efforts so that a development or management scheme is realistic, not illusionary, to the extent that other parties (particularly donor countries and agencies) can be confident of its feasibility. The Indicative Basin Plan elaborated by the Mekong Committee was successful in getting basin countries harnessed towards an integrated development scheme of the catchment. However, it should still be examined whether the contents of the Indicative Basin Plan are sufficiently realistic to the extent donor countries and aid agencies find the plan “doable.”

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Multi-Country Cooperation for Sustainable Development of International Lake Basins: Lessons from the Global Environment Facility[1]

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Introduction

Lakes are sensitive ecosystems that are highly susceptible to anthropogenic impacts. Management of lake environments in a sustainable fashion requires a basin-wide approach that integrates all sectors. The issues are further complicated by the fact that many lake basins are shared by two or more countries.

This paper draws upon the experiences gained by the Global Environment Facility (GEF). The GEF was established with the objective to forge international cooperation and finance actions to address threats to the global environment. The Facility contributes to the management of international waters as a catalyst to the implementation of comprehensive ecosystem-based approaches to managing the transboundary waters and their drainage basins (Duda and El-Ashry, 2000). In particular, two recent evaluations focusing on institutional arrangements of projects dealing with transboundary environmental resource management (Ollila et al., 2000) and on the overall experiences of the international waters programme area of the GEF (Bewers and Uitto, 2001) inform the analysis presented in this paper. Lessons from the World Bank's similar experiences with the management of lakes and reservoirs are also referenced (Dinar et al., 1995).

Examples are drawn from the East African Great Lakes – Malawi, Tanganyika and Victoria – as well as the Tonle Sap in the Mekong basin.

1 UNU Workshop: Lakes and Reservoirs as Important Elements of International Water Systems, 9th International Conference on the Conservation and Management of Lakes, Otsu, Japan, 14 November 2001.

These cases demonstrate the key role of integrated land and water management on a basin-wide scale, and how upstream development may threaten the ecosystem and resource base upon which large populations depend for their livelihood.

Experience shows that it is necessary to focus on processes that bring together all sectors and actors at regional, national and local levels whose actions affect lakes and their drainage basins. The development of science-based diagnostic analysis is essential to identify the threats to a transboundary ecosystem and to break down the complex issues into manageable parts, with the aim of developing a strategic action programme to move the basin towards sustainable development. Ensuring political commitment that can result in institutional, policy and legal reforms in the countries concerned is the key to sustainable development of the transboundary resources.

Experiences with the East African Great Lakes

The East African Great Lakes form some of the most complex and sensitive ecosystems in the world. They also provide the basis of livelihood for millions of people who depend on the fisheries and other resources in and around the lakes. Since its establishment a decade ago, GEF has been active in the region. This section focuses on the experience gained through the management of Lake Malawi, Lake Tanganyika and Lake Victoria. It is worth noting that while the two first are parts of the East African Rift Valley system, Lake Victoria is physiographically very different, being a relatively shallow depression lake (figure 1).

Lake Malawi and Lake Tanganyika

Lake Malawi – Lake Malawi, Africa’s third-largest lake, covers an area of 28,760 km^2. It is shared by Malawi, Mozambique and Tanzania. The lake fisheries are important, especially for Malawi, as fish from the lake provide about 70 per cent of the annual animal protein consumed in the country (Chipofya and Mapila, 2000).

The physiography of the lake is such that only the southern part, which is within the territory of Malawi, provides a shallow shelf that allows for small-scale coastal fisheries. In other parts of the lake, this shelf is missing and the shores are steeper. Furthermore, because Mozambique and Tanzania both have a long coast on the Indian Ocean, there is greater emphasis on oceanic fisheries in these countries. For these reasons, the

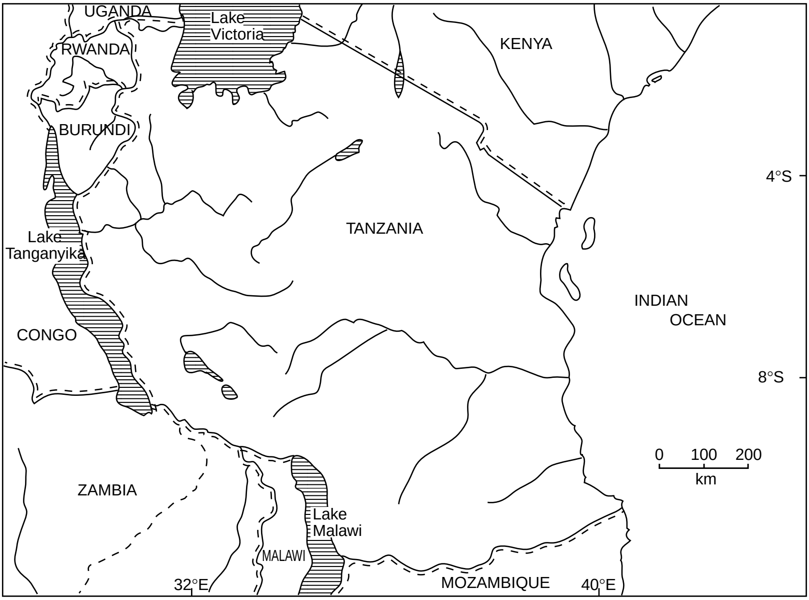

Figure 1. The East African Great Lakes

pressures on the lake fishery in Mozambique and Tanzania are significantly less severe than in Malawi, where intensive small-scale fishery in the southern part of the lake, in response to the rapid population growth in the country, has caused a noticeable decrease in fish yields and stocks.

Lake Malawi has not been not as important a resource for the two other countries, nor have they caused significant threats to the lake. This situation is starting to change, however, as more people are moving to the shores of the lake in Tanzania and, especially, in Mozambique (where an extended civil war is now over, and displaced people are being resettled on a large scale).

Apart from over-fishing, the lake environment is also threatened by sedimentation. Intensive smallholder agriculture, deforestation and erosion in the watersheds surrounding the lake are placing strains on the lake environment that need to be addressed. Environmental management of Lake Malawi, thus, requires an integrated approach to land and water management.

The emphasis of the GEF pilot phase “Lake Malawi/Nyasa Biodiversity Conservation Project,” implemented by the World Bank, was on establishing the scientific, educational and policy basis for sustainable conservation and management of the lake's globally important biodiversity. A major objective was the strengthening of capacity among the participating countries in freshwater management, research and environmental education disciplines. The project has provided baseline biological and water quality information as a basis for future scientific monitoring and lake resources management. These outputs, together with the initiatives to harmonize policy and legislation, are expected to strengthen trinational lake research and management and provide the capacity and information necessary for maintaining biodiversity in the lake. The legal framework is being implemented through an Agreement of Technical Cooperation, signed by the three countries with FAO in 1997.

The greatest scientific challenge of the project has been to collect sufficient information on fish taxonomy and systematics, physical and chemical descriptors of fish habitats, and the interaction between habitats and the associated biological communities that describe the lake's ecology so as to enable preparation of a management plan for Lake Malawi.

The reports coming from the research work clearly show that exploitation of the near-shore fisheries and accelerated sedimentation from catchment soil erosion are now causing adverse impacts to and loss of lake biodiversity. The southern part of the lake in Malawi is most affected because of a large increase in population in the last two decades, and intensive deforestation and cropping patterns.

Habitat loss, interference with fish reproduction through turbidity, and physical sedimentation were key issues assessed in the project, but these are not addressed through management activities. In fact, mud enters the lake as underflow and, during July and August, persistent southern winds cause upswelling of bottom water that fertilizes the surface layers and can result in massive fish kills, such as those that occurred in 1999 affecting both Malawi and Mozambique (Chipofya and Mapila 2000). In essence, the basis for a transboundary diagnostic analysis resulted from the research, and the urgent need for action on the land and in reducing fishing pressure is to be supported in a follow-on project.

The first project focused almost exclusively on fisheries and on one of the countries, Malawi, which also reaped most of the benefits. Although the implementation of all project components was guided by a tripartite Steering Committee, the participation of the Mozambique and Tanzanian governments was quite limited. The Steering Committee was chaired by the

Principal Secretary of the Malawi Ministry of Natural Resources and Environmental Affairs, the funds for the project activities were channeled through Malawi, and that country also dominated most project decisions. There was only one GEF Legal Grant Agreement with the Government of Malawi. Tanzania and Mozambique have expressed throughout the project their desire for a more formal agreement, one which would guarantee a more equal sharing of the project resources between the three countries for future monitoring and management activities.

The need for expanding the focus to actual resource management and the critical issue of sustainability of the management activities in the three countries has been recognized in planning for a follow-on project. The new "Lake Malawi/Nyasa Environmental Management" project, currently under development, will identify and demonstrate practical, self-sustaining environmental management interventions in critical pilot zones, while simultaneously building the capacity of local institutions for ecosystem management. It will have as its central objective maximizing the benefits to riparian communities from fisheries and the improved management of soils, generating employment and income while sustaining the ecosystem from which these benefits arise.

One of the main lessons from the first project is that, in order to effectively engage countries in a multi-country project around a shared resource, there is a need to fully incorporate all participating countries as equal partners in the management of the shared resource.

If sustainable development is to be achieved in the Lake Malawi basin, there is need to develop a shared vision of action to reverse land degradation and reduce fishing pressures where these are adversely affecting the biodiversity. This vision must incorporate environmental management with the requirement of improving the livelihood of the stakeholder communities in which poverty is still prevalent. As many threats to the lake's biodiversity and environment as a whole are related to the management of the land-based resources and the growing population that intensively farms the land or extracts fish from near-shore areas, it is important to assume an approach that integrates land and water management and engages all relevant agencies and stakeholders in all three countries.

Lake Tanganyika – Lake Tanganyika is the second-deepest lake in the world and contains an amazing variety of biodiversity. Thus far, more than

1,200 species of organisms have been found in the lake, despite the fact that only about 10 per cent of the lake's coastline has been explored scientifically (Patterson and Makin, 1998). From the point of view of biological diversity, Lake Tanganyika has one of the highest rates in any lake in the world and must, therefore, be considered a globally significant ecosystem.

Amongst the most important environmental problems threatening the lake are deforestation, intensification of land use and unsustainable land-use practices. These have resulted in land degradation and sedimentation, leading in some places to eutrophication of the lake.

The multi-country Lake Tanganyika project, "Pollution Control and Other Measures to Protect Biodiversity in Lake Tanganyika," was designed in a radically different way from the predominantly single-country Lake Malawi project. UNDP took advantage of early experiences to assist Burundi, Democratic Republic of the Congo, Tanzania and Zambia in addressing their shared lake basin and building institutional commitments for joint multi-country collaboration.

A project coordinating unit was established to facilitate each country's participation in activities, both singly as well as jointly. High-level officials from each nation participated in a Steering Committee that was responsible for the project. Various programmes were established with the objective of helping the riparian countries to produce an effective and sustainable system for managing and conserving the biodiversity of the lake. By involving local communities in programme design, the programmes embraced the dual needs of development and conservation so that livelihoods of the people (i.e., sustainable use of the biodiversity resource) can be maintained into the future. The programmes varied from biodiversity conservation to fisheries, the impacts of sedimentation and catchment degradation and pollution to socio-economic issues, and education to development of a joint geographic information system (GIS).

The original planning called for the production of a strategic plan for the lake. Following adoption of the GEF Operational Strategy by the GEF Council (GEF, 1996), UNDP worked with the project to modify its programme of work to become more consistent with the international waters portion of the Operational Strategy. The project adopted the approach of joint fact-finding in compiling information so all countries could review and update it through the GIS. The result of the assessment is a transboundary diagnostic analysis (TDA) that identifies two or three top-priority shared resource issues and relegates other environmental problems to other efforts.

Pollution discharges in Bujumbura, Burundi, and Kigoma, Tanzania, were cited as hotspots for abatement activities. Excessive sediment loading from certain river basins, mostly in Burundi and the Democratic Republic of the Congo, and scattered elsewhere, were identified for accelerated attention. Over-fishing was identified as an important issue because of the large commercial fishery, its economic importance to the nations and the transboundary nature of the stock and pattern of landings and markets.

The programme also adopted the formulation of a strategic action programme (SAP): a series of activities to be implemented not only jointly but also by individual countries to address the top-priority issues. Various assessments conducted under the programmes built the capacity of country officials to sample and assess environmental status in the areas of biodiversity, pollution and sedimentation. Many of the publications are available on the project website (www.ltbp.org).

The website is essential, since the project has inter-country linkages as well as linkages with UNDP, GEF, and coaches from international organizations. A firewall for internal use has been implemented; this is important for the exchange of information in this remote area in preliminary form and to allow the countries to carry out dialogue about shared issues among themselves in a confidential atmosphere. For those participants without an Internet connection, CD-ROMs are produced every three months. These, together with the public portion of the website, promote transparency among NGOs, government officials, the different countries and funding organizations.

Of great importance was that as of the end of 1999, the Lake Tanganyika governments were on the fourth draft of an international treaty ("The Convention on the Sustainable Management of Lake Tanganyika") to affirm their political support for the restoration and protection of the Lake Tanganyika ecosystem. The draft convention would establish a Lake Tanganyika Authority, consisting of a joint Management Committee and a Secretariat to assist the nations in operationalizing sustainable management of the lake, its biological resources and the catchment area draining to it. Various protocols and annexes would specify progressively more stringent country commitments as implementation proceeds. The draft SAP includes the commitment to move toward the convention and the Lake Management Authority as well as provisions for national actions within the regional framework.

Despite the war and unrest that have plagued the Democratic Republic of the Congo and Burundi during the project's lifetime (which necessitated moving the coordination office to Tanzania), important progress has been made in understanding the technical issues of a transboundary nature, identifying hotspots for concerted action, building a joint understanding and shared ownership of their lake basin, harnessing the scientific organizations and local communities, and setting the stage for building political commitments at the top level for joint management of the resource.

Lake Victoria Environment Management Project

The situation in the Lake Victoria region is significantly different, both from environmental as well as socio-economic points of view. These differences start with the fact that the lake itself, unlike Lakes Malawi and Tanganyika, is not a deep Rift Valley lake, but a relatively shallow lake covering a water area of 68,800 km^2. Some 25 million people live in the catchment area of 184,000 km^2 within the territories of five countries: Kenya, Tanzania, Uganda, Rwanda and Burundi. The three first-mentioned share the shores of Lake Victoria.

The Nile Perch fishery, which was introduced in the 1960s, has evolved into the largest freshwater fishery in the world, with an approximate value of US$200 million per annum. The basis of this fishery is in a changed environment that has resulted from the increased level of nutrients and sediment in the lake. However, later developments have demonstrated the negative effects of excessive eutrophication, and infestation by water hyacinth and other weeds (e.g., hippo grass and papyrus) is threatening not only the fishery but also the economic viability of all lacustrine communities. Since the late 1980s, toxic algal blooms have been recorded, reducing light transmission, and the deep waters of the lake have been deoxygenated (Hecky, 2000).

While the Nile Perch now dominates the fishery and has replaced approximately 200 of the 500 original fish species in the lake over the past couple of decades, some smaller satellite lakes in the basin still contain significant remnants of the original species. These are important repositories of unique biological diversity and should be protected. However, even these satellite lakes are under increasing pressure from fishing as well as development.

The root causes of the changes in the lake environment lie in the surrounding land areas, but these vary from country to country. In Tanzania, population densities and urbanization levels are not as high as in the other countries, but livestock and the sewage of one urban area (Mwanza) contribute to the eutrophication of the lake. It is the dense population concentrations, urbanization and industrialization in Kenya and Uganda, however, that are the major contributors to the environmental problems of the lake. In Kenya, Kisumu and other major towns release virtually untreated sewage into the lake. A paper mill, a brewery, and industrial-level production of sugar in multiple mills are major sources of nutrient inflows into the lake, as is the application of subsidized fertilizer on the sugar and tea estates. Other contributors include the drainage of critical wetlands, such as the Yala Swamp, that no longer trap nutrients.

A key element of the World Bank-implemented GEF "Lake Victoria Environmental Management Programme" is control of the water hyacinth infestation. The project is testing various methods for water hyacinth control, including biological control (showing great promise, especially in Tanzania), mechanical methods, and the utilization of harvesters. However, one of the major drawbacks in this and other respects in the project is that not all basin countries are party to it. This becomes particularly clear when considering that much of the water hyacinth reaches the lake through the Kagera River from Rwanda and Burundi. Therefore, it will be essential to engage these countries in the programme as soon as this is politically possible.

From the multi-country project arrangement point of view, several lessons emerge. First, it has proven to be important to have an effective system for coordinating the activities not only between sectoral authorities involved in the project but also between the countries. As it now stands, the programme consists very much of three separate country projects that have advanced at very different paces and with somewhat different approaches. Although a detailed tripartite agreement was signed at the time of the launching of the preparation process in August 1994, such an integrated approach to project implementation has not been realized. In this regard, emphasis was originally placed upon working through the Lake Victoria Fisheries Organization (LVFO), but this was not maintained in the longer term.

A unique achievement has been the establishment of a regional Tender Board to service the entire project. This feature is intended to provide economies of scale and to smooth the processes of purchases in the project, but in practice it has been somewhat hampered by increased bureaucracy. Nevertheless, the concept is seen as highly beneficial.

For the project to be successful, it is essential that the national project executing authorities are located close to where the activities need to be executed. In Tanzania, the move of the project office from Dar es Salaam to Mwanza in 1999 resulted in accelerated progress in the project. In Kenya, while the project offices are now located in Kisumu and other basin towns, implementation of the project has still been slow. Most of the heads of the project components are also still based in Nairobi. These implementation differences contribute to disparities between the countries, which are likely to slow down the overall progress.

One problem with the project is its large number of components, and the fact that their status of implementation amongst each other and between the different participating countries varies significantly. Each of the components is encouraged to have regular harmonization meetings with its counterparts in the other participating countries. These efforts towards harmonization have been successful to a varying degree depending on the component, but ad hoc meetings cannot substitute for an independent, dedicated facilitating organization that can establish a sense of trust among all countries.

Furthermore, the lack of process indicators as well as comprehensive monitoring and evaluation at the regional level make it difficult to assess the progress that has been made. It will be important to better coordinate the activities of the sectoral or thematic components within each country as well as between the three. A joint and shared management information system for the entire project would be helpful, but this is yet to be put in place.

There is also a need to make a stronger link to policy formulation, legal and institutional reforms, and harmonization at both national and regional levels. Only such linkages could result in the required institutional developments that would guarantee the sustainability of the actions.

Tonle Sap and its connections to the broader Mekong basin

The case of Tonle Sap – Cambodia's Great Lake – highlights the need for taking a basin-wide approach even when a lake is within a single-country jurisdiction. Tonle Sap is situated within the borders of a single country, but its environmental future is entirely dependent on the developments in the

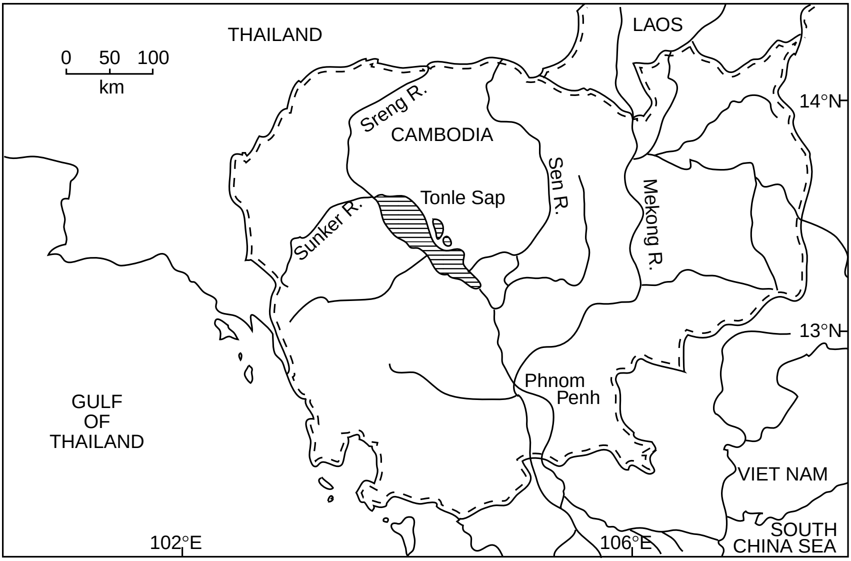

Figure 2. Tonle Sap and the Mekong basin

broader international basin of the Mekong River (figure 2).

The lake's importance for the population of what is now Cambodia as a source of fish protein and water for rice cultivation is well recorded historically (Osborne, 2000). The Tonle Sap river, which connects the lake to the Mekong through a distance of only 130 km, flows through a flat terrain. During the dry season, water from the lake flows through the Tonle Sap river to the Mekong, but during the rainy season the direction of the flow is reversed, and the lake becomes a temporary reservoir for the Mekong. This function is one of the key features of the lower Mekong Basin (Hori, 2000).

The Great Lake's annual cycle directly reflects that of the Mekong. During the dry season, the lake covers an area of about 3,000 km^2, while in the rainy season it expands more than threefold to 10,000 km^2. This absorption of a huge amount of Mekong water during the rainy season significantly reduces flooding in the Mekong delta. In the dry season, on the other hand, the waters from the Great Lake replenish the Mekong river, thus contributing to irrigation, making navigation possible throughout the year, and stopping seawater intrusions in the coastal areas. This self-regulatory system is, thus, highly beneficial to both the natural and human activities.

However, construction of a large dam on the Mekong main stream or a tributary would have a considerable impact on the water volume in the delta and, especially, the Tonle Sap lake. In recent times, the Great Lake has become shallower due to siltation and inflows of mud and sand carried by the Mekong waters. Its current depth is only 1–10 m. A large dam upstream would reduce this depth significantly, which would take a toll on the lake fishery that is of utmost importance to Cambodia (Hori, 2000).

GEF is currently developing a project through UNDP and the Asian Development Bank on Integrated Resource Management and Development in the Tonle Sap Region. The objectives of this project are to:

(i) support economic development and natural resource management;
(ii) strengthen community-based natural resources management systems for rural development; and
(iii) conserve globally significant biodiversity through protection and sustainable use of resources in threatened components of the ecosystem and critical habitats.

While action is needed to protect the biodiversity in the lake region, it is recognized that events in the broader basin, such as damming the upper reaches of the Mekong, could have significant negative impacts on the Great Lake that would be beyond the control of the Cambodian project. Therefore, GEF is also supporting the work of the Mekong River Commission to establish mechanisms to promote and improve coordinated and sustainable water management in the basin, including reasonable and equitable water utilization and ecological systems, such as wetlands, flooded forests and the estuary system. This is intended to be achieved through preparation of “rules” for water utilization – in particular, minimum in-stream flows on the Mekong river – and protocols for information exchange, notification and consultation in accordance with the Mekong Agreement.

A critical issue is that while the lower riparians – Cambodia, Laos, Thailand and Vietnam – cooperate around these actions, the upper riparians – Myanmar and, notably, China – have stayed outside of the formal agreements. Including them in developing a shared vision for the sustainable development of the entire Mekong Basin should be a future priority.

Conclusions

Several lessons have been learned from the first decade of GEF operations assisting developing countries to manage transboundary water resources, as demonstrated by the above examples of the Great Lakes in East Africa and Southeast Asia. These lessons can be broadly categorized into scientific, institutional and operational processes.

On the scientific front, the lessons show the importance of focusing on the key issues influencing the prospects of conservation and sustainable development on a basin-wide scale. Concentrating on immediate issues facing the lake alone risks treating only the symptoms without addressing the root causes. A case in point would be Lake Malawi, where the initial project dealt mainly with the problems facing the fisheries, while the mud entering the lake from the surrounding watershed is the most important cause of the environmental problems. There is, thus, a need to treat land and water issues in the basin in an integrated manner. As the root causes of the problem are mostly linked to population growth and intensification of land use in the catchment in an unsustainable manner, leading to deforestation and land degradation, it is important to link addressing the environmental issues to local benefits for the people using the resources.

Furthermore, as the Tonle Sap example clearly shows, the environmental linkages at a basin-wide level are often far reaching. Upstream actions, such as infrastructure development, can have significant impacts downstream. While local actions are necessary, it is important to consider and address the broader issues involving all basin countries. It is important, therefore, to involve all basin countries as equal participants.

Science-based joint fact finding by the countries leading to a transboundary diagnostic analysis of the threats to the lake and its basin is a useful way of bringing objectivity to the process. This helps the riparian countries to come to grips with and agree upon the problems that need to be addressed. The aim is then to develop a strategic action programme that identifies a few priority issues and hotspots that the countries agree to address either jointly or individually. The local scientific community in the riparian countries can play a key role in this process.

It is equally important to involve all stakeholders at the regional, national and local levels. At the regional level, the participating countries should agree to the implementation of the SAP. In this process, having an institutional mechanism or convention – like the Mekong River Commission or the Lake Tanganyika Convention – is often helpful. At the national level in each of the countries, it is important to involve all sectoral ministries and agencies in order to ensure that the objectives of the authorities in charge of, say, energy, agriculture, transportation and environment coincide.

Capacity building may be provided through the project, as needed. Strong linkages should be established to policy formulation and legal and institutional reforms affecting sustainable development of the basin, both at the national and regional levels. Finally, at the local level, the buy-in to the project's objectives by all stakeholders and resource users – including local communities, NGOs and the private sector – is essential for the success and sustainability of the actions.

Processes such as information exchange, monitoring and evaluation are also essential. There is a need for the project participants in all participating countries to cooperate in an open manner in harmonizing and monitoring their activities. At the same time, the project must provide transparent information and communication to other stakeholders, such as NGOs and local people affected by the project, in order to create understanding and trust. Modern technology tools, such as the Lake Tanganyika project website, can be usefully utilized for both of these purposes.

Lakes are sensitive ecosystems whose management for conservation and sustainable development requires complex actions covering all sectors having a direct or indirect impact on the lake environment. The issues are even more complex in cases where the lake basin is shared by two or more countries. International organizations, such as GEF, can play a facilitating role through promoting processes and providing funding for international cooperation amongst the countries.

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A Lake Today, a "Puddle" Tomorrow?: The Case of the Disappearing Chad

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Introduction

On 1 March 2001, *The New Vision*, a Ugandan daily, quoted the Reuters news agency on the continuing problem of the shrinking Lake Chad: "Africa's Lake Chad has shrunk dramatically in the last four decades due to increased water use and low rainfall, and is destined to become a 'puddle'." The report went on to describe how the lake, bordered by Cameroon, Chad, Niger and Nigeria, now covers a mere 1,350 km^2 (521 sq. miles), down from 25,000 km^2 (9,653 sq. miles) in 1963, as reported by scientists Michael Coe and Jonathan Foley based on computer models as well as satellite photographs. Their findings, the report stated, were published in an unnamed edition of the Journal of Geophysical Research.

The lake, according to the scientists, was once the size of Lake Erie but is now smaller than Utah's Great Salt Lake (both in the USA), due in part to unsustainable demands for drinking and irrigation water from the four nations that share it. Coe and Foley warn that "... you'll get crops and drinking water out of it, but you'll have no ecosystem left to speak of." Lake Chad's prospects, they concluded, look grim.

Background

Situated in the eastern part of the Sahel region of Africa, at the southern edge of the Sahara desert, Lake Chad is a vast expanse of freshwater shared by Cameroon, Chad, Niger and Nigeria. Its area varies considerably with the amount of annual rainfall. Lake Chad is considered the fourth-largest lake in Africa (after Victoria, Tanganyika and Nyassa), and it is the third-largest endorheic lake in the world in terms of area (after the Caspian and Aral Seas).

As the lake lies in a shallow closed basin, it is shallow itself. Lake

Chad has a maximum depth of 10 to 11 m. Its mean depth in the north basin is 4–8 m, while that in the south basin is 2–4 m. In normal, years the average depth over the entire lake is about 1.5 m.

The lake is thus of relatively small volume, and its area varies considerably from one year to another. Although it is subject to considerable evaporation (a consequence of very long hours of sunshine per annum – 3,402 hrs/yr; total annual evaporation is about 2,032 mm from free freshwater surface, compared to, for example, annual rainfall of 711 mm at Maiduguri), the lake is not saline like many other large land-locked bodies of water. This particular feature puts Lake Chad in the first rank of freshwater lakes, after Lake Balkhash in Russia (18,400 km^2), although the latter is much less sensitive to changes in area.

For thousands of years, Lake Chad has been a centre for development, trading and cultural exchange between the peoples living to the north of the Sahara and those to the south. Almost 25 million Africans depend for their livelihood on activities carried out in the lake and its basin – a figure that could reach more than 45 million after 2020.

Lake Chad and the wetlands within its basin form a unique ecosystem for the region, and represent a biodiversity reserve of worldwide interest. For example, 21 species of fish have been inventoried in the lake (Neiland et al., 1994), while 372 species of birds have been inventoried in the basin.

Currently, and throughout the persistent drought that has affected the Sahel over the past 25 years, the area of the lake (the *"Little Lake"*) has been only between 1,500 and 4,000 km^2. In the period 1880 to 1970, in contrast, the level of Lake Chad varied seasonally by 1 metre (i.e., a rough seasonal variation of 2,500 km^2) around mean inter-annual levels situated between 284 m and 280 m, or about 10,000 km^2 (*"Big Lake Chad"* and *"Mean Lake Chad"*). The effect of inter-annual regulation by the natural reservoir formed by the lake is limited to a few successive years. This is then quickly cancelled, and with each new period of extended drought, the lake settles around a new equilibrium level.

The extreme reduction in the area of the lake at present, and the overall decline observed over the past century, have led the region's inhabitants to fear its eventual disappearance. Olivry et al. (1996) revealed that Lake Chad has for thousands of years undergone even more serious natural fluctuations. For example, there were very high levels in the eleventh, twelfth and seventeenth centuries, while the lake has also dried out in the past (for 20 to 25 years, i.e., for almost an entire generation), particularly in the latter half of the fifteenth century.

In 1964, the four countries bordering the lake created the Lake Chad Basin Commission (LCBC) to handle the problems of development centred on Lake Chad in an area formerly referred to as the "conventional basin" (an area of about 427,300 km^2). This Commission did not include the Central African Republic, and excluded the upstream part of the active basins of the Chari-Logone and Komadugu-Yobe. Since 1994, the Central African Republic has been a member of the LCBC, and the definition of the conventional basin has been enlarged to include the upper basins of the Chari-Logone and Komadugu-Yobe systems. It may now be considered that the LCBC's mandate covers the entire active basin (also referred to as the "new conventional basin"), which covers 966,955 km^2 and is divided between the five countries as shown in table 1.

Table 1. Distribution of the active basin (or "new conventional basin") according to LCBC

Country	Area of new conventional basin (km^2)	Population in 1991 ('000)	Density in 1991 (h/km^2)
Cameroon	56,800	2,100	37
CAR	197,800	700	3.5
Niger	162,375	240	1.5
Nigeria	188,000	13,856	74
Chad	361,980	5,048	14
Total	966,955	21,944	22.7

Source: LCBC Strategic Action Plan, 1998.

This new definition of Lake Chad thus takes into account almost all the surface water that supplies the lake, the Yaeres and the aquifer in the lake area. It is now possible, in each sub-basin, to envisage integrated water resources management. Figure 1, a map of the new conventional basin, shows the drainage networks.

Challenges

Physical challenges

Physical challenges comprise essentially the constraints that affect water resources in the area, and concern the lake, rainfall pattern, hydrology of the rivers, and groundwater.

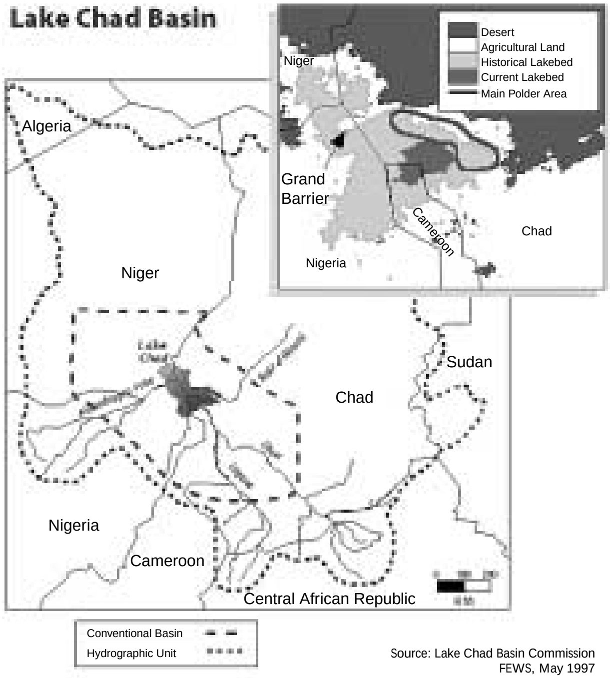

Figure 1. Lake Chad "conventional basin" and hydrographic limit

The lake – The LCBC Vision 2025 provides a dramatic picture showing how the lake's surface area evolved over the 16-year period from 1973 to 1990. The maps (see figure 2) illustrate the sudden way in which the "normal" Lake Chad, covering 22,000 km^2, fell to the "small Lake Chad" of only 2,000 km^2 during a span of three years (1973-1976).

This enormous (90 per cent) reduction in the lake area was due both to a major change in the rainfall pattern over the entire basin and to the flat, shallow profile of the lake itself. It may also be partly attributable to other, not yet fully investigated structural and hydrogeologic characteristics of this basin.

Some form of cycle can be seen in the changes in the surface area of the lake between 1973 and 1990; whether these apparent cyclic changes are related to a ten-year climatic cycle is worth investigating. The maps also suggest that a ten-year drier cycle was possibly starting in 1976 and ending in 1988, while a wetter cycle was possibly starting in 1989. This sort of 10-

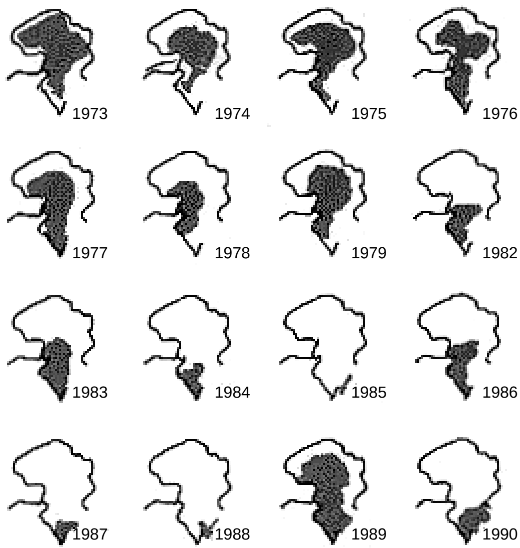

Figure 2. Changes in surface area of the lake – 1973–1990 (from Lake Chad Vision 2025)

year cycle apparently was observed by Buchanan and Pugh (1958) when they reported that Lake Chad in its "normal state" has an area of 12,950 to 13,727 km^2, but declined to 11,914 to 12,432 km^2, with a mean depth of 0.91 to 1.57 m and a maximum depth of 3.05 to 3.96 m. They also found that from 1850 to 1890, the lake covered some 17,094 to 21,497 km^2, with an average depth of 3.96 m.

What was responsible for the reduction of the lake to a size below the "Bama Ridge," which is suspected to be an ancient Pleistocene shoreline? Miller et al. (1968) noted that an accurate sand ridge, about 97 km southwest of Lake Chad and sub-parallel to the lake, extends from a point west of Maigumeri, past Maiduguri and Bama, to as far as Dar-al-Jimeil – a distance of about 106 km.

To understand better what is happening at Lake Chad with respect to the impact of global warming, it is necessary to attempt to separate the changes caused by a possible 10-year climatic cycle from the current impact of global warming/climate change.

Rainfall pattern – Since the first serious sharp phase in the years 1972–73, there have been consistent shortages of rainfall in the dry areas of tropical Africa, including the subject area, although these have varied in severity and extent from one year to another. A notable worsening in the drought occurred in 1983–84, and shortages have remained the general rule up to the present day. These have greatly affected flows in the major rivers. The geographical extent of the problem and its duration have led several scientists to conclude that there has been a change in climate.

As suggested above, global warming may further be exacerbating an

El Niño effect or short-term climate cycle effect. *Findings* (issue 120, October 1998) hints at the possibility of global warming leading to stronger and more frequent El Niño.

Annual rainfall at N'Djamena, the capital of Chad, has shown a continuous decline for more than twenty-five years. Available files from all measuring stations throughout the lake area (thanks, in particular, to the work carried out by the ORSTOM, France) make it clear that all isohyets in this area have descended southwards by a distance of 180 km (figure 3).

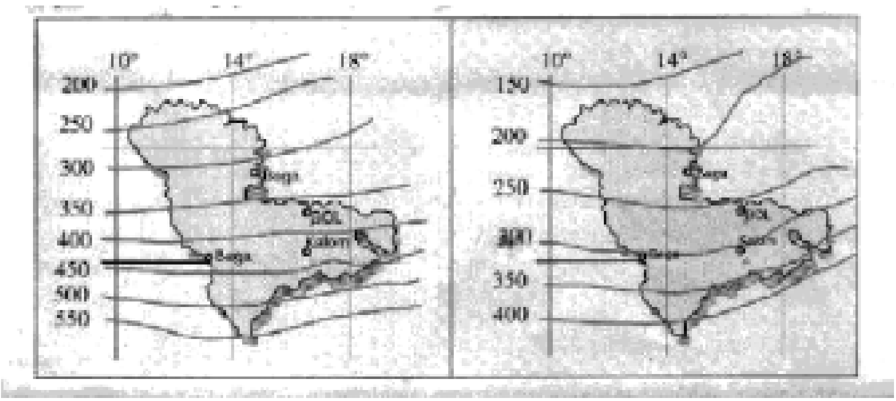

Figure 3. Interannual isohyets (180-km southward shift of isohyets in two decades)

Hydrology of the rivers – The severe decline in rainfall over the entire lake basin has naturally affected the flow regime of rivers. The hydrological regime of the rivers in the basin is affected directly by the rainfall as well as, after a certain lag time, the cumulative effect of repeated rainfall shortages.

In the recent period, it has been confirmed that, in spite of some periods of relative abundance, flow in the rivers in the Lake Chad region has continued to decline. This persistent downward trend must be stressed, as it reveals a lasting decline in the hydrological system in spite of a fairly significant recovery in terms of rainfall conditions.

The natural low-water flow regime of the Chari at N'Djamena, like that of other Sudano-Sahelian rivers, is severely affected by the present drought. The absolute low-water levels reached in the last two decades are systematically the lowest.

Is the lake really devoid of any river that flows out of it? And what hydrologic link exists between the lake and Bodele Depression? Miller et al. (1968) provided a probable answer to these questions. They claim that the lowest point in the Chad basin is the Bodele Depression, 322 km (200 miles) northeast of Lake Chad, which is about 82.3 m lower than the lake level. They also postulate that the lake is connected with this depression by an ephemeral stream, Bahr al Ghazal, which carries overflow only during exceptionally high stages of the lake. If, as noted by several authors, most riverbeds in this region are permeable, and since the lake's water seeps into the subsurface, the question is: What prevents the Bahr al Ghazal from serving as a hydraulic conduit through which some of the Lake's water is lost?

Groundwater – There is very little information available on groundwater. Although it is considered to be abundant, this does not necessarily mean that it is always easy to exploit. However, it may be stated that the cumulative rainfall shortages and virtually general decline in low flows will eventually lead to an increasing reduction in groundwater reserves in the Chad basin aquifer.

Institutional challenges

The Lake Chad Basin Commission (LCBC) was established by convention and statute in 1964 by the four states sharing the lake shore: Cameroon, Chad, Niger and Nigeria. The activities of the Commission are limited to what is termed "the conventional basin," a total area of 427,000 km^2, or about 20 per cent of the geographic basin.

The objectives of the Commission are:

(a) to regulate and control the utilization of the waters and other natural resources of the basin,

(b) to initiate, promote and coordinate natural resources development projects and research within the basin area, and

(c) to promote the settlement of disputes.

The Commission is governed by eight commissioners, two from each country, who report to a council of heads of states. The distribution of the conventional basin among the member states is: Chad, 42 per cent; Niger, 28 per cent; Nigeria, 21 per cent; and Cameroon, 9 per cent.

During the period 1964–1980, the LCBC carried out a number of pre-investment studies, finally arriving at the Action Plan of 1981. Assistance was received from the UN Development Programme, USA, France, Italy and the Netherlands. The studies mainly concerned an agriculture pilot project, training and other centres in agriculture and fisheries, forestry centres for nursery stock, exploratory boreholes for water supply, cattle watering points and other activities. Thus, it seems the Commission placed little emphasis on the water-related component of its objectives.

The Commission was reorganized in 1990 to engage in the following main activities focusing on water resources:

(a) preparation of a Master Plan,
(b) planning and management of the water resources of the basin,
(c) modelling groundwater resources, and
(d) coordination of national activities in plant protection and animal health.

With the redefinition of its strategy in 1990, the Commission started to focus more on master planning. In water affairs, the Master Plan report of 1992 put forward three major projects:

(a) the Lake Chad Multi-Purpose Project,
(b) a Feasibility Study of Water Transfer into the Lake Chad Basin, and
(c) the Chari/Logone Multi-Purpose Project.

Projects (a) and (c) have sound and fundamental components that are essential to any clear understanding of the water resources of the Lake Chad Basin. Project (b), on the other hand, is a very long term concept involving water transfers into the Chad basin from the Congo basin in the Central African Republic.

It is important to note that, although the articles of the agreement that set up the Commission may be well-intentioned, national interests typically override such articles. Furthermore, it is difficult to find any article that spells out the issue of water allocation in the LCBC treaty, thus ensuring that "reasonable" diversions in the headwaters of the rivers that flow into this lake are a challenge.

Political challenges

Frequent political instability in some countries of the LCBC poses a challenge to the proper management of the basin's water resources. For example, unrest in Chad forced the temporary move of the Commission from N'Djamena to Maroua, Cameroon, in the period 1981–82. During this period, very little was achieved, and the 1981 Action Plan remained dormant. Of the nineteen projects included in that plan, of which ten were designated for early execution, only a handful of pilot projects survived in the programme with funding from the commission's own resources.

Social challenges

Increased economic activities have resulted in over-fishing, over-grazing, poor farming practices and deforestation, which have led to degradation of the ecosystem in the Lake Chad basin. Furthermore, increased economic activities in the future could further hasten the spiral of degradation in the basin. It is believed that the 25 million people who depend on the resources of the lake and its basin for their livelihood could reach more than 45 million after 2020.

Lake Chad and its perennial tributaries, including the Logone River and Chari River, are rich in fish, with 1,305 species. The pre-1973 "normal Chad" was a tropical lake rich in phytoplankton (SSA Hydrological Assessment, 1992).

The Yaeres floodplains of the Logone River support flood-recession agriculture, pasture, fisheries, the Waza National Park, and drought security. Irrigation development in the Lake Chad basin has been carried out in all four riparian nations, although much of this is uncoordinated and thus affects flows into Lake Chad. The Maga Dam in Cameroon, for example, has reduced the flow of the Logone River and seasonal inundation of floodplains in the Waza National Park; consequently, the wetland functions have been diminished. Fisheries and livestock pasture have been seriously affected, and wildlife is infringing on cultivated land for forage and causing considerable damage to the agricultural fields. Unregulated human migration and the resulting activities – over-cutting of trees for fuel wood or construction purposes, overgrazing and trampling by livestock, land clearing for agriculture, waterworks or human settlements – have intensified soil degradation and put significant pressure on the basin resources.

Lake water levels have declined below the threshold of reversible equilibrium. Reduced surface supplies have resulted in intensified groundwater pumping for municipal and industrial water supply. For example, JICA (1995) noted that in the Maiduguri urban area, there is a serious problem of lowering of the groundwater table due because of the indiscriminate withdrawal for water supply and the recent construction of Alau Dam, which has resulted in the reduction of flooding over the Sambissa wetland. Similar indiscriminate construction of dams in the upper reaches of the Komadugu-Yobe River system has had adverse impacts on the Nguru wetlands and regime of the river.

The World Bank Technical Paper No. 331 (1995), in a discussion of "interdependence and risks" of international waters, has a table captioned "Dependence of External Surface Water, Selected Countries." If this table were modified to include "Selected Lakes," Lake Chad would be almost right at the top. The discussion of this table could be extended to the three or four shoreline riparian states of the lake. The dependency of these countries on such an "exotic" source creates insecurity, misuse of the resource and possible conflicts.

Data availability

A reliable model of groundwater flow in the Chad basin requires extensive and intensive data that currently are not available. Such data should include flow directions, groundwater travel times, volume of flow, flow boundaries, etc. Compilation of such data, however, requires a huge cost in both time and funds.

One of the four proposed activities of the LCBC when it was reorganized in 1987 was modelling of groundwater resources. While the HYCOS and HydoNiger can furnish data for modeling of the surface-water part of the hydrological cycle in the Lake Chad basin, it is doubtful if the Commission has similar efforts directed at accumulating data for a meaningful attempt to model the groundwater resources. The need to direct more effort towards data accumulation regarding groundwater resources cannot be overemphasized if one considers the claim of Isiorho et al. (1996) that future water resources development in the Chad basin requires an understanding of the hydrogeology of the basin.

Issues that require resolution

The Chari-Logone system has been credited at one time for 90 to 95 per cent of the inflow into Lake Chad. What volume of flow did the figure represent? And what percentage does the current flow from this river system contribute to the lake's volume?

The Chari-Logone's headwaters are neither within the borders of the four shoreline riparian states of the lake nor within the climatic belt of the lake area. The persistent drought in the Lake Chad area should, therefore, not be as significant as it appears to be now. Thus, other explanations for the shrinking lake are needed.

Two "major fractures, certain and inferred" are observable to the southwest of the lake on the Hydrogeology Map, Monguno Sheet 15 (Nigeria, Federal Ministry of Agriculture, Water Resources and Rural Development, 1992). But how important are these, and any yet-unidentified structural lineaments near the lake, with respect to their hydraulic link between the lakebed and the phreactic aquifer or other aquifers below it? It is worth noting that the Lake Chad basin is believed to have been a structural depression since the early Tertiary period and, therefore, has been a locus of subsidence and sedimentation. Are the fractures shown on Monguno Sheet 15 related to the structural depression?

The heavy groundwater development of the Chad Basin in Nigeria started in the early sixties, with the help of USAID. It was noticed that most of the artesian wells developed then lost their artesian heads and became sub-artesian (Miller et al., 1968). The author (Deptol Consultants, 1984) surveyed the causes of abandoned boreholes in Borno state in 1981, and witnessed the impact of wasteful and continuous flows from the artesian wells in the areas. For example, the observed artesian head near Maiduguri in 1981 was about 20 m below what Miller et al. predicted for 1965. How is this observation related to beginning of the reduction in the lake levels?

With rapid urbanization in and around Maiduguri, for example, the phreactic aquifer has been heavily pumped. An evaluation is needed with respect to the fact that the lake water seeps to the sub-surface.

Considering the fact that the lake was virtually nonexistent for about 25 years during the fifteenth century (Olivry et al., 1996), when the in-stream diversion along the Chari-Logone system was probably insignificant, what was then responsible for the disappearance of the lake at that time? A comprehensive paleoclimatic study of the region around Lake Chad would be necessary to respond meaningfully to this question. If seepage from the lakebed accounted for about 21 per cent of the annual water input to the lake (Isiorho et al., 1996), the creation of a faster flow path, tectonically or otherwise, could result in the disappearance of the lake even when other things are equal.

If a paleoclimatic study reveals that precipitation during the disappearance of the lake over five hundred years ago was not as low as to be responsible, then it is not too far-fetched to consider slight tectonic activity that could create fast downward percolation from the lakebed. One is tempted to go along with this hardly plausible explanation because economic activities in the upstream areas of the Chari-Logone system can be considered negligible compared to what obtains now.

Isiorho et al. (1996) investigated relationships between Lake Chad and the Chad aquifers. They examined the hydraulic relationship between the lake and the phreatic aquifer of the Chad Formation. They also combined electrical resistivity data from 30 surveys with over 60 open well measurements to construct a water-table map of the southwestern quadrant of the lake. That map indicates that the Lake Chad water level is at a higher hydraulic level than the phreatic aquifer, and that the groundwater flow is southwest, away from the lake. The average measured seepage rate into the phreatic aquifer in the southwestern and southern parts of the lake was 7.1 x 10^{-3} m/d (median = 1.3 x 10^{-3} m/d), which is about 21 per cent of the annual water input into the lake. This measured seepage flux (9.96 x 109 m/yr) can account for about 107 per cent of the annual solute input into the lake.

Solute transport model simulations by these scientists indicate about 32 per cent (15.3 x 109 m^3/yr) of the input water and 152 per cent (2.87 x 1012 g/yr) of the annual solute input can be removed by groundwater recharge (seepage) from the lake. These results provide an explanation that accounts for the freshness of the lake's water despite its closed basin geologic setting: Solutes delivered to the lake via surface-water inflow leave the lake via groundwater recharge. These results also indicate that recharge from the lake (~ 10 m^3/yr) represents an enormous amount of water available as a groundwater resource in the African Sahel.

The findings of IWACO (1985) estimate groundwater recharge along the Yobe River between Gashua in Nigeria and Lake Chad in 1984 (286 km) at 17 x 106 m^3. These findings corroborate those of Isiorho et al. concerning surface water bodies recharging the phreatic aquifer in the Chad Basin.

Proposals for proper management of the waters of Lake Chad basin

1.Considering the basin as a management unit that includes the headwaters of all rivers that flow into Lake Chad.

Rothberg (1995) proposed a win-win solution for basinwide cooperation, which will ensure that the Central African Republic (CAR) receives resources management assistance while the four shoreline states (Cameroon, Chad, Niger and Nigeria) are assured of stewardship of basin headwaters. While 90 per cent of total lake inflow comes from the Chari-

Logone system, which rises in CAR and flows through Chad, the organization of shoreline states has a mandate over only 19 per cent of the "conventional basin," which does not include the CAR. This sub-basin management flaw as well as droughts and over-extraction of lake waters by the riparian states have created disastrous falls in the lake levels.

Rothberg's "win-win solution" entails the inclusion of the CAR in the LCBC, and cooperation on the part of all five basin states. CAR specifically needs some positive inducements for making an effort to preserve the Chari-Logone headwaters. It needs information on current and future water supply and demand, reasonable and public long-term development plans and an understanding of the costs and benefits of water-use schemes. Building of such capacity requires a long-term set of actions, but in the near future, the win-win scenario looks something like this:

- The four shoreline states require water flow in the Chari-Logone system that is of high quantity, quality, and consistency. Simultaneously, CAR requires forestry assistance for national income and local development.
- If the shoreline states offer human, technical, financial, and organizational resources for CAR's sustainable forest management of the Chari-Logone headwaters area, all five states benefit. CAR sees continuous income from its forests, while the shoreline states see reduced flooding and sedimentation, and increased river flows as their gain.

2. Establishment of an adequate monitoring network for surface water and groundwater

The Lake Chad Basin Commission Strategic Action Plan of 1998 bemoans the fact that there is little information concerning groundwater. It notes that while groundwater is considered to be abundant, it may not be easy to exploit. Isiorho et al. (1996) acknowledge the fact that they have to adopt an idealized and simplified conceptual model of the actual system in the Lake Chad basin, whose aquifer system is complex. They had to do this because of the limited data available for calibration; thus, their modelling effort provided only a rough estimate of the groundwater flow system.

They noted that the intent of the simulation was not to provide an accurate quantitative model of the water table elevations in the southwest Chad Basin, but rather to provide another estimate of recharge to the groundwater by seepage across the lake bottom. They also noted that their estimate of 10^{-15} x 109 m^3/yr of groundwater recharge through the lake bottom represents an enormous groundwater resource that is available, though little exploited, in an area in great need of reliable water supply.

Recently, Coe and Foley (2001) also used modelling because of the paucity of data in this basin. They claim that their study extends the previous modelling studies of Lake Chad in terms of complexity and length of investigation. Just like other studies before theirs, their study did not include the groundwater component of the hydrologic cycle in this area, although there is an important hydrologic link between the lake and the phreactic aquifer.

Even if their work took the groundwater component into account, it is important to note that models are only as good as the assumptions on which they are based. Thus, for a better understanding of future models with respect to how well they correspond to reality, a good (with respect to coverage and adequacy in all respects) data gathering network is essential.

To be able to utilize maximally the groundwater resource in the Lake Chad basin, there is the need to establish an adequate monitoring network, especially for groundwater. There is also the need to adopt remote sensing techniques, GIS and other modern technologies in monitoring and evaluation.

However, one is aware of the financial implications of the above proposal, as well as the fact that most governments in developing countries are constrained by funds in meeting monitoring requirements.

3. Development of an appropriate management structure for the Chad shared aquifer

There is a need to facilitate the development of an appropriate management structure for the shared aquifer of the Chad basin, as is being done in the Middle East by the World Bank for the shared aquifer in the Israel/Palestine area.

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UNU Workshop: Lakes and Reservoirs as Important Elements of International Water Systems

9th International Conference on the Conservation and Management of Lakes

Convention Hall OHMI, Otsu Prince Hotel, Otsu, Japan
14 November 2001

The objective of this UNU self-organized workshop is to contribute to the World Lake Vision focusing on international aspects of lake system management as on integrated system. The UNU may make best use of previous experience and knowledge in international water system managements as well as taking responsibility for the international water system part of the World Lake Vision development. The fact that many large lake systems in the world are shared by two countries or more does not seem to be widely appreciated. While many argue about the ways and means of managing international river systems, much less people are aware of the nature of lakes as international water systems. Lakes have been seen mainly from such viewpoints as water quality, wetland ecosystems, fauna, flora, and catchments management.

19:00–19:20 Opening and Keynote Address
Prof. Motoyuki Suzuki, Vice-Rector, United Nations University, Tokyo, Japan

19:20–19:30 Introduction to the workshop and speakers
Prof. Yutaka Takahasi, United Nations University, Tokyo, Japan

19:30–19:50 Sustainable Water Resources in South America: The La Plata and Amazon Basins

	Prof. Jose Galizia Tundisi, International Institute of Ecology, Sao Carlos SP, Brazil
19:50–20:10	Emerging Issues in Sustainable Water Resources Management in Africa **Prof. Chris H.D. Magadza**, Lake Kariba Research Institute, Harare, Zimbabwe
20:10–20:30	The Caspian Sea as an International Lake System **Prof. Genady N. Golubev**, Moscow State University, Moscow, Russia
20:30–20:50	River Danube: Needs for Integrated River Basin Management **Dr. Libor Jansky**, United Nations University, Tokyo, Japan
20:50–21:10	Institutional Aspects of International Water Management – Lessons from Mekong River Basin **Prof. Mikiyasu Nakayama**, Tokyo University of Agriculture and Technology, Tokyo, Japan
21:10–21:30	Multi-country Cooperation for Sustainable Development of International Lake Basins: Lessons from the Global Environment Facility **Dr. Juha I. Uitto**, GEF Secretariat, Washington DC, USA
	A Lake Today, a "Puddle" Tomorrow? The Case of the Disappearing Chad (POSTER) **Dr. Depo Adenle**, Vice-chair of the Environmental Thematic Group of the Africa Water Forum
21:30–22:00	Panel Discussion and Closing Remarks (Moderator: **Prof. Yutaka Takahasi**)

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