HYDROPOLITICS AND CONFLICT RESOLUTION

Professor Masahiro Murakami
Department of Infrastructure Systems Engineering
Kochi University of Technology
Japan

There were 214 international rivers and lake basins, covering 47% of the land area in the world, in 1978. After the termination of the cold war in 1989, the number of international rivers has increased in Central Asia, Eastern and Central Europe, with some fears of increasing potential conflicts among the riparian states.

Intensive development of the large rivers had some significant influence and/or adverse effects on the water and ecosystem balance, not only along the rivers, but also, in the inland and/or coastal deltas. Very few concerns have been manifested to solve increasing potential conflicts and the creeping environmental problems over international waters, and time is fast running out.

This study of hydropolitics and conflict resolution of international rivers aims to identify the issues in dispute, concerning water resources and environment, select alternative scenarios, and recommend processes through which the countries concerned are likely to agree on mutually satisfactory solutions to the problems, by sharing resources and benefits. The study will also try to identify the ideas for a comprehensive and objective environmental management setting for sustainable development, with or without international co-operation in view of the 21st century, by reviewing some lessons from the past. The Danube riparian questions will be compared with other major international rivers, including the Colorado, Indus, Nile, Jordan and Euphrates, in reference to lessons from the past, of which the cases could either successfully or unsuccessfully resolve the conflicts on hydropolitics and environmental decision-making along the rivers crossing national boundaries.

Colorado: hydropolitics and conflict over quantity and quality

The Colorado River is an international drainage system that drains an area of approximately 583,000 km2 and flows through seven states in the United States and the Republic of Mexico (Figure 1). The Colorado River is one of the world's most regulated rivers with a series of dams. But the regulation necessary to ensure a sufficient quantity of water for users has also exacted a price in the quality of the water available. As the south-western United States was being developed during the early part of 20th century, the big question was whether there would be enough water. Today people also ask how good the available water is. Under a 1944 treaty with the United States, Mexico has a guaranteed allotment of 1.85x109 m3 of water per year. Between 1945 and 1961 there were no major problems resulting from the treaty, as the salinity of the water crossing the border into Mexico was generally within 400 mg/l at Imperial dam, the last major diversion for users in the United States.

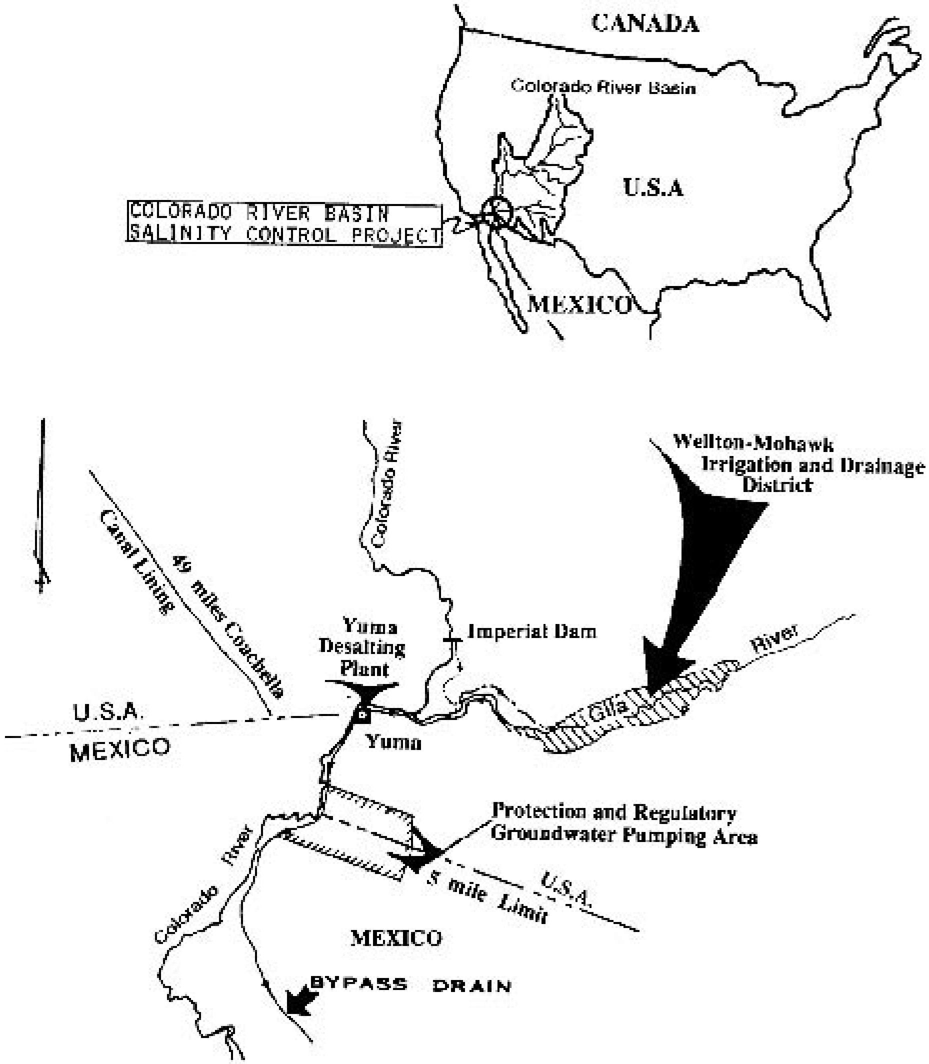

Figure 1 The Colorado River

Regulation of the Colorado by a series of large dams has substantially increased stream salinity by two processes: the tremendously increased evaporation surface, and contaminated irrigation return flows. The stream salinity at the Mexican border has been doubled, from 400 mg of total dissolved solids (TDS) per litre in the early 1900s to 800 mg in the 1950s.

The Wellton-Mohawk Irrigation and Drainage District in south-western Arizona, east of Yuma (Figure 1), established in the early 1950s, was one of the last districts to be developed. The project included a system of drainage wells, the discharge from which included a substantial amount of highly saline groundwater that had been concentrated through re-use during the previous 50 years. Initially it had a salinity of 6,000 mg/l. This resulted in a sharp increase in the salinity of the water crossing the border into Mexico from around 850 mg/l in 1960 to more than 1,500 mg/l in 1962. At about the same time, releases into Mexico were greatly reduced in anticipation of storage behind the newly constructed Glen Canyon dam. This loss of dilution water is illustrated by the fact that from 1951 to 1960 the average delivery to Mexico was 5.2x109 m3 per year, while from 1961 to 1970, the flow averaged only 1.9x109 m3 per year, Mexico raised strenuous objections1. In 1961 Mexico began complaining that the increased salinity was harming crops in the Mexicali valley.

The United States agreed in Minute No.242 of the International Boundary and Water Commission in 1973 to a salinity level for water being delivered to Mexico at Morelos dam. This agreed upon salinity level has had to be achieved by constructing a massive desalination plant. Enough of the salts have to be removed from irrigation return flows to make the water acceptable for discharge into the river, and later delivery to Mexico. As a result of "Minute 242" of 1973, the salinity of water as it enters Mexico at Morelos dam now averages no more than 115 mg/l plus or minus 30 mg/l over the average annual salinity of waters arriving at Imperial dam.1 To comply with Minute 242, the United States has undertaken the following works:

- the Yuma desalination plant for Wellton-Mohawk drainage waters
- extension of the Wellton-Mohawk drain by 85 km to the Gulf of California
- lining or construction of a new Coachella canal in California

- reduction in the Wellton-Mohawk district acreage and improved irrigation efficiency
- construction of a well-field on the US side of the international boundary to balance well-fields recently installed by Mexico near the border

All of the costs in money or water to satisfy "Minute 242" are to be borne by the United States, at a cost of several hundred million dollars annually. Both the United States and Mexico will receive tangible benefits. The United States Bureau of Reclamation estimates that an increase of 1 mg/l in salinity at Imperial dam results in a cost of US$ 240,000/year to water users in Arizona, California, and Nevada. In the absence of any measures to control salinity, the total impact of salinity increases on users in the three lower-basin states was predicted to be about US$ 80 million per year by the year 20001. The dollar values of detriments to users in Mexico would be additional, but have not been estimated.

Authorisation to begin the salinity control work was provided by the Colorado River Basin Salinity Control Act, passed by Congress in June 1974. This legislation was in two parts: one for salinity-control measures downstream of the Imperial dam, and one for salinity-control measures in the seven Colorado River basin states upstream of Imperial dam. The agreed upon salinity level is being achieved by desalination. Enough of the salts are removed from irrigation return flows to make the water acceptable for discharge into the river and later delivery to Mexico. When the Yuma desalination plant was commissioned in 1993, the irrigation return flows of 138x106m3 per year from the Wellton-Mohawk farmland were diverted and salvaged to produce 98x106m3 per year of fresh water, supplementing the quantity of 1.85x109 m3 of water owed to Mexico.2

It is noted that the bilateral political negotiation between USA and Mexico on the Colorado river water could resolve the long-standing dispute over the quantity and quality simultaneously, by introducing techno-political alternatives of the membrane desalination technology which was adopted in the negotiation process as a measure of confidence building.

Indus: bilateral negotiations in line with World Bank support

The Indus, one of the mightiest rivers of the world and the second longest in western Asia, has a mean annual discharge of 207.5x109 m3 with a yearly maximum of 264x109 m3 and minimum of 171x109 m3. The Indus River system has ten times that of the volume of flow of the Colorado river in the United States and Mexico, and more than three times that of the Nile (Figure 2).

As rainfall is scarce in the plains, where the cultivable areas lie, agriculture on the Indus plains has to depend almost exclusively on an irrigation system utilising the river flows. The development of the irrigation project was mostly carried out after 1850 but elements of an ancient flood irrigation channel can still be found. Many weir and canal systems were built on the Indus and its tributaries from the middle of the nineteenth century onwards, the first of which was the Upper Bari Doab canal, built between 1850 and 1859, to bring water from the Ravi River at Madhopur to the upper half of the Doab, or inter-river land, in the vicinity of Lahore (Figure 2).

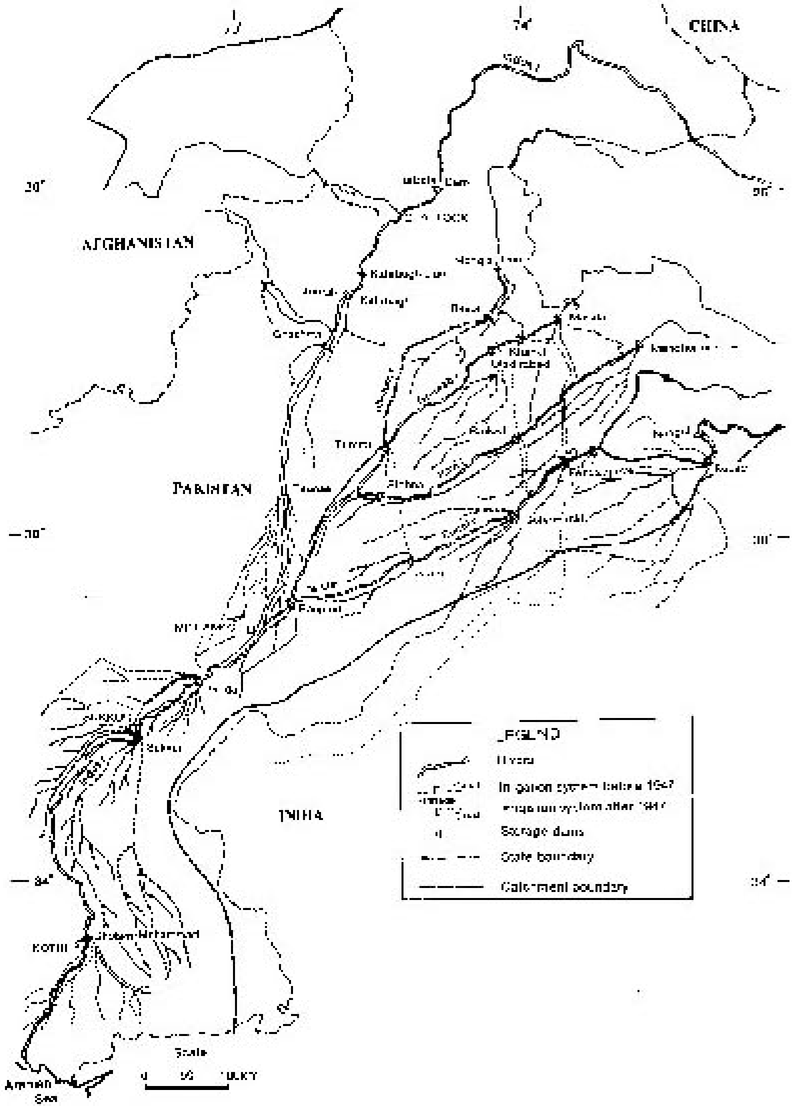

Figure 2 The Indus River

The Indian Independence Act of 15 August 1947 internationalised the dispute between the new states of India and Pakistan and heightened political tensions in the population. For India, water sources in Pakistani territory now originated in another country, of which the geopolitical relations were increasingly hostile. Because the new international boundary cut across the common canal system of Punjab, leaving one part in India and the other in Pakistan, controversy on the use of the canal waters arose soon after the Partition.3 By 1947, when India and Pakistan achieved independence as separate countries, the Indus water system had already been developed to provide irrigation to about 10.9 million ha, but it is remarkable that no storage reservoirs had yet been built in a system serving the world's largest irrigation area. Question over the flow of the Indus is a classic of the conflicting claims of upstream and downstream riparians. The conflict can be exemplified in the terms for the resumption of water delivery to Pakistan, worked out at an Inter-dominion conference held in Delhi, 3-4 May 1948. India agreed to the resumption of flow but Pakistan could not claim any share of those waters as a matter of right. Although these conflicting claims were not resolved, an agreement was signed, later referred to as the Delhi Agreement, in which India assured Pakistan that it would not withdraw water delivery without allowing time for Pakistan to develop alternative sources. Pakistan later expressed its displeas-ure with the agreement in a note, dated 16 June 1949, calling for the "equitable apportion of all common waters," and suggesting turning jurisdiction over the International Court. Statement on these two positions lasted through 1950.

Attempts at conflict management was initiated by David Lilienthal, former chairman of the Tennessee Valley Authority (TVA) in 1951, including the steps from the psychological - a call to ally Pakistani suspicions of India intentions for the Indus headwaters - to the practical - a proposal for greater storage facilities and co-operative management. He suggested that international financing be arranged, perhaps by the World Bank, to fund the workings and findings of an "Indus Engineering Corporation" and to include representatives from both states as well as the World Bank. Both sides accepted the World Bank initiative to attend the first meeting of the Working Party, which included Indian and Paki-stani engineers along with a team from the Bank, in Washington, in May 1952.

In August 1959, David Black, the president of the World Bank, organised a consortium of donors to support development in the Indus basin, which raised close to US$ 900 million, in addition to India's commitment of US$ 174 million.4 The Indus Treaty was sighed in Karachi on 19

September 1960, and government ratification's were exchanged in Delhi in January 1961. It took twelve years of patient negotiation before the controversy was settled by the Indus Waters Treaty in 1960, in which the World Bank organised an International Funding Settlement to promote future opportunities for regional co-operation and management.

Nile: downstream riparian initiatives on either conflict or compromise

Despite the great area of the Middle East, there are only three rivers, the Nile, the Euphrates, and the Tigris, that can be classified as large rivers by world standards. Of these, the Nile, which is the world's longest river, receives most of its discharge from precipitation falling well outside the Middle East on the upland plateau of East Africa and the highlands of Ethiopia (Figure 3). The Nile is the whole life of Egypt. The country owes its existence to the river, which provides water for agriculture, industry, and domestic use. Cultivation is dependent on irrigation from the river.

The Nile, which is the world longest river - 6,690 km - covers approximately one-tenth of the African continent. The catchment area of 3,007,000 km2 is shared by nine countries: Egypt, Sudan, Ethiopia, Uganda, Kenya, Tanzania, Rwanda, and Zaire. Its main sources are found in Ethiopia and the countries around Lake Victoria. All along the Nile's course from its most remote source, the Cagier River in Central Africa, to the Mediterranean, people are affected to some extent by the river or its water. With a few exceptions, the water resources in the headwater areas of the system are not yet much developed. The main development has taken place in the countries situated in the semi-arid and arid zones such as Sudan and Egypt. The upstream countries, however, are now considering Nile resource-development projects in their territories. For the size of the Nile basin with its catchment area of 3,007,000 km2, the annual discharge is as small as 99.5x109 m3, which is equivalent to 4.3% of the annual runoff. The annual average for the 95 years is estimated to be 91.2x109 m3, which was the basis of design for the year-to-year storage at the Aswan high dam.

The proposal to build a single large dam at Aswan for multiple objectives including flood control, year-to-year water storage, and hydro-power generation was put forward by Adrein Danionson in 1949, as an alternative to a "century storage" scheme. Construction of the high dam, of which the proposal was made in 1952, started in 1960 and was completed in 1970. Before building and operating the High Dam, the Nile floods, brought silt containing potassium and phosphorous, but also could leach away any accumulated salts. The fine-grained alluvial soils of the Nile valley do not drain easily and need artificial drainage. Due to the hot arid climate, irrigation water evaporates quickly, leaving behind its salt, causing salinisation. The water levels in the Nile have been falling for nine years since the early 1980s. In 1985-1986 there was a three metre drop in the level of Lake Nasser, the reservoir behind the Aswan dam, and in 1986-87 it fell from 195.6 m to 184.7 m.5 Egypt has been attempting to avert a national crisis by three strategies: rationalisation, river development, and groundwater development. The reservoir storage has been recovered by steps with intensive rainfall and inflow in the early 1990s. This long-term fluctuation depends on the large scale basin hydrology in the humid through the arid zones.

With the end of World War I, it became clear that any regional development plans for the Nile basin would have to be preceded by some sort of formal agreement on water allocation. In 1920, the Nile Projects Commission was formed with representatives from India, the UK and the USA. The Commission estimated the Nile river flow at 84x109 m3 per year in average. Egyptian needs were estimated to be 58 x109 m3 per year, while Sudan was thought to be able to meet irrigation needs from the Blue Nile alone. The Commission's findings were, however, not acted upon. In 1925, a new water commission made recommenda-tions, based on the 1920 estimates, which would lead, finally, to the Nile Water Agreement between Egypt and Sudan on 7 May 1929. Sudan was allocated 4x109 m3 per year, but the entire timely flow and a total annual amount of 48x109 m3 per year were reserved for Egypt. Egypt's irrigation practices require nearly 55x109 m3 of water from the Nile every year, which is the amount allotted by the 1959 Nile Waters Agreement with Sudan. Sudan was allotted 18.5x109 m3, but has been using only 16.5x109 m3 per year in the 1970s.

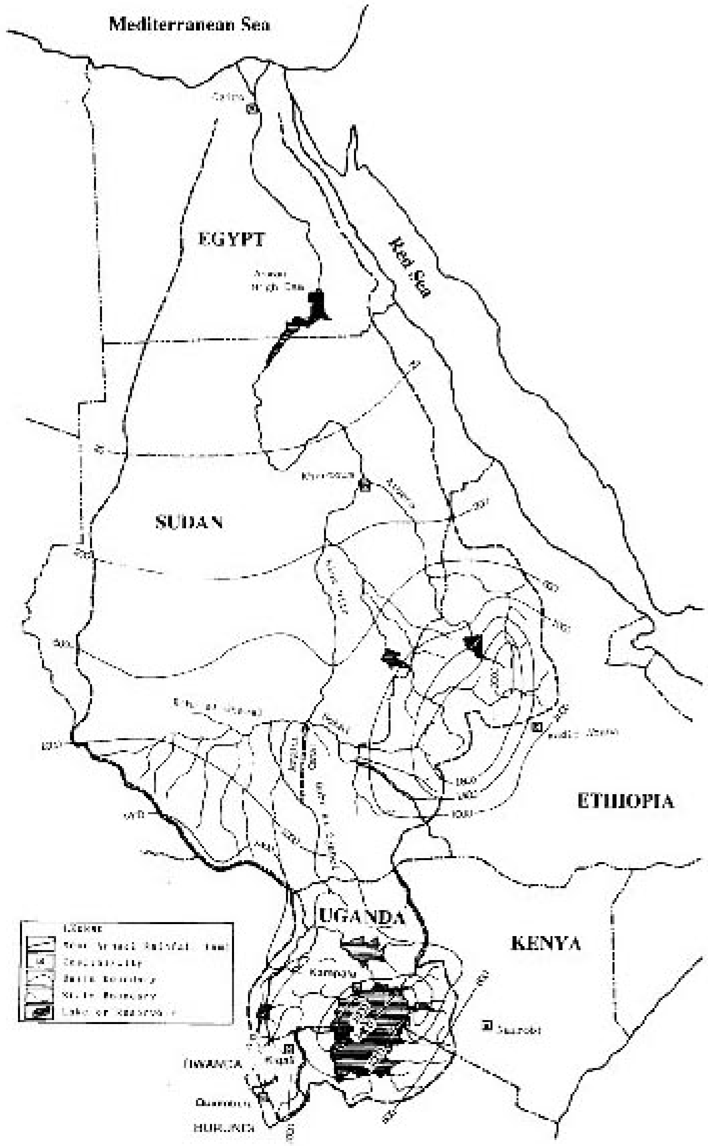

Figure 3 The Nile River

Some bilateral agreements on water allocation are identified in Middle East rivers such as the Nile, Jordan and Euphrates, but no multilateral - more than three countries - agreement was succeeded in many efforts of political negotiations except for scientific and/or academic co-operation. The national, economic and social objectives of developing Nile resources may vary from country to country. Certain Nile projects in the upper parts of the basin could be also advantageous for the more downstream countries. The timing of such projects could have a significant effect on the development of the resources of the basin as a whole. A small step in achieving multilateral collaboration among the Nile basin states was initiated in 1967, when the five countries Kenya, Tanzania, Uganda, Sudan, and Egypt started a hydro-meteorological survey of the basins of Lakes Victoria, Kyoga, and Albert, with the assistance of the UN Development Program.

Jordan: long-standing conflicting river and Middle East peace process

Owing to the general aridity of the region, a very large portion of the total area consists of endoreic or inland drainage. The Jordan River, the third largest perennial river in the Middle East, receives most of its discharge from precipitation on the southern part of the Anti-Lebanon range. The Jordan is a multinational river, flowing southwards for a total length of 228 km through Lebanon, Syria, Israel, and Jordan (Figure 4). It is already overdeveloped except for a winter flow in its largest tributary, the Yarmouk River, which forms the present boundary between Syria and Jordan for 40 km before becoming the border between the Israel and Jordan. In the absence of irrigation extraction, the Jordan system delivers an average annual flow of 1,85x109 m3 to the Dead Sea, equivalent to 2% of the annual flow of the Nile and 7% of the annual flow of the Euphrates. Fifty percent or more of this discharge originates in pre-1967 Israel boundary, in Arab territory.

Few regions of the planet offer a more varied physiography or a richer mix of ethnicities, religions, languages, societies, cultures, and politics than the Middle East. At the same time, no segment of the globe presents its diverse aspects in such an amalgam of conflicts and complexities. Out of this compound, one issue emerges as the most conspicuous, cross-cutting, and problematic: water. Its scarcity and rapid diminution happen to occur in some of the driest sectors of an area where there are also some of the fiercest national animosities. River waters in the Middle East are thus a conflict-laden determinant of both the domestic and external policies of the region's principal actors. Equally, though, they could be a catalyst for lasting peace.

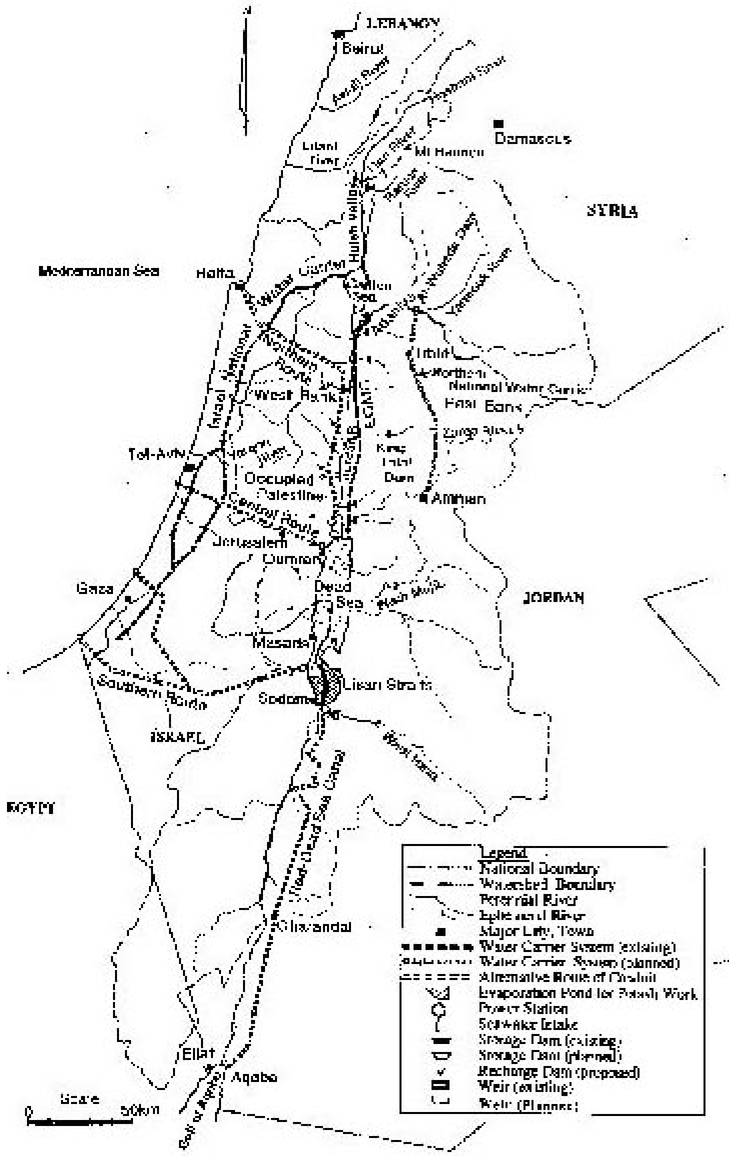

Figure 4 The Jordan River

As water shortages occur and full utilisation is reached, water policies tend to be framed more and more in zero-sum terms, adding to the probability of discord. The severity of Middle Eastern water problems will, unavoidably, increase significantly year by year. In an already over-heated atmosphere of political hostility, insufficient water, to satisfy burgeoning human, developmental, and security needs among all nations of the Middle East, heightens the ambient tensions. By the end of the 1990s, Israel, Jordan, and the West Bank will have depleted virtually all of their renewable fresh water sources if current patterns of consumption are not quickly and radically altered.

Despite the endless political complications in the Middle East, there is a recent history of tacit, although limited, co-operation over multinational river development, even among the bitterest opponents. Israel, before its invasion of Lebanon and its troublesome stand on clearing out obstructions to the intake of Jordan's East Ghor canal, had more or less agreed, informally, to share the Jordan River system within the framework of the 1955 Johnston Plan.

Since the early 1950s, Israel and later Jordan, have taken steps to utilise the fresh water flowing into the Dead Sea for intensified irrigation and other purposes, which has reduced the amount of water entering the Dead Sea by 109 m3 per year. Consequently, the water level has declined in recent years to 403 m below sea level today, almost 10 m lower than its historical equilibrium level.

In 1953, the four countries Lebanon, Syria, Israel, and Jordan, agreed in principle on the priority use of Jordan River waters, in the so-called Johnston Agreement, which provided for the priority use of the main stem of the Jordan River by Israel and Lebanon, while the biggest tributary, the Yarmouk, running along the national boundary, was to be exclusively used by Syria and Jordan. This established a water allocation of the useable Jordan River, estimated at 1.38x109 m3 per year in total: 52%, 720x106m3, to Jordan 32%, 440 x106m3, to Israel; 13%, 180 x106m3, to Syria; and 3%, 40x106m3, to Lebanon.6 It is widely assumed that the technical experts of each country involved in this discussion agreed on the details of this plan, although soon afterwards the governments rejected it for political reasons.

With the failure of these negotiations, both Israel and Jordan decided to proceed with water projects situated entirely within their own boundaries. As a result, Israel began work in 1958 on the National Water Carrier, which is a huge aqueduct and pipeline network carrying water from the Jordan southwards along the coastal region. The water is pumped from the En-Sheva intake in the north-west of Lake Tiberias at an elevation of 210 m below sea level to a height from which it flows by gravity to a reservoir at Rasalom. The installed capacity of the En-Sheva pumping station was 360x109 m3 per year in 1968, and it could conceivably be increased to a maximum level of 500 x106m3 per year, which is 90% of the Jordan's inflow of 544 x106m3 per year at the inlet to Lake Tiberias.7 Such cutting of fresh water flows in the upper Jordan River would, however, have seriously adverse effects on the quality of Lake Tiberias and its lower reaches by increasing salinity.

The Arabs started work on the Headwater Diversion project in 1965. Israel declared that it would regard such diversion as an infringement of its sovereign right. According to estimates, completion of the diversion work would have deprived Israel of 35% of its contemplated withdrawal from the upper Jordan, constituting one-ninth of Israel's annual water budget. In a series of military strikes, Israel hit the diversion works. The attacks culminated in April 1967 in air strikes deep inside Syria. The Maqarin dam, first conceived in 1956, would be built about 20 km north of Irbid, to store 273x109 m3 per year on average flows of the Yarmouk River. The dam site, which is located in the boundary between Jordan and occupied Golan Height by Israel, was also seriously attacked by the Israeli airforce to be abandoned. The increase in water-related Abab-Israeli hostility was a major factor leading to the June 1967 war.

The 1988 protocol of understanding between Jordan and Syria, paved the way to renewing work on the Al-Wuheda dam, which is located 20 km upstream from the Maqarin site. The dam reservoir would have a gross capacity of 225x109 m3 with effective storage of 195x109 m3 annually. The water would irrigate an additional 3,500 hectares in the Jordan valley, and supply 50x109 m3 of water a year to the Greater Amman area and the eastern heights. It would also generate an average of 18,800 MWh of electricity a year. Syria would use part of the water and 75% of the total hydroelectric power generated by a power station near the dam. However, immediately after the construction of 800-metre long diversion tunnel in 1989, the Al-Wuheda dam project was stopped by Israeli opposition over water allocation in the downstream.

Israel currently uses as much as 90% or more of the stream water from the upper Jordan River. Jordan's water problems have undoubtedly been exacerbated by Israel's actions to deny it the right to develop fully the water resources of the Jordan River within its borders. The political constraints have just been mitigated by steps of bilateral peace agreements between Israel and the PLO in 16 September 1993, and Jordan and Israel in 26 October 1994.

It is now possible to conceive a comprehensive development plan that will be not only technically/economically feasible but also politically desirable and urgent. The Mediterranean/Red-Dead Sea conduit, Al-Wuheda dam, brackish groundwater development and desalination, and, additionally, some storage and pumping facilities on the lower Jordan system could now be discussed simultaneously, without risking new political disputes, but promoting peace and economic development, in Palestine and possibly Syria and Lebanon.8,9,10 Discussion can now be based on hydrology, energy and politics along the Jordan and the Dead Sea. The Mediterranean/Red-Dead Sea Canal will be one of the key alternatives to sustain the water balance of the Dead Sea after completing developments in the Jordan river system by the beginning of the 21st century.

Euphrates: upstream riparian initiatives on either conflict or compromise

Despite the great size of the Middle East, there are only three rivers, that can be classified as large by world standards - the Nile, the Euphrates, and the Tigris. The watersheds of both the Euphrates and the Tigris are situated within the Middle East, predominantly in Turkey, Syria, and Iraq (Figure 5). Before Turkey began building large dams on the Euphrates, the river's average annual flow at the Turkish-Syrian border was about 30x109 m3. To this, a further 1.8x109 m3 is added in Syria from the Khabour River, a major tributary. On several occasions in recent years, low water levels in the Lake Assad reservoir, behind the Tabqa dam, have restricted both the hydro-power output - with installed capacity of 800 MW - and irrigation development. In the longer term a reduction in Euphrates water entering the country could be a major constraint on Syrian power generation and agriculture. Iraq used to receive 33x109 m3 of river water per year at Hit, 200 km downstream from the Syrian border before the 1970s, when both Turkey and Syria built a series of large dams on the Euphrates river. By the end of the 1980s, the discharge decreased to as little as 8x109 m3 per year at Hit. By 1989, 80% of the natural runoff of the Euphrates River had been developed by adding a third large dam, the "Ataturk", which is the largest dam in Turkey, with a gross reservoir storage volume of 48.7x109 m3 - effective volume, 19.3x109 m3.

Following the World War II, river control schemes tended to concentrate on the problems of flood control. Two of the earliest projects, completed in the mid-1950s, were situated towards the upper part of the alluvial valley. The Samarra barrage was constructed on the Tigris River with the objective of diverting flood waters into the Tharthar depression, to provide a storage capacity of 30x109 m3. A similar scheme was also built on the Euphrates, where the Al-Ramadi barrage diverted flood waters into the Habbaniyah reservoir and the Abu Dibis depression. It had been hoped that stored water from these two projects might be used for irrigation during the summer months, but it was discovered that the very large evaporation losses, together with the dissolution of salts from the soils of the depressions, seriously diminished water quality and rendered it unsuitable for irrigation purposes. In conjunction with the barrages on the main streams themselves, two major dams were constructed on tributaries of the Tigris. The Dukan dam, with a reservoir storage capacity of 6.3x109 m3, was completed on the Lesser Zab River in 1959, while further south, on the Diyala River, the Darbandikhan dam, with 3.25x109 m3 of storage, was opened in 1961.

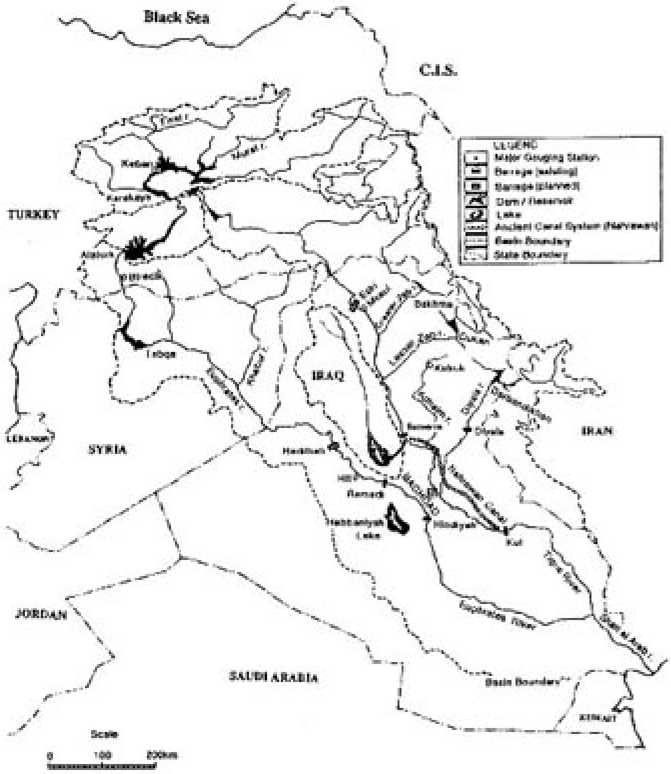

Figure 5 The Euphrates River

The Tigris and Euphrates are the main sources of water in Iraq. Because of flood irrigation, 1,598,000 ha have been affected by salinity, and the government is trying to reclaim this land. Before the 1970s, when both Turkey and Syria built a series of large dams on the Euphrates, Iraq received 33x109 m3 of water per year at Hit, 200 km downstream from the Syrian border. By the end of the 1980s, the flow discharge at Hit had decreased to as little as 8x109 m3 per year.11

Before Turkey began building large dams on the Euphrates, the river's average annual flow at the Turkish-Syrian border was about 30x109 m3. To this, a further 1.8x109 m3 is added in Syria from the Khabur River7. In the 1970s, Syria was planning to reclaim 640,000 ha or more in the Euphrates basin. However, progress has been slow, and only about 61,000 ha of new land either has been brought into cultivation or will be in the near future. The water requirements for this area are minimal, and can at present easily be supplied from the 12x109 m3 Lake Assad reservoir, or from the river's flow. In the longer term, however, a reduction of the Euphrates water entering the country could be a major constraint on Syrian power generation and agriculture.

The water resources of the Euphrates River have been almost fully developed since the 1970s by construction of large dams at Keban, Karakaya, Karababa, and Tabqa on the upper and middle reaches of the main stream. In 1989, 80% of the natural runoff of the Euphrates River was developed by closing the "Ataturk" dam, the biggest dam in Turkey. During the initial impounding, Iraq has accused Turkey for violating International Law, while Syria further claims that Turkey has caused significant damage to the Syrian agriculture, as well as to hydropower generation and water supply facilities, and is requesting that the International Law Commission studies the sharing of the resources, in line with data collection in the Joint Technical Committee among the three states.

An inter-basin development plan was studied in the context of Turkey's ambitious "Peace Pipeline" project in 1987, which would include the transfer of fresh water from the Seyhan, Ceyhan, and Euphrates basins by a series of dams and diversion tunnels to supply countries in the Arabian peninsula, including Syria, Jordan, Saudi Arabia, Kuwait, Bahrain, Qatar, the United Arab Emirates and Oman. The Peace Pipeline would have a total length of about 6,550 km and a capacity of 6x106m3 per day.12 Fresh water supplies are finite, and it is becoming more and more difficult to undertake projects that include the shifting of available water supplies to new areas of demand, especially if the project involves crossing political boundaries. The "Peace Pipeline" will probably not be a key application for individual states but an option in water resources planning at a multinational level. Hydropolitics will be a key issue in transboundary river development in the Middle East. There is as yet no political commitment to the Peace Pipeline, but this project and variations on it may remain options for consideration if Turkey could sustain water resources development in its own territory without any deficit of supplying water in the 21st century.

Danube: hydropolitics and decision-making

A 1992 development of the Gabcikovo dam in Slovakia, which diverted most of the flow in the Danube main channel, is a focus of discussion between Slovakia and Hungary. A large dam on an international river entails not only questions on riparian rights, but also potential fears for the ecosystem crossing the international border. Environmental problems in large reservoirs can be disastrous for ecosystems unless the water is kept clean. The hydropolitics of sharing resources and benefits among riparian states are the priority issue in decision-making concerning the protection of flora, fauna and the people living there. The geopolitical setting of the Gabcikovo dam and reservoir, with fears of environmental damage in the lower riparian region, may lead to either conflicts or compromise. Also, environmental decision making in co-operative projects relies on neutral political stands and dependable accessible data and information.

The United Nations University's (UNU) activities focus mainly on peace and conflict resolution, development, environment, and management in a changing world, and science and technology in relation to human welfare. The programme area of the UNU on sustaining the Global Life-Support System responds to the priorities identified in Agenda 21, in 1992. The research on hydropolitics and decision-making aims to identify the issues in disputes concerning water resources, select alternative scenarios that could lead to the solution of complex problems related to water and environmental issues, and recommend processes throughout which the countries concerned are likely to agree on mutually satisfactory solutions by sharing resources and benefits. The research project will also provide a comprehensive and objective environmental management setting for sustainable development in view of the 21st century. The Danube program aims to assess environmental phenomena, including the wetlands ecosystem of the Danube and water quality in the Gabcikovo reservoir, as they relate to inter-national politics in the aftermath of the cold war, which was terminated in 1989. The analyses would include some comparative studies on the negotiation process and on treaties of major international rivers. Some engineering perspectives, including hydraulic works, energy supply and wastewater treatment, will also be added to cope with decision-making in co-operative international projects.

Conclusion

Comparative studies on resolving international river disputes suggest patient regional co-operation, taking into account that many of the negotiation processes on cross-border riparian issues tend to take a long time, often more than ten years or several decades, with or without successful results. One of the successful results of applying non-conventional techno-political alternatives to resolving the conflict is identified in the bilateral negotiation between the USA and Mexico on Colorado river water allocation, in which the key technology of membrane desalination is introduced as a measure of confidence building. In the Indus treaty case, however, neither political nor diplomatic negotiation, in line with intensive support of the World Bank and international agencies, could resolve the long-standing dispute over water allocation between India and Pakistan.

Some bilateral agreements on water allocation are identified in the Middle East rivers such as the Nile, Jordan and Euphrates, but no multilateral agreement was reached in many efforts of political negotiations, except for scientific and/or academic co-operation and navigable water use. A good effort is being conceived in the joint hydro-environmental monitoring of the Danube inland delta, crossing the border between Slovakia and Hungary, which would lead to the mitigation of political conflicts and terminate the dispute between the two parties, with or without international co-operation.

Lessons from the past, some successful and others unsuccessful, can be effectively used in conflict-prevention measures in the development and management of international rivers, as long as people approach them with wisdom. Respecting different cultures, wisdom, and quality information will be the key element in either resolving or preventing the conflicts and/or disputes over the use of international rivers in the 21st century.

References

1. Worthington E.B. (1977) Arid land irrigation in developing countries; environmental problems and effects. Pergamon Press, pp.149-152/font>
2. Buros O.K. et al. (1992) Issues associated with large scale desalination plants. National Water Supply Improvement Association's Conference, Yuma, Arizona/font>
3. Biswas A.K. (1992) Indus water treaty: the negotiating process. International Water Resources Association (IWRA). Water International 17 4:201-209/font>
4. Bingham G., Wolf A., and Wohlgenant T. (1994) Resolving water disputes, conflict and co-operation in the United States, the Near East and Asia. ISPAN-USAID, pp. 102-113/font>
5. WPDC (1988) Egypt moves to avert Nile crisis. World News, February 1988, pp. 3/font>
6. Naff T. and Matson R.C. (1984) Water in the Middle East; conflict or co-operation? Westview Press, Boulder and London, pp. 1-62/font>
7. Beaumont P., Blake G.H. and Wafstaff J.M. (1988) The Middle East: a geographical study. 2nd edition. David Fulton Publishers, London/font>
8. Murakami M. and Musiake K. (1991) Hydro-powered reverse osmosis (RO) desalination for co-generation. Proceedings from the International Seminar on Efficient Water Use. International Water Resources Association (IWRA), Mexico City, October 1991/font>

9. Murakami M. (1991) Arid zone water resources planning study with applications of non-conventional alternatives. Dissertation. Dec. 1991, University of Tokyo, Japan/font>
10. Murakami M. (1995) Managing water for peace in the Middle East. Alternative strategies. United Nations University Press, Tokyo-New York-Paris/font>
11. WPDC (1987a) Turkey-Syria water accord signed. World News, Sept. 1987, pp. 3/font>
12. Gould D. (1988) The selling of the peace pipeline. MEED, 26 March 1988, pp. 10/font>

Professor **Masahiro Murakami** studied Engineering at the University of Akita, and obtained a Ph.D. in Engineering at the University of Tokyo. He specialises in water resources development and management, hydro-politics and eco-decision making of international rivers, membrane separation technology, desalination and water reuse. He is a Consultant to the Academic Division of the United Nations University, and to the World Bank Agriculture and Natural Resources Department. He is Associate Editor and Committee Member of International Waters to the IWRA. He is Member of the International Desalination Association and the American Geophysical Union, Committee Member of the Japan Society of Civil Engineers, Executive Editor of the Japan Society of Hydrology and Water Resources, and Board Director of the Japan Society of GIS. He has published books and papers on water issues of the Middle East, has worked at the Engineer of Overseas Department at Nippon Koei Co. Ltd, where he held positions as Deputy General Manager (1991-1995) and Senior Researcher (1995-1997), and served as a Visiting Project Researcher at the Institute of Industrial Science at the University of Tokyo. He currently holds the position of Professor in the Department of Infrastructure System Engineering at the Kochi University of Technology.