4 / Prospects for Technical Cooperation in the Euphrates-Tigris Basin

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1. INTRODUCTION

Over the last decade, numerous reviews and studies have appeared in books and journals addressing the Middle East water issues. These have generally been diluted with multiple political arguments. A very sensitive and misused commodity by nature, water has often been manipulated by human beings driven by different aspirations and political ambitions. Several divergent views and political arguments have emerged concerning the use of transboundary rivers. It is not, however, the intention of this paper to go into the merits and demerits of these distinct approaches; rather it attempts to indicate some technical solutions which could help determine the supply and demand balance of the water required by the riparian countries in the Euphrates-Tigris basin.

Public perception of water issues is generally influenced by politics, and as such is highly ambiguous. In this context, a scientific and technological approach is required in order to comprehend the issues clearly and objectively.

2. WATER RESOURCES MANAGEMENT AND ALLOCATION ISSUES IN THE EUPHRATES-TIGRIS BASIN

It would be useful to define water resources management as 'the art of matching the supply of water with the demand while controlling the quality'. Throughout this process, we confront two complementary policies:

(i) *Supply-augmenting policies*, which include making use of storage facilities, water transfer among rivers and non-conventional water supply methods.

(ii) *Demand-management policies*, which include making more efficient use of existing supplies through structural, operational and economic means. Demand management could reduce the scale of supply-augmenting projects or even remove the need for them.

These two policies are treated inseparably while setting up project alternatives and searching for optimum solutions. However, this paper is mainly confined to the engineering aspects of water resources management.

2.1 Optimal Run-Off Regulation in the Basin

Large annual and seasonal variations observed in the run-off of most large basins make it necessary for water resources managements to store adequate water in the upper catchments in order to allow regulated flows throughout the year and over the years.

The seasonal and annual flows of the Euphrates and the Tigris rivers have extremely high variance. At the Birecik gauging station on the Euphrates near the Syrian border, the average annual flow is 30.5 km^3. Two distinct dry cycles were recorded over the 1937–90 period. The first was in 1958–62, 1961 being the year with the most severe shortfall when the annual flow was as low as 14.9 km^3 which accounts for just 49 per cent of the long-term average. The second dry cycle started in 1970 and ended in 1975. The lowest flow was in 1973 with an annual flow of 18.8 km^3, representing 62 per cent of the average. On the other hand, the recorded peaks of annual flow were 56.4 km^3 and 57.7 km^3 in 1969 and 1988, respectively. These represent 185 per cent and 189 per cent of the long-term average. The flow rate of the Euphrates also has significant seasonal variations. In an average year, the highest flow is generally observed in April or May and the lowest in September. The fact that the monthly flow of the Euphrates fluctuates between 530 per cent and 16 per cent of the monthly long-term average is sufficient evidence of the high seasonal fluctuations (DSI 1992).

The historical records of the annual and monthly run-offs occurring on the Euphrates river at Belkisköy (Birecik) in the 1937–80 period are illustrated in Figures 1 and 2, respectively.

Similar high seasonal and annual fluctuations are also observed in the Tigris river. According to the discharge records at Cizre gauging station on the Tigris near Turkey's border with Syria, the annual average flow was 16.8 km^3 over the 1969–90 period. The Tigris' annual flow variations are similar to those of the Euphrates. The 1970–75 period experienced a drastic decline in the flow rate, the lowest being in 1973 at 9.6 km^3, corresponding to 58 per cent of the average. On the other hand, 1969 was a peak year with 34.3 km^3 measured at Cizre station (204 per cent of the annual average) (DSI 1992).

The historical records of annual and monthly run-offs occurring on the Tigris river in the 1946–82 period at Cizre are also illustrated in Figures 1 and 2, respectively.

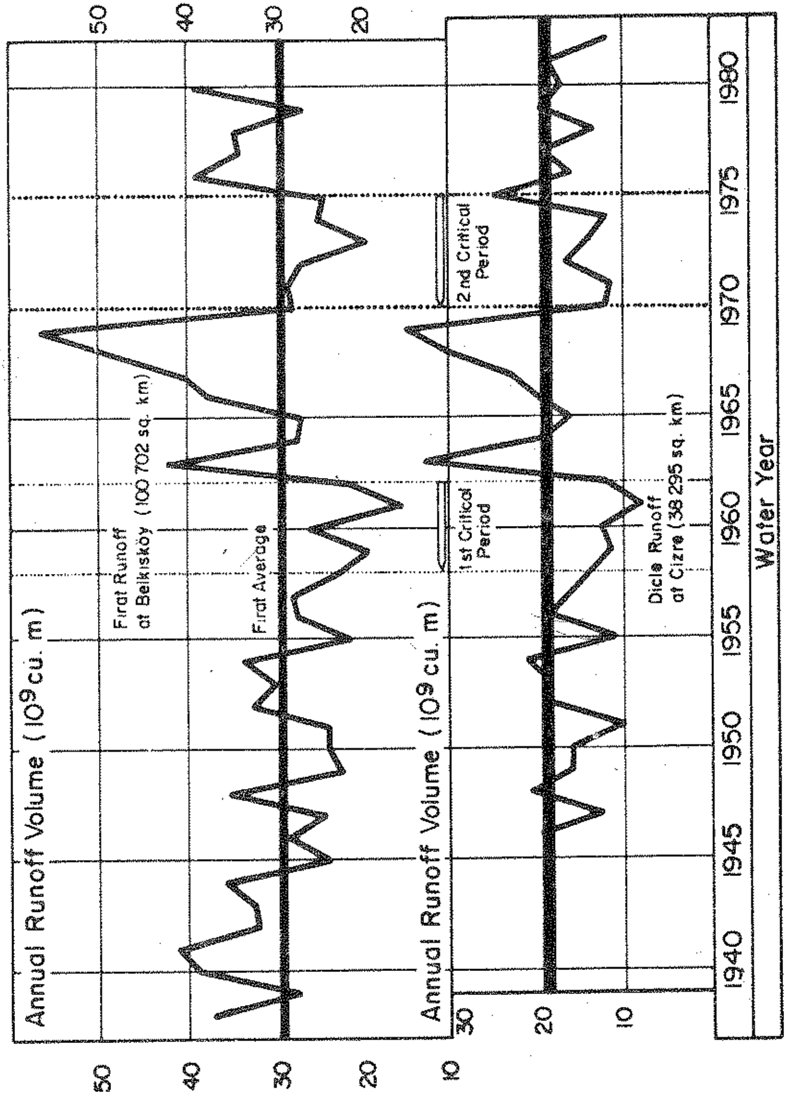

Figure 1. Historical Annual Run-off on Firat and Dicle Rivers.
Source: Bagis (1989, pp. 43–44).

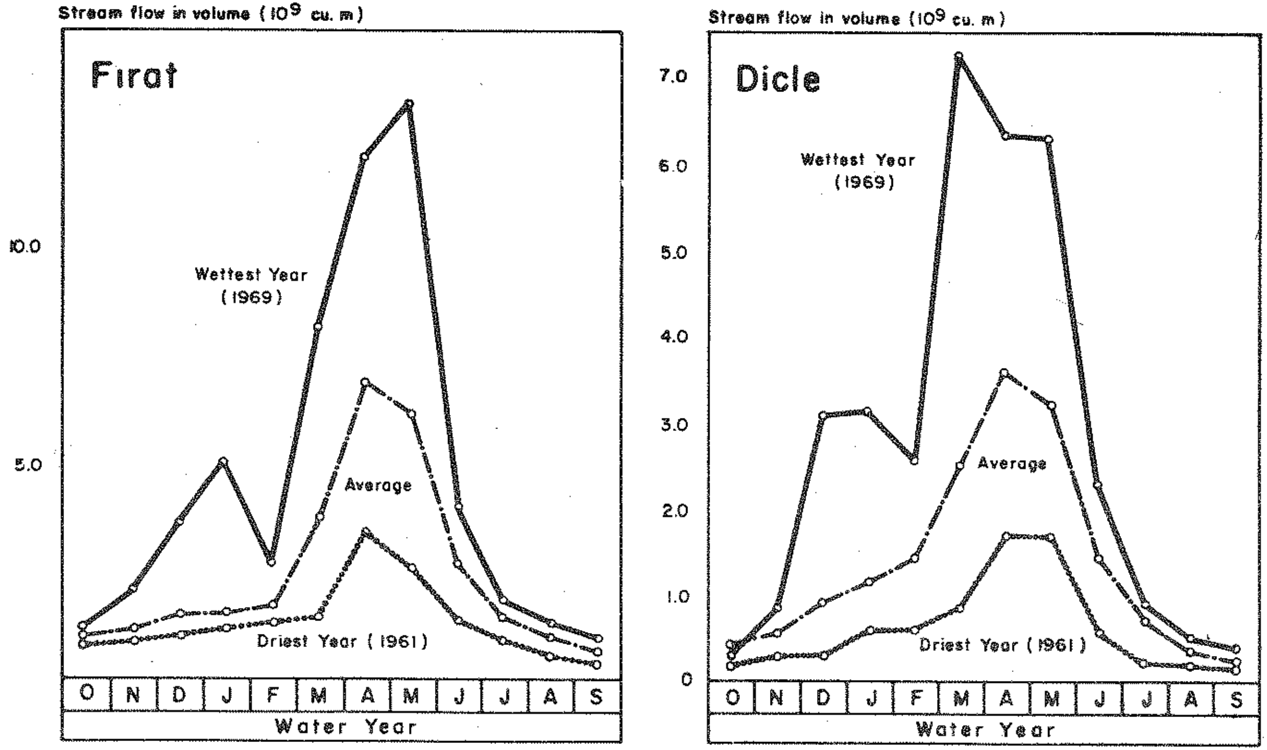

Figure 2. Monthly Run-off on Firat and Dicle Rivers.
Source: Bagis (1989, pp. 43–44).

Because of the extremely high seasonal and annual flow fluctuations in the Euphrates and the Tigris rivers, storage facilities are a key concern in the problem of water resources management for the riparian countries in the Euphrates-Tigris basin. However, the Euphrates, along its entire course in downstream countries, does not provide ideal sites for the creation of large dams and associated reservoirs (Figure 3). The largest dam in Syria (Tabqa) has only 9 km^3 active storage capacity which accounts for only 30 per cent of the natural flow of the Euphrates. Main storage facilities, existing or planned, on the Euphrates river in Turkey are Keban, Karakaya, Atatürk, Birecik and Karkamiş dams, of which Keban and Karakaya are currently operating and the Atatürk dam is being built. Feasibility studies and the final designs of the Birecik and Karkamiş dams have been completed. Since the active storage capacity of these reservoirs will be 47.6 km^3 (1.6 times the annual mean flow of 30.5 km^3), the natural flow of this river will be regulated to a great extent by utilizing the head of 503 m from Lake Keban to the border over a distance of 468 km. Evaporation rates at the reservoirs in Turkey compared to those at Tabqa, Qadisiyah and Habbaniya are much less, due to the climatic conditions and improved volume-to-surface ratio of the Turkish reservoirs in the Euphrates valley.

On the other hand, the absence of large reservoirs in Syria and Iraq indicates that little practical use has been made of reservoirs in these countries for storing water from high-flow years to low-flow years, and flood waters will continue to flow to the sea.

The timing of the floods on the Euphrates and Tigris has never been ideal for crop production. As Garbrecht notes (quoted in Goldsmith and Hildyard 1984, p. 304):

> First the floods of the Tigris and Euphrates were very erratic and occurred at the 'wrong time', the period April–June being too late for summer crops and too early for the winter crops. Secondly, the two rivers carried a much greater amount of sediment than the Nile River. And, finally, the very small incline of the alluvial plain [1:26,000] and the fine texture of soil easily gave way to waterlogging and salinization (lack of natural drainage).

The low-lying plains in Syria and Iraq form a natural expansion zone for high waters. The combined area of the lakes and swamps at the head of the Gulf varies from 8288 sq. km at the end of the dry season to 28,490 sq. km during the spring flood, covering the area having irrigation facilities. During the 1946 flood, the total inundated area reached 90,650 sq.km (Naff and Matson, 1984, p. 85), causing severe property damage and loss of life.

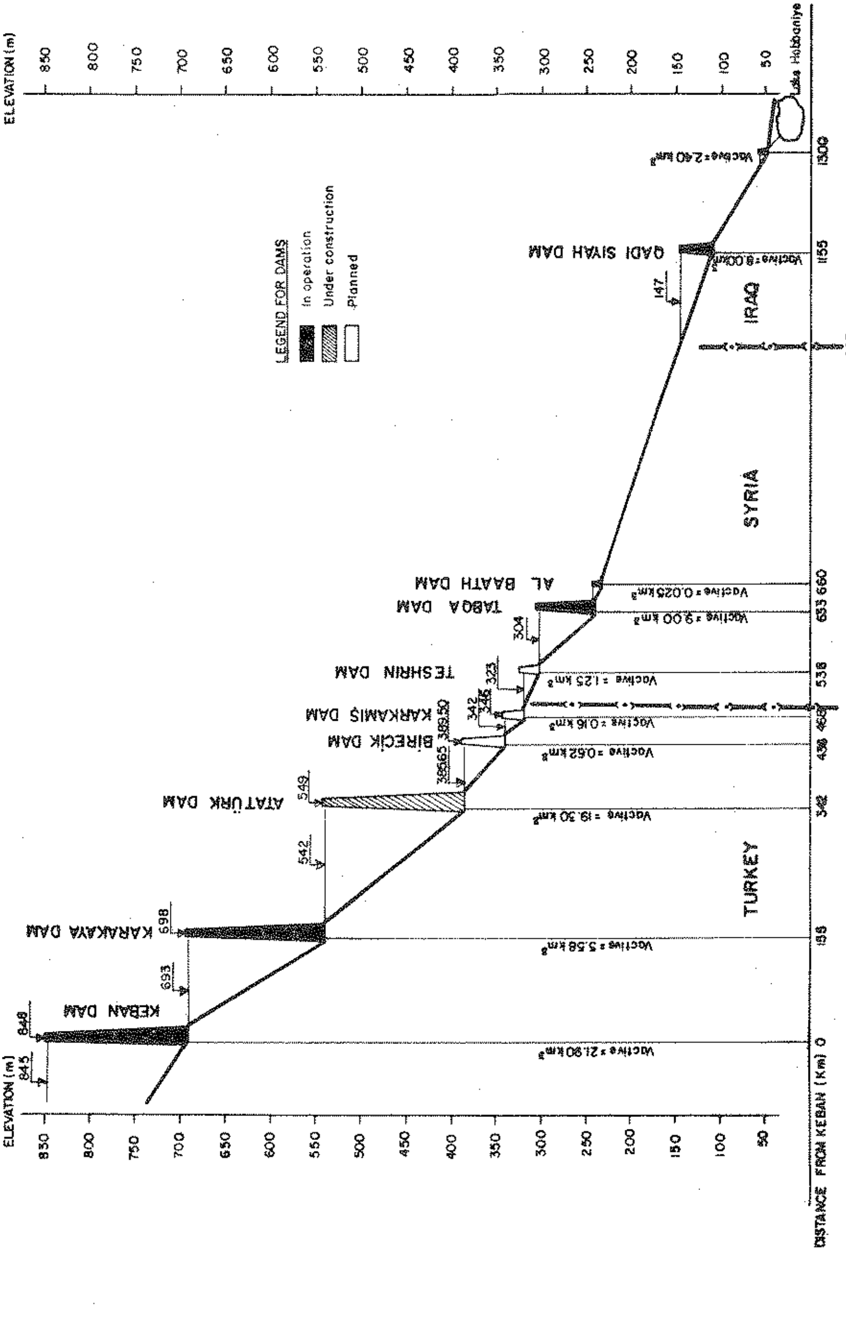

Figure 3. Profile of the Euphrates River (*Source:* DSI, 1992).

Downstream riparian countries have no over-year water storage capacities. Therefore they are unable to store water for later use, as became clear during the long drought periods of 1958–62 and 1970–75. From the engineering point of view, potential reductions in natural flow at full development in the basin could be greatly mitigated by water savings provided by the regulation effects of the reservoirs in Turkey. On the one hand, Turkey's reservoirs could provide its neighbours with water security; on the other hand, the rate of siltation of downstream reservoirs would be much diminished.

Quantity parameters of a river can be transformed by storage reservoirs; in other words, the characteristics of a stream can be dramatically altered with the help of storage facilities. Such a change could be depicted in a flow-duration curve. For this purpose, a statistical analysis of the stream flow for the Euphrates at the Turkish-Syrian border was carried out with and without the regulation effect of the Keban dam. The annual run-off duration curves for the years 1937–90 for both cases are given in Figure 4 (DSI 1992). According to these curves, the frequency of mean annual flow rate of 968 m^3/s, corresponding to 33 per cent of the time span, increased to 46 per cent after the construction of the Keban dam. Much higher rates are expected to be realized upon the completion of Atatürk dam.

Kolars (1993, pp. 13–14) asserts the positive implications of upstream regulations and points out that:

> Variation in the flow of both rivers ranges from conditions of severe drought to destructive flooding, and it is on this basis that the *Turks make one of their strongest justifications for implementing the GAP with its giant dams and reservoirs* capable of smoothing out such variance and providing a dependable year-round flow downstream. However, this argument has not been persuasive enough for the Syrians and Iraqis. (Emphasis added.)

One of the most intensively impounded river systems in the world is the Colorado river which drains the south-western United States and enters into Mexico. A brief examination of the discussions which took place between the USA and Mexico provide us with an interesting insight into the run-off regulation within the context of the management of the entire basin.

At the time of negotiations on the Colorado river compact between the USA and Mexico, in view of certain allegations raised by Mexico, the USA's Department of State released the following statements on 30 June 1941 (Whiteman nd, pp. 947–8):

Figure 3. Profile of the Euphrates River (*Source*: DSI, 1992).

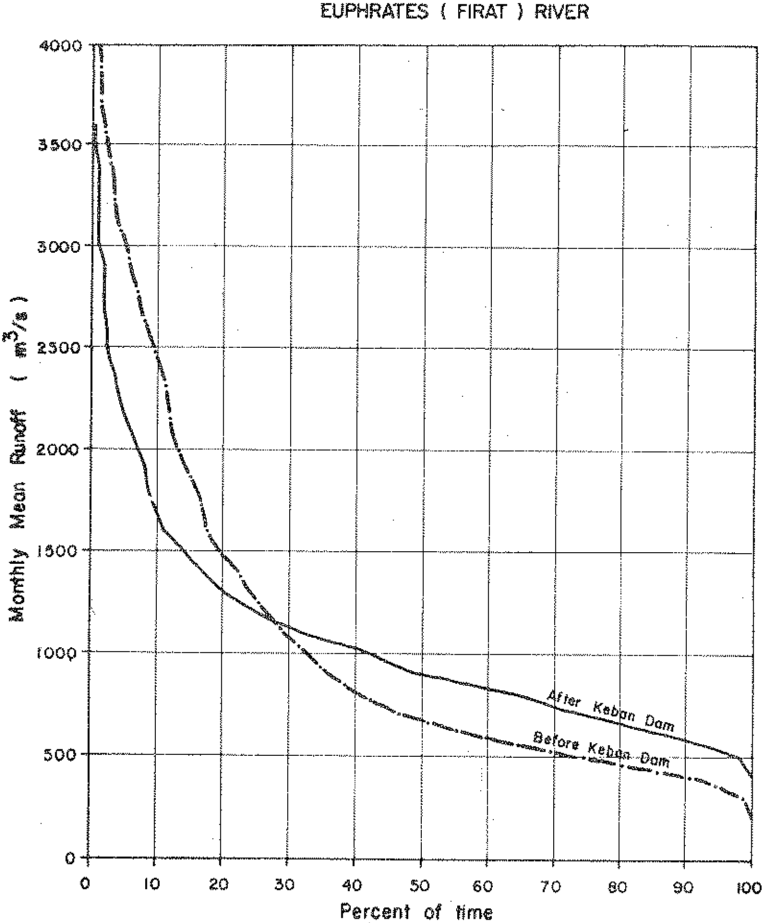

Figure 4. Run-off Duration Curve at the Border

The water it is proposed to deliver to Mexico from Colorado river in perpetuity is obviously worth many times a larger amount of uncontrolled normal and natural flow and hence would seem to be no less valuable than the 3,600,000 acre feet of normal and natural flow of water requested by Mexico in 1930. It is to be noted that there has been great variation in the annual flow of the river and that Boulder dam prevented serious shortages, even greater than those which would otherwise have occurred in 1937, 1939 and 1940. Moreover, the construction of the Boulder dam and the maintenance of expensive storage facilities and the water to be delivered to Mexico have not involved any cost to that country under the plan herein presented; no charge would be made to Mexico for storage costs at Boulder dam.

In the Department of State's memorandum of 11 February 1942, it was stated that:

. . . the Department of State felt that it had more than met the requirements of Mexico based upon that country's past claims since the quantity suggested of *controlled water would be so much more valuable than a much greater quantity of uncontrolled water*. It was noted with satisfaction that Mexico recognized this to a certain extent by its counter-proposal that approximately 2,000,000 acre-feet of water would be acceptable. . . . (Whiteman nd, pp. 948–9.)

These two memoranda clearly underline the importance of upstream regulation for basin-wide water resources management. It is interesting to note that, in the case of the Colorado, the annual volume of Colorado river water guaranteed to Mexico under the treaty of 1944, of 1,500,000 acre-feet (1,850,234,000 cubic metres), accounted for little more than 40 per cent of the 3,600,000 acre-feet of normal and natural flow requested by Mexico in 1930.

2.2. Water Transfer from the Tigris to the Euphrates

The total quantity of water flow in the Euphrates river regulated by large upstream reservoirs is likely to be adequate for domestic water supply, industrial growth and agricultural development in the foreseeable future; but there might still be a problem in matching the supply to the demand at certain places and times (e.g. during severe drought periods). To this end, Tigris river diversions seem to be technically, economically and hydrologically appropriate for the following reasons:

(i) Unlike the Euphrates, the Tigris river has several major tributaries in Iraq which enter the Tigris at the left bank from the Zagros mountains in the east. Among these tributaries are the Greater Zab, the Lesser Zab, the Adhaim and the Diyala. The average annual mainstream flow at Mosul is 23.2 km^3 and the tributaries supply a volume amounting to 29.5 km^3/year (Beaumont 1978). The total water resources of the Tigris basin, therefore, amount to 52.7 km^3/year, thus, 1.73 times as much as the annual mean flow of 30.5 km^3 in the Euphrates river.

(ii) According to the balance sheet of water resources versus water uses from the Tigris river prepared by Kolars (1992, p. 108), the amount of surplus water in the Tigris river is 11.9 km^3/year. In his balance sheet, Kolars accepts the natural flow as 49.2 km^3/year which is less than the figure of 52.7 km³/year given by Beaumont. Based on Beaumont's figure, surplus water amounts to 15.4 km³/year, of which 50 per cent could be transferred to the Euphrates. Topography in the Iranian part of the basin precludes the practical possibility of any significant water use there, or diversion to the other parts of Iran. Therefore, it is unlikely that Iran would be affected as a result of this transfer project.

(iii) In connection with this water transfer project, several authorities on Middle East water issues pointed out the important mutually supporting roles that both rivers play to each other. Some are quoted as below.

Iraq could well make greater use of the discharge in the Tigris. In fact, the Tharthar canal project which at the moment diverts Tigris Water into the Tharthar depression, thereby controlling floods, is planned to be extended to the Euphrates, facilitating therefore the transfer of flow from one river to the other (Anderson 1986, p.19).

The Iraqis are also planning to transfer water from the Tigris to the Euphrates. The Tharthar canal project presently diverts water into the Tharthar depression, controlling the flood flow of the Tigris. The next stage of the plan is a canal from the Tharthar into the Euphrates, and outlet canals back into the Tigris and Euphrates to channel water as needed into agricultural projects (Naff 1984, p.92).

Fortunately for Iraq, however, there is little suitable land in these two countries which could be irrigated by using the waters of the Tigris. As a result, it seems unlikely that serious international problems will be generated concerning the use of its waters, and Iraq will be able to make the fullest use of them for its own needs. This explains why Iraq is able to divert a significant proportion of the flow of the Tigris through the Tharthar Basin to augment the water resources of the Euphrates (Beaumont 1978).

Kolars (1993, p.49) makes a different recommendation concerning the route of a transfer canal, viz.:

. . . a canal might be built from the Mosul reservoir (or from a smaller retaining or diversion facility farther upstream) in order to bring a supplemental supply of water to the Euphrates river. Such a canal could run almost straight south following the 500-metre contour to the Euphrates below the Haditha Dam. This, in combination with water stored in reservoirs on the eastern tributaries of the Tigris, might alleviate Iraq's predicted water problems. The expenditure on such ventures should be considered as an international, regional item to be shared by all the riparians. Such an idea raises the possibilities of potential basin-wide/regional cooperation.

Another recommendation made by Beaumont (1991) is as follows:

On the Tigris the picture is clearer as much less development has occurred, or indeed little is planned outside Iraq. In Turkey some water use takes place in the Diyarbakir basin, but as yet no major water structure has been built, or seems likely to be built in the near future. Leaving Turkey, the river flows into Iraq, though for a short distance the boundary between Syria and Turkey is marked by the Tigris river itself. In this area the head waters of the Khabour, the major tributary of the Euphrates, are close by, and it would not be too difficult from an engineering point of view to divert some of the waters of the Tigris into the Khabour at this point.

Among the above-cited project proposals, the one which links the Tigris to the Euphrates through the Tharthar Valley has already been realized and operative since 1988 (Dhanoun 1988).

From time to time, it is argued that salinity in the Tharthar depression precludes the transfer of water except in extreme cases (Kolars 1993, p.13). However, a bypass canal to be built north of the Tharthar depression could transfer the fresh Tigris water directly into the Euphrates, by making use of the existing canal between the Tharthar depression and the Euphrates, avoiding the rather saline earth formation in the Tharthar lake bed (Figure 5).

While discussing the possibility of linkage between the Tigris and Euphrates rivers, it is interesting to note that the original idea dates back to pre-Christian times. It was then thought to link the two rivers by the Shatt el Hai canal (McDonald and Kay 1988, pp. 1–2).

This issue can be better put as follows:

Suppose two transboundary rivers enter into a lower riparian State. One of these rivers receives a large portion of its water from tributaries which run exclusively within national boundaries while the other river is highly susceptible to the demands of upper riparian countries. How ethical would it be for the lower riparian State to insist on maintaining all its existing and potential water rights on the latter river (which is very much needed and susceptible to depletions by other States) while reserving the surplus water of the former river only for itself?

A relatively similar case involving a water transfer was experienced by India and Pakistan. In 1954, the World Bank put forward a proposal for the equitable distribution of the water resources available to India and Pakistan. The proposal had three important features:

(i) The waters of western rivers were to be allocated to Pakistan and the waters of eastern rivers to India. Parts of Pakistan which were fed by

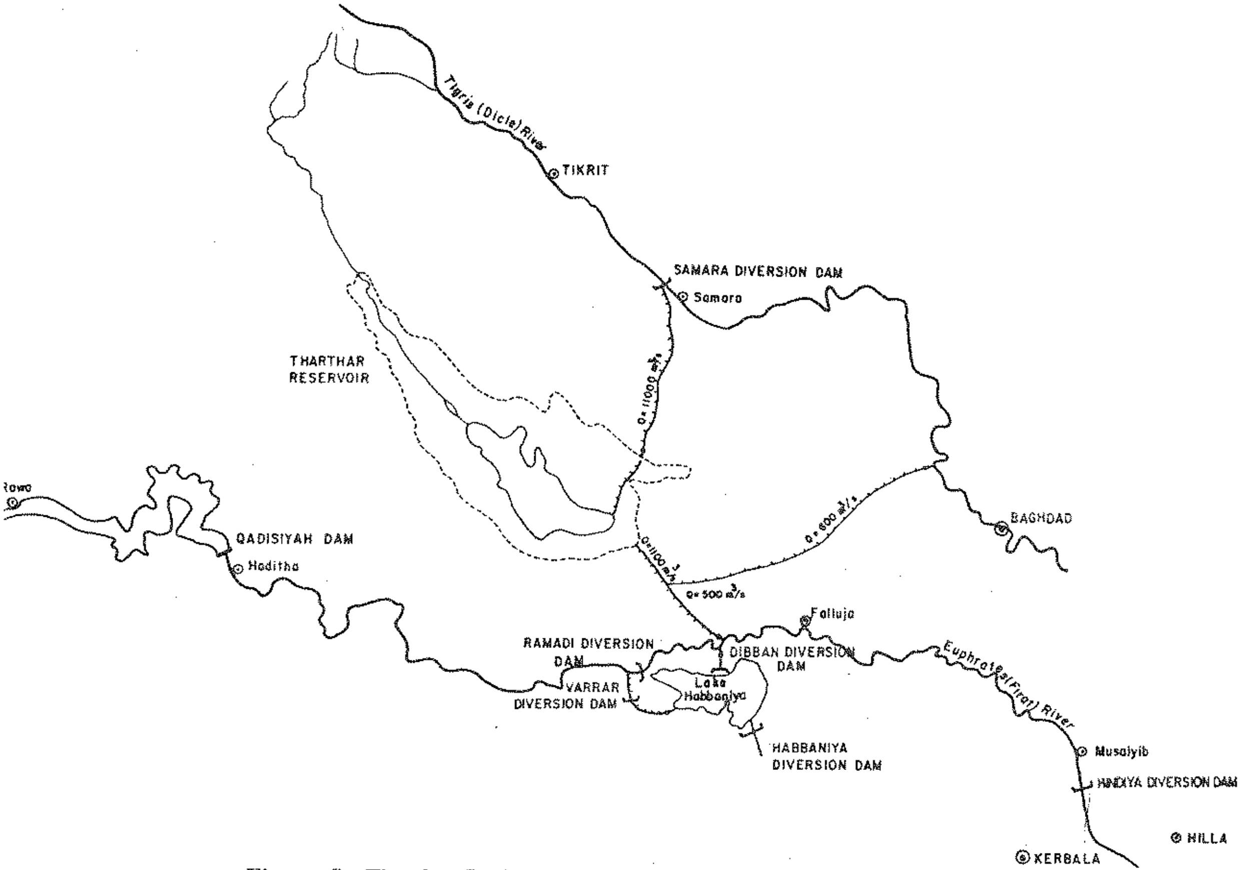

Figure 5. Tharthar Project: diversion from the Tigris to the Euphrates

the eastern rivers, would in future be fed by waters to be transferred from the western rivers by means of a system of link canals. It was estimated that 17.3 km^3 of water would be required, ultimately, to replace the water designed for use in India.

(ii) India would make a contribution to the cost of the replacement works.

(iii) During the construction phase, India would limit her withdrawals from the eastern rivers to proportions which would match Pakistan's capacity to replace (Framji et al. 1982).

The Bank's proposal differed from Pakistan's (which provided for existing uses to be supplied from existing sources), but it did recognize Pakistan's right to water in providing that India should pay the cost of building the replacement link canals. The gain to India would be that the waters of the eastern rivers would then be available for the expansion of irrigation in undeveloped Indian lands.

In sum, the Bank proposal protected existing irrigation uses from disturbance, and allocated surplus supplies to areas already developed or to be developed through water transfers among rivers. This was a technical solution which involved no judgment upon the legal contentions put forward by the concerned parties.

The India-Pakistan experience is of relevance in the Middle East. It illustrates that the existing and future agricultural water requirements in this region need not all continue to be met from the Euphrates. Some areas fed by the Euphrates could be more efficiently commanded by waters to be transferred from the Tigris river. A system of link canals can easily serve to augment the Euphrates-fed irrigation.

This possibility constitutes the most promising technical solution to help matching the supplies with the demands in the Euphrates-Tigris basin.

2.3 Environmental Issues

It is evident that water resources development projects have created some environmental problems. The goal of '*no damage to nature*', if strictly adhered to, would in some cases mean that developing or even using water resources might not be possible. However, economic development and environmental management can be concordantly pursued to minimize negative effects. This point was well made by McDonald and Kay (1988, p. 107):

> There is a dichotomy between those who favour a technical fix to the problems of water supply and those who suggest that the technical solution will never solve this resource problem. . . . Such a rigid stance on this issue is unwise. To

suggest that large-scale projects are not relevant to the needs of developing nations, where the water supply problems are huge, is clearly nonsense.

2.3.1 Impact on the Arabian-Persian Gulf

While dealing with the impacts of run-off regulation and irrigation schemes along the Euphrates and Tigris rivers, the dumping of the highly toxic trace metals and other forms of wastes into coastal and offshore waters by industrial plants should not be overlooked. Considering the fact that the Gulf countries have not yet reached a point of comprehensive marine management, we can anticipate even more dubious environmental consequences in the region in future. With or without irrigation development, under any circumstances, the Gulf area has been under serious attack by industrial and oil pollution, and agricultural pollution remains a trivial externality. The bottom line is that if one were to cite water resources development as the major cause of pollution in the Gulf, one would be missing the forest for a single tree.

2.3.2 Salinization and Return Flow Issues

It is a well recognized fact that the major part of arable lands in Iraq and Syria, including most of the present irrigated area, is seriously affected by salinization, and large areas have fallen out of production over the last few years. According to Tariq Harran (1973), Director General of Soils and Land Reclamation, in 90 per cent of the arable areas of central and southern Iraq, levels of salinity are so high that the average level of crop productivity per unit area in this region is below that in the majority of the Middle East countries. Indeed, Erik Eckholm describes vast areas of South Iraq which now 'glisten like fields of freshly fallen snow' (quoted by Goldsmith and Hildyard 1984, p. 140).

As for Syria, M. M. Gabaly (quoted by Goldsmith and Hildyard 1984, p. 140) noted that: 'Due to the aridity of climate, with evaporation exceeding precipitation in many locations it is estimated that 70 per cent of the soils put under irrigation are potentially saline.' Nonetheless, plans are afoot to irrigate a further 1.5 million acres as part of the giant Euphrates project. Annual crop losses due to salinity and waterlogging in the Euphrates valley alone already amount to $300 million. In short, we can conclude that all of the above-cited problems emerge from natural soil conditions and poor drainage.

On the other hand, the head-waters of Euphrates and Tigris are of high quality and the return flow from irrigation will be only moderately mineralized, containing about 700 ppm dissolved solids, and of satisfactory quality for irrigation supply (Lower Euphrates Project 1970). In this context we should note that under the terms of a joint treaty signed between Mexico and the United States, the USA agreed to reduce the salinity level of water entering Mexico to less than 800 ppm from an average salinity level of 2800 ppm at the Yuma desalinization plant (Goldsmith and Hildyard 1984, p.157). Thus, the agreed upon salinity level of return flow provided to Mexico is almost equal to that given by Turkey to its neighbours.

Moreover, the return flows from irrigation schemes around the Atatürk Dam enter directly into the dam reservoir and are diluted with large amounts of fresh Euphrates water. It is expected that the return flows may ultimately total 20 per cent or more of the diversions. This return flow is significant and is clean enough for additional irrigation in the downstream riparian countries.

Kolars (1993, p. 36) states that:

> Syria may experience relatively little additional trouble regarding salination from Turkey, but its own soils are notoriously gypsiferous and saline and their proper washing and cleansing could dump oppressive loads of dissolved solids on Iraqi fields.

Although the lack of drainage facilities and the basic properties of soils are the major causes of salinization in arid climates, the salinization of soils is often solely attributed to quality of irrigation water. In this respect Kovda (quoted by Goldsmith and Hildyard 1984, p.147) makes the following point:

> It has always underestimated the importance of the groundwater and properties of saline soils . . . secondary salinization of soils is attributed mostly to salts of irrigation water, which in fact are of secondary importance.

Conclusively, an efficient drainage scheme in the Euphrates-Tigris basin is of great significance, and the lack of drainage facilities is a major cause of several environmental problems, including salinization.

Issues of water quality as well as quantity in the Euphrates-Tigris basin, even under full development, are not more serious than those in any other developed countries' river basins (such as the Colorado), although doomsday scenarios are frequently drawn up for the future in this region.

2.4 Integrated Planning Concept of the Euphrates-Tigris Basin

With reference to the problems of transboundary rivers among riparian countries, the concept of integrated planning is merely presented in the context of resource allocation. However, the agreement on proper water allocation should be based on findings derived from a basin-wide planning process, and any negotiations should emphasize basin-wide planning as a goal. Such a plan depends on the collection, interpretation and evaluation of basic data relating to hydrology, climate, soils and other physical and socio-economic factors.

The presence of evident data anomalies in the available records concerning water and irrigable land resources in the Euphrates-Tigris basin have been noted several times in various reports, and the question of data validity is pertinent to the formulation of any firm conclusions. The current levels of extraction for irrigation and plans for development are not known with any precision.

Kolars (1993) points out that:

> Understanding of the use of the Euphrates river and its tributaries in Syria for irrigation is obscured by lack of data and conflicting reports . . . much of the 640,000 ha originally scheduled for irrigation has had to be abandoned because of gypsiferous soils [p.42].
>
> Early schemes to develop as many as 650,000 hectares along the Euphrates by building the ath-Thawrah Dam were reduced by 1983 to 345,000 ha and subsequently to 240,000 ha. Inaccurate soil surveys conducted by German firms failed to warn the Syrians about the effect of gypsiferous soils both on canals and on field applications of water. The Rasafah project originally estimated by the Russians to encompass 150,000 ha was actually abandoned and no more than 208,000 ha (12,000 ha government projects, 196,000 ha private lands) were under irrigation in the Euphrates valley in 1985–86. Moreover, large tracts of fertile valley land have been lost beneath the waters of Lake Assad and to poor drainage and salinization. Revisions in Syrian agricultural plans now place greater emphasis on dry farming and ancillary projects on the Khabur [p.9].

Naff and Matson (1984, p.97) noted that: 'Unexpectedly high reclamation costs of between $4000 and $10,000 per hectare had already led Syrian agricultural officials to admit privately that Tabqa's ultimate goal of 650,000 ha would probably never be reached.'

According to the USAID report quoted by Kolars (1991, p.8), less than half of the original 640,000 ha is reasonably good land for irrigation purposes.

According to Beaumont (1992, p.180), the actual amount of irrigation which is planned by Syria remains controversial, and figures have ranged from as low as 350,000 hectares to values in excess of 1 million hectares. Beaumont also adds, 'Recent estimates suggest that the final total will be between 400,000 and 800,000 hectares. . .' and he also points out, 'Iraq, too, has ambitious plans for irrigation expansion in the Tigris-Euphrates basin. Figures of in excess of two million hectares are quoted, but details are not available and it is not certain just how much of this proposed irrigation is to be located within the Euphrates catchment . . . .'

Based on the above quoted figures, Table 1 reveals data discrepancies on the existing and proposed irrigation project areas fed by the Euphrates river in Syria and Iraq.

Table 1. Conflicting Data on the Total Irrigation Project Areas Fed by the Euphrates in Syria and Iraq (all figures in hectares)

Country Source	Syria	Iraq	Remarks
Official	773,000[1]	1,952,000[1]	
Kolars	375,000[2,*]	1,294,000[2]	*240,000 ha from the main stream plus 135,000 ha on the Khabur
	397,000[3]	1,550,000[3]	
USAID Report	320,000[4]		
Anderson	200,000[5]* to 500,000		*Figures include irrigation from the main stream
Beaumont	400,000[6] to 800,000		

Sources:

[1] Figures given to Joint Technical Committee (JTC) in 1982 and 1983
[2] Kolars (1991), pp. 8–10
[3] Kolars (1992), p. 107
[4] The USAID Report is not available to the author; quoted from reference 2 above, p. 8
[5] Anderson (1986), p. 18
[6] Beaumont (1992), p. 180

It is clear from Table 1 that a variety of local and foreign experts contend different figures concerning availability of irrigable land in each riparian country. Since irrigation is the major water consumer, a lack of consensus on irrigable land potential is an important issue. Such inconsistent figures can mislead analysts.

In conclusion, it can be seen that consistency and reliability of data on the land to be irrigated is a major concern for all parties and much work needs to be done to clarify the existing situation. Considering soil quality, soils are being classified in six categories ranging from excellent (class I) to poor (class IV) and to uncultivable (class VI). Among these categories, class IV has particularly severe limitations for crop production. High-textured soils, together with salinity and alkalinity, will cause serious difficulties in the process of reclamation, making it uneconomical. It is therefore not worthwhile to drain and reclaim such soils. Even after drainage and reclamation, the productivity of these soils would be very low compared to lighter-textured and better structured soils. Low productive soils, on which low yields are likely to be obtained despite enormous water use must be removed from irrigation in all riparian countries. Even if only a small percentage of the lands which are least suited for irrigation are removed from irrigation, the resultant water savings will be considerable.

Agricultural withdrawals from the Euphrates and Tigris, which correspond to 70–75 per cent of total consumption, are differently accounted for by the parties because of the soil data inconsistency mentioned above. National guidelines being practised by each country for data collection, evaluation and processing are based on different criteria and are not readily applicable to transboundary water courses. Data collection and survey of water and land resources need to be jointly performed by the riparian countries so as to acquire a basis for water allocation questions.

Based on the above considerations, a three-stage plan can be proposed in brief as follows:

(i) Inventory studies for water resources should include *inter alia*: unified measurement, data compilation, exchange of flow and meteorological data from agreed upon meteorological and gauging stations, correlation of flow data as appropriate, and extension of the short period records to generate longer period records in consistence with an acceptable level of data reliability. The following key gauging stations are proposed:

Key Stations	*Turkey*	*Syria*	*Iraq*
On the Euphrates	Belkisköy	Kadahya Abu-Kamal	Husabia (Hit) Nasiriya
On the Tigris	Cizre	—	Fishkhabow Mosul Kut

(ii) Inventory studies for land resources should include: unified classification of soils, and determining irrigation water requirements for projects in operation, under construction and planned by following the general rules of the '*Rapid Rural Survey Approach*' through visits to jointly selected project areas.

(iii) The two major stages very briefly described above, concerning water and land resources inventory studies, should be integrated into a comprehensive master plan, combining the riparian countries' resource management plans and including water transfer projects from the Tigris to the Euphrates. Based on this master plan, a simulation study can be carried out to develop water budget and allocation models among riparian countries.

In order to expedite cooperative efforts, the three-stage plan should be carried out in accordance with a time-table. During the period needed to put the plan into action and during the implementation of the projects based on this plan (such as water transfer from the Tigris, or modernization and rehabilitation of irrigation schemes) water withdrawals from the Euphrates might be limited. Since final allocations will be calculated on the basis of the plan itself, the utilization of waters will be adjusted according to the outcome of this plan.

The two extreme points of view, *absolute territorial sovereignty* and *absolute territorial integrity*, must be moderated by the concept of 'equitable and reasonable utilization' of a transboundary water-course and the obligation of a riparian country 'not to cause appreciable harm to other water-course states'.

Biswas (1993, p.21) draws our attention to the complexity of the relation between the principle of equitable utilization and the principle of obligation not to cause harm. However, there is always a way to challenge this complexity by means of well-considered technical approaches. In order to put the above-mentioned principles into practice, comprehensive basin-wide plans including water transfers should be used as a technical tool.

Until today, only the protection of downstream riparians' claims to priority use of waters has been sought by the international media, notwithstanding the consideration of a basin-wide integrated planning concept. Beaumont (1992) stressed this point in the following comment:

> With irrigation water what seems to have happened up to the present is that international lawyers place too much emphasis on the rights of the 'downstream' states and not enough on those of the 'upstream' users. It is all too easy to

ignore that in the case of the Euphrates almost 90 per cent of total flow of the river is generated within Turkey.

In this context, reference should also be made to a statement by McCaffrey, special rapporteur of the International Law Commission (ILC):

> . . .a downstream State that was first to develop its water resources could not foreclose later development by an upstream State by demonstrating that the later development would cause it harm; under the doctrine of equitable utilization, the fact that a downstream State was 'first to develop' (and thus had made prior uses that would be adversely affected by new upstream uses) would be merely one of a number of factors to be taken into consideration in arriving at an equitable allocation of the uses and benefits of the water course. (McCaffrey, 1992.)

To this end, upstream riparians will have to utilize a reasonable portion of outgoing transboundary waters in future, although this might entail reducing the water consumption of downstream states.

3. CONCLUSIONS

The Euphrates-Tigris Basin provides a typical example of maldistribution of waters in time and space. However, this problem can be solved if some effort is made by all concerned. In this respect, two points for action have been identified:

(1) Run-off regulation, provided by upstream reservoirs, is of great importance.

(2) In matching supplies to the demands on the Euphrates, it is in the best interest of all riparians to reach a decision for the amount of water to be transferred from the Tigris to the Euphrates without too much delay.

As stated earlier, a reasonable and appropriate assessment of the amount of water each country needs from both rivers, depends upon the availability of complete and accurate information on the land and water resources of the Euphrates-Tigris basin, to be included in a basin-wide comprehensive master plan.

In spite of the doomsday scenarios envisaged by some experts, implementation of the solutions discussed here can contribute to peace and prosperity in the Euphrates-Tigris basin.

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Water is a very important resource for socio-economic development in arid and semi-arid countries. With rapidly increasing demands, water has become a critical resource in such regions. For the very arid countries of the Middle East, use and management of the scarce water resources have become issues of war and peace, or life and death.

Because of the critical importance of water to ensure lasting peace and prosperity in the region, the International Water Resources Association and the United Nations University convened a Middle East Water Forum in Cairo, Egypt, in February 1993, with the support of the Sasakawa Peace Foundation and the United Nations Environment Programme. Twenty-seven leading world experts were invited to participate. This book is based on the papers specially commissioned for the Forum.

The seven chapters of this book study the three major river basins and address the many difficulties faced by countries in this region. After a brief introduction by Mostafa Kamal Tolba, which underlines the need for action rather than prolonged talks and deliberations, Aaron Wolf provides a historical background to the politics of water in the Middle East. Chapters by John Kolars and Özden Bilen study the problem of international river management and possibilities of technical collaboration in the Euphrates–Tigris Basin. Masahiro Murakami and Katsumi Musiake analyse the Jordan River, where water issues are tied up with strategic and political problems. Yahia Abdel Mageed traces developments in the Nile Basin and suggests what could be done to ensure more equitable distribution of water. The final chapter by Asit K. Biswas provides a comprehensive analysis of recent developments in international water management.

While political differences often stand in the way of cooperation between countries, the contributors to this volume believe that discussions on water sharing, by bringing people together, can make a significant contribution to peace in the Middle East. The water crisis which is looming on the horizon will be much more devastating than any oil crisis ever was. Unilateral action will have sub-optimal outcomes, and co-riparian countries must work together on basin-wide management programmes if lasting peace and prosperity in the region are to be achieved.

The convenor of the forum, Professor Asit K. Biswas, Past President of the International Water Resources Association, is also the Editor of this volume. Professor Biswas is a leading world expert on water management. Author of 51 books and over 500 papers, his work has now been translated into 31 languages. He is currently the Chairman of the Middle East Water Commission.

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