Analysis of future water needs for different sectors in Syria

Dr.Wakil Mikhail

ABSTRACT

Water demands for different sectors in Syria have been increasing steadily and at a high rate . It is expected that by the year 2010 the country will face a deficit in its water balance. To define the importance and the evolution of the future water shortage, an analysis of the future water needs for the domestic , agricultural and industrial sectors is performed. The actual water consumptions in Syria for different sectors are estimated at about 12 billions m^3/yr, 90% of them are consumed to irrigate around 700 x 10^3 ha. At the completion of the planned irrigation projects, which are expected by the year 2020 , the irrigated areas will amount to 1350 x10^3 ha consuming 20.5 billion m^3/ yr. (12,3 X 10^9 m^3) Sixty percent of the new areas brought under irrigation will rely on the Euphrates river waters and its tributary Al-Khabour. Within the same period, the Syrian population will reach 32 million inhabitants consuming 3.5 billion m^3/yr for domestic, municipal and industrial uses .

The available water resources in Syria are estimated at about 23.5 billion m^3 taking into account the Syrian share of the Euphrates river (13 billions m^3) . Ten percent of the water resources is lost by evaporation. Therefore , it is expected that by the year 2010 Syria will reach an equilibrium in its water balance. However, starting from this date, it will experience an ever- increasing water deficit. The situation will curtail future development plans and lead to a decreased standard of living. Also it could be a serious source of conflict in the Middle-East if no agreement is reached regarding the allocation of Euphrates water .

23,50
2,35 evap
21,15
13,00 Euph/Kh
8,15 other

23,5
13,0 Euph
10,50
1,05 evap
9,45

13,00
1,30 evap
11,70

1. INTRODUCTION:

Increasing water demands in Syria are influenced primarily by two factors : population and irrigation. The rate of demand keeps pace or surpasses that of population growth due to the increasing standard of living. Likewise rapid expansion in the irrigated areas is considered as a keystone in the future economic development plans of the country.

Syria is not self-sufficient in cereals and food grains and it is experiencing an increasing food deficit . For example Syria imported 1128 x 10^3 tons, of wheat and wheat flour in 1989 (which represent 9.1 % of the total value of the comodities imported by the country) compared to 9.6 x 10^3 tons of wheat in 1977.

Total cultivable lands at present total 6029 x 10^3 ha. Only 11% of which is under irrigation and the rest (89%) is cultivated under rainfed conditions. Seventy five percent of the rainfed areas receive on average of only 250-300 mm yearly precipitation, hence rendering relatively low crop yields .

To overcome the increasing food deficit and ensure solid economic growth, it is of utmost importance for Syria to increase irrigated agriculture .

On the other hand , Syria has limited water resources and the expansion in the irrigated areas will affect in the long term the

future water allocations for domestic, municipal and industrial uses. In addition the main rivers in Syria have their origins outside of the country (Euphrates and Orontes). This situation has serious implications for the Syrian water resource development .

2. FUTURE WATER NEEDS :

2.1. Domestic and municipal sector

Water needs for the domestic and municipal sector(including small businesses and public services inside towns) is steadily increasing in Syria as a result of two factors : natural population growth and urbanisation along with the increasing standard of living .

In order to estimate future water demands we have considered a straight-line extrapolation of previous population and per capita consumption growth over the past twenty years .

During the period (1970 - 1990) , the average [redacted] population growth rate was found to be equal to 3.35 % [redacted] average per capita water consumption in the urban communities has increased from 250 lcd in 1970 to 290 lcd in 1990(an average of 2 lcd per year), and in the rural communities from 100 lcd in 1970 to 120 lcd in 1990 with an average increasing rate of 1 lcd per year .

Table 1 gives the estimated future water needs for the domestic and municipal sector. Thus by the year 2020, the total water consumption for this sector will amount to 3.2 billions m^3 which

represents 15% of the readily avaiable water resources .

2.2- Industrial sector

Water demands for industrial uses are consumed :

- As cooling water in 5 thermal station, generating electrical energy .
- In industrial plants for some specific processing purposes end/ or as cooling water .

According to the Ministry of Electricity, the total installed electrical capacity in the year 1990 was 2999 M.W., 50% of it was produced by thermal (steam) generating stations, and it is expected that by the year 2000 the total installed capacity will amount to 5177 M.W. including 2520 M.W. generated by thermal stations. But by the year 1995 and the completion of Tishrin hydro-electric station (630 M.W) on the Euphrates River , Syria will be exploiting 95% of its suitable hydro-electric potential. Thus starting from the next century the country will rely on steam and gas stations to ensure its growing needs of electrical energy . It is estimated that starting from the year 2000 the annual increase of the installed thermal capacity will average 200 M.W.

Table 2 gives the estimated future needs of cooling water for the thermal stations . This is computed on the basis of 6000 working hours /yr and 40 l/sec./M.W. of cooling water discharge resulting in 5 % water loss .

The estimated future water consumptions for industrial plants presented in table 2 are computed by considering the value of 15.75 lcd for the mean water consumption on a country-wide basin, average of the period 1980-1990 . Thus the estimated total water needs for industrial uses will amount to around 500 millions m^3 by the year 2020 which represents 2.5 % of the country's water resources .

2.3- Agricultural sector :

Since independence in 1945, Syria has formulated modern plans to increase irrigated areas, such as the Euphrates basin project in 1947, and Al-Ghab project in 1951. The Syrian economic growth during the past 40 years is attributed mainly to gains in agricultural output through increasing irrigation. Expansion in the irrigated areas is officiially considered as the basis of any economic development. At the present time, land reclamation and dams projects are under execution in all the Syiran hydrological basins .

Table 3 gives the actual and the projected irrigated areas in the different basins. As shown the actual 1989 irrigated areas in Syria are 670 x 10^3 ha and the total projected irrigated areas are 1350 x 10^3ha, 60 % of them are located in the Euphrates basin (Euphrates project and Al-Khabour basin) which hence contains the largest potential for developing irrigated areas in Syria . The potential for increasing irrigated areas in the other basins is limited .

1350
.6
810

The evaluation of the future irrigation water requirements in the different basins is given in table 4. This evaluation is done by taking into consideration : the crop rotation applied (or to be applied) in each basin and the total irrigation water efficiency of 0.55 . Effective rainfall was taken into account in the calculation of ETc for winter crops.

It appears from table 4 that the total irrigation water needs for the projected irrigated areas is 20.68 billions m^3/yr. 65% of which is needed from the Euphrates river and its tributary Al-Khabour. $13,44 \times 10^9 m^3/yr$

3. AVAILABLE WATER RESOURCES :

Available water resources in Syria are estimated at about 23.5 billions m^3/yr. (taking into account the Syrian share of Euphrates river equal to 13 billion m^3/yr) . The underground water is evaluated at about 2 billion m^3/yr. Approximatly 12% of the surface water is lost by evaporation from reservoirs and some underground aquifere have high salinity water . Thus the readily available water resources are estimated at about 21 millions m^3/yr.

Table 5 gives the available water resources in different Syrian watersheds. It is clear that the assumed Syrian share of the Euphrates River & Basin represents ~~55~~ 56% of the total Syrian water resources, and hence it plays an important role in local water availability and economic development. This situation is emphasized by the fact that the Syrian part of the Euphrates basin constitutes 41% of the entire

20.68
.65
10340
12408
13420

area of the country (Figure 1).

4. WATER BALANCE

Table 6 presents the evolution of future water demands for the different sectors until the year 2030 . It is assumed in this table that the land reclamation throughout the country is progressing at a rate of 20000 ha/yr. Figure 2 gives a graphical representation of the future water demands .

It is clear from this figure that by the beginning of the second decade of the next century (the year 2010) , Syria will experience an ever-increasing water deficit and by the year 2020 this deficit will amount about 5 billion m^3.

It is obvious that the expected future water shortage will curtail future development plans which are based substantially on developing the agricultural sector . Likewise will implicate important social changes and carry potentially grave economic effects .

5. CONCLUSION :

It is evident that Syria will feel within the two next decades an ever-increasing water deficit which will have serious effects on its social and economic development. Facing this situation calls for several important measures. At the internal level, the needed measures include : a master water plan for the whole country,better management of the irrigation water, the introduction of water conservation techniques in the irrigated sector, the implementation of

water reuse techniques and water harvesting systems, and the reduction of losses in water supply networks in towns. At the external level, an agreement for the allocations of the Euphrates water among the three riparians: Turkey, Syria and Iraq is of primary importance for Syria which is more dependent on the Euphrates river than the others .

At the present time, the three riparians of the Euphrates river are projecting and executing large scale irrigation projects : GAP (. South eastern Anatolian project) in Turkey , Euphrates basin project in Syria and Al- Haditha project in Iraq . Thus a water crisis is now emerging throughout the Middle East forming the potential for probable future conflicts. A real international effort is needed now to reach a fair and just water allocations among the riparians.

REFERENCES

Adel F.B., 1989. Potential of irrigated agriculture in Syria. Journal of Water Resources Planning, ASCE .Vol. 115 No.3 .

Annual bulletin of land uses 1986. Ministry of Agriculture , Syria.

Annual Report , 1990. Ministry of Electricity, Syria.

Georgian State Institute for Design of Water Resources Developments Projects, Tbilisi 1982. Sheme of water resources in four areas of the Syrian Arab Republic.

Jouneid G., 1987. Irrigation projects in Orontes basin.Symposium on water resources management proc.,Univ. of Aleppo, Syria.

Statistical abstracts , 1984. General Organisation for Lands Reclamation, Ministry of Irrigation, Syria.

Statistical abstracts, 1970,1979,1989,1990 . State Planning Comission.Syria

State Economic Engineering Corporation (AGROVOD COMPLECT),1975. Irrigation project of Khabour basin, Sofia, Bulgaria.

Manache G., 1990. Water resources evaluation in the main basins in Syria. M.Sc. dissertation. Univ. of Aleppo, Syria.

Rifai W., 1983. Euphrates water between Turkey , Syria and Iraq . Arab Engineer Journal, Vol. 68 , Damascus , Syria.

Wakil M.,1987 Some solutions for the forseenable future water shortage in Syria. Symp. on Water Resources management proc. , Univ. of Aleppo , Syria.

Wakil M., 1992- Analysis of future water crisis in Syria. Submitted for publication Research Journal, Univ. of Aleppo, Syria.

WATER RESOURCES AND DEVELOPMENT IN SYRIA
THE ROLE OF THE EUPHRATES BASIN

Walil Mikhail

Faculty of Civil Engineering
Aleppo University, Syria

Introduction

In order to achieve socio-economic development and to face a growing food deficit, Syia, a traditionally agricultural country, is ~~developing~~ planning and implementing water resources development plans in all of its watershed basins. The object of these plans is to increase the irrigated area from 650,000 hectares (ha) (as existed in 1962) to 1,350,000 ha and to produce about 5000 kwh/yr of electricity.

The major development plans are under construction in the Syrian Euphrates basin and the Khabur River valley which cover 41% of the total land mass of the country and contain within that area the largest land and water improvement potential: 65% of the total economically irrigable lands, 66% of the total water resources, and 95% of the economically viable hydroelectric potential. The water development plans in the Euphrates basin aim to increase the irrigated area from around 390,000 ha (in 1962) to 750,000 ha, of which 594,000ha depend on the Euphrates River, and another 155,000 ha are located in the Khabur River valley. The water demands of the different water sectors, at full development of the irrigation projects, is estimated to be 13,000 Mcm (million cubic meters)/yr in the Euphrates River basin and at 2,140 Mcm/yr in the Khabur River basin. When

the water development schemes are completed, the Khabur River water balance should be completely satisfied. The water balance of the Syrian Euphrates River basin depends on the in-flow from Turkey, the precise amount of which has yet to be formally settled between the two riparians. This circumtance seriously affects water resource development in the Syrian Euphrates basin. Thus, an agreement for the allocation of Euphrates water among the river's three riparians—Turkey, Syria, and Iraq—is of prime importance for Syria which is more dependent on the Euphrates River than its riparian neighbors to the north and east.

Just how dependent—and vulnerable—Syria is, and some of the major implications of this condition, will become clear from the following mosaic of needs, demand, supply, and development plans.

Location and Climate

Syria, encompassing an area of some 185,000 square kilometeres (km^2), lies on the eastern coast of the Mediterranean Sea bounded by Turkey to the north, Iraq to the east, Jordan, Palestine, and Israel to the south, and by Lebanon and the Mediterranean to the west. The Mediterranean climate, characterized by a rainy winter and dry, hot summer separated by two short transitional seasons, generally prevails in western Syria. The rainy season lasts between five and six months, reaches its maximum precipitation in December and January, and ends in May.

Syria may be divided into two large environmental regions (Figure; though some geographers prefer to partition the country into four regions):

1) <u>The Arid Region.</u> This section of the country, designated as arid because it receives an annual average total precipitation of less than 250 millimetres (mm), constitutes 72% of the total area of Syria; it includes the southern and southeastern portions and it forms the natural extension of the Arabian steppe desert. Annual rainfall declines in this region from northwest to southeast where the mean annual precipitation is less than 100 mm.

A sub-desertic climate prvails in this region, a climate of infrequent rains and high evaporation loss rate that averages 2200 mm/yr. The annual relative humidity is very low, varying between 20%-50%. The air temperature, on the other hand, is very high, varying from 19° centigrade (C) in the north to 22° C in the south, and may reach as much as 44° C in summer. These conditions make this region unsuitable for rainfed agriculture; consequently, agricultural development in this area is not possible without the introduction of irrigation.

2) The Semi-Arid Region. This area encompasses the rest of the country where the average total annual precipitation is more than 250 mm. Sixty percent of this region, mainly the northern plains, receives less thatn 350 mm/yr, while along the coast the annual precipitation varies between 800 mm and 1000mm. Annual evaporation ranges between 1900 mm in the northern plains and 600mm in the coastal plain s. The annual average temperature is around 17.5° C in the northern plains and 19° C along the coast. Rainfed agriculture is traditionally practiced in this region where cereals are mainly grown. However, due to the high fluctuation of the annual precipitation, the risk of crop failure and unsatisfactory yields is high.

Land Use

Cultivable lands in Syria are appraised at about 6.15 million ha which corresponds to 33% of the total area of the country (Table 1). In 1991 about 91.5% of the cultivable land was planted, of which 12% (or 693,000 ha) was irrigated. 53% of all cultivable land in Syria is situated in the Euphrates basin (Table 1).

Water Resources

Hydrologically, Syria may be divided into seven watershed basis (Figure 2): 1) The Euphrates basin and its sub-watershed Al-Khabur; 2) Aleppo (the Queiq and Jabul Rivers); 3) the Orontes and its sub-watershed Al-Afrin; 4) Coastal; 5) Desert; 6) Damascus; 7) Horan.

Taking into account the Syrian share of the Euphrates River—13 billion cubic meters per year (bm^3/yr)—the available water resources in Syria are estimated to be about 23.5 bm^3/yr, of which eight percent is underground water.[1] About 90% of the total water resources are located in three basins: the Euphrates, Orontes, and the coastal plain (Table 2). The other four basins are either poor in water resources or experiencing chronic deficits in their water balance as is the case of the Damascus and Aleppo basins where much of the population of Syria, some 40%, is clustered.[2]

The Euphrates basin is the largest in Syria, covering 41% of the total area of the country and, taken together, the Euphrates River and its tributary the Khabur constitute the major riverine water sources in Syria (Table 2). The Orontes River is the second largest basin with an average annual flow of 2,860 Mcm/yr, of which approximately 20% is generated in Lebanon. The water resources of the coastal basin are evaluated at 2,600 Mcm/yr of which about 50% occur as ephemeral water flow during intense winter storms.[3]

The Agricultural sector is the major consumer of water. In 1990 approximately 90% of all water consumed (12 bm^3) was used to irrigate 693,000 ha of land.[4]

Water Resources Development Plans

The main expansion of irrigated areas so far realized in Syria was achieved during the fifteen years that followed independence in 1945. The irrigated area has increased from 295,000 ha in 1947 to 657,000 ha in 1962.[5] This rapid development is due mainly to the introduction of motor-pumps combined with the rise in cotton prices during the Korean war.[6] The expansion was produced chiefly by private farmers and occured on the plains of the river valleys and on the low terraces of the Euphrates, Khabur, and Orontes rivers. Thus, by 1962, all of the river valley low plains suitable for irrigation were fully exploited for that purpose. Therefore, any additional development in irrigated agriculture necessitated large-scale irrigation projects requiring important

hydraulic works, e.g. dams, largescale irrigation networks, etc., carried out by state agencies.

Beginning in 1963, the Syrian strategy for water resources development had two major objectives: the exploitation of the main rivers for large-scale projects, and the construction of dams (surface earth dams) on ephemeral streams and seasonal rivers in order to increase water resource availability. Since that date, Syria has developed plans to use the water of the Euphrates, Khabur, and Orontes rivers for irrigation and the generation of hydroelectricity, with special emphasis being placed on the construction of Tabqa Dam on the Euphrates River and on developing and improving the existing irrigation projects covering 123,000 ha in the Orontes basin.[7] During the period 1965-1990, about 125 small surface earth dams, with a total storage capacity of 410 Mcm, were built on ephemeral streams and seasonal rivers.[8]

Presently, large dams (i.e., with a storage capacity of more than 500 Mcm) and medium and small dams (below 15 meters in height) are under construction in Syria's three main basins (Table 3); altogether, their designed total storing capacity amounts to 3.3 bm^3. Medium and small dams having a total storage capacity of about 1 bm^3 are planned for construction before the year 2000. Thus, it is expected that before the end of this century, about 16 bm^3 of water, which is 85% of Syria's total surface water, will be under storage in resevoirs to be used for irrigation purposes.[9] Therefore, by the beginning ofthe next century, it is expected that 90% of Syria's total surface water (including run-off river water) will be usable. Upon completion of all irrigation projects, the irrigated lands of Syria will amount to some 1,350,000 ha.

Water Resource Development Plans in the Euphrates Basin

The Euphrates River rises in the mountains south of Erzerum in central Turkey, fed by rainfall and melting snow. It is joined by the Murat River, its largest tributary, just upstream of the Keban Dam. B elow the Keban, it flows southward to the Karakaya and the Ataturk dam sites in a deeply sloping and

narrow valley north of Syria. At 175 km south of the Syrian-Turkish border, the river reaches the Tabqa dam site from which it flows eastward.

In Syria, the Euphrates is joined by the Al-Sajur and Al-Balikh rivers (100 Mcm/yr and 190 Mcm/yr, respectively)—both of which rise on the southern slopes of the Anatolian mountains—and by the Al-Khabur River. In actuality, both the Al-Sajur and the Al-Balikh Rivers are entirely used in Turkey. One hundred kilometers downstream from its confluence with Al-Khabur, the Euphrates enters Iraq where it is joined downstream by the Tigris River only 100 km from the head of the Arabian Gulf, forming the delta that is the Shatt al-Arab. The total area of the Euphrates basin is 444,000 km^2, of which 25% lies in Turkey, 17% in Syria, 40% in Iraq, and 5% in Saudi Arabia.

The main discharge of the Euphrated at it entrance into Syria at the Yousef Basha hydro-metric station, is 998 cubic meters per second (m^3/sec); this is the average of the period 1950-1969.[10] This rate diminishes progressively along the watercourse primarily as a result of infiltration and evaporation from surface and underground water along the river bank; thus, its mean discharge at Deir El-Zor is 735 m^3/sec, the average for the period 1930-1955.[11]

The Al-Khabur River is the largest tributary of the Euphrates River outside Turkey. It stems from the Taurus Mountains in Turkey, though the springs of Ras El-Ain are its major source. The Khabur River basin covers an area of 31,000 km^2 of which 32.6% lie in Turkey, 62.3% in Syria, and 5.1% in Iraq. Above Hassakeh, the Khabur is joined by the Al-Rad River which has the Jagh-Jagh River as its main confluent 200 Mcm/yr); the latter is completely used up by Turkey during the summer months.

The flow of the Khabur River is relatively stable throughout the year. Its mean natural discharge at Saouar station (81 km from its confluence with the Euphrates) is 59.5 m^3/sec, the average for the period 1956-1975.[12] Recently, there have been some indications that during the summer, the discharges of the Ras el-Ain springs diminish from 6-10 m^3/sec to ????, which may be attributed to pumping from the aquifer in Turkey which feeds the springs.[13]

History of Water Usage in the Euphrates Basin

The Euphrates basin in Syria has been used for irrigation for more than 6000 years. The political andsocio-economic organization of the first ancient kingdoms of the middle and lower Euphratesin Syria relied upon a well developed hydro-agricultural system. The Amonitic civilization contemporary with the Sumarian and Babylonian civilizations in lower Mesopotamia (Mari Kingdom, 4000-1500 B.C.) developed irrigation systems in several locations on the Euphrates river (Mari, Terga) and on its tributaries, the Al-Balikh and Al-Khabur.[14] Aramean (the Aram Nahrein Kingdom) and the Assyrians (1000 B.C.) accomplished such important hydraulic works in the Al-Khabour basin as the Daurin Canal and the Al-Balikh basin.[15] During the Roman era, several communities flourished in the Euphrates valley: the Dora-Europos, Pales, Serijio-Polis etc. A major agricultural innovation was achieved during the Arabo-Islamic era: the adaptation, in this semi-arid area, of such warm weather plants as cotton, rice, and sorghum.[16] This led to the intensification of irrigation and to e execution of large-scale irrigation systems. In the seventeenth century, some hydraulic water lifts the nasbu and later the gharraf, were developed in the basin.

The introduction of the motor-pumps after World War II led to the rapid development of irrigation agriculture in the basin, with the irrigated area increasing from 175,00 ha in 1947 to 390,000 ha in 1962, of which 322,000 ha were in the Euphrates valley.[17] These developments consumed around 4 billion m^3 /yr.

Development Objectives:

The Syrian Euphrates basin possess the largest potential for agricultural and economic development in the country. In fact, 65% of Syria's total economically irrigable lands (Table 3), 66% of the Syrian water resources, and 95% of the hydro-electric generation potential, are located in the Euphrates basin.

Water resource development plan in the Euphrates basin envisage the construction of six dams on the Euphrates and Khabour rivers. It is planned that at full development more than 750,000 ha of land will be irrigated, which corresponds to approximately 50% of the total economically irrigable area in Syria, and around 4,500 million kWh of hydro-electric energy will be produced which would represent 95% of the Syrian economically viable hydropower potential.

The implementation of irrigation projects in the Euphrates basin will increase the actual cropping intensity from 80% to 135%. A new cropping pattern/rotation will be applied using new crops: corn, alfalfa, etc. Thus, the actual gross agricultural production of the area should be increased more than 4 times. This will help to reduce the country's food deficit which is increasing steadily. For example, the importation of wheat and wheat flour increased from 220,000 tons in 1961 to 1,436,000 tons in 1990. In addition, the agricultural development of the area will promote an agro-related manufacturing industry such as cotton textiles, edible oils, vegetable and fruit processing, milk processing, etc. As a result, the employment opportunities will increase. It is expected that at the completion of the irrigation projects the population of the Euphrates will increase by 3 million inhabitants.[18]

Euphrates River Development Plans:

Syria began to develop plans to utilize the water of the Euphrates River soon after its independence in 1945. In 1947, Syria signed an agreement with a British Engineering Company (Alexander Gibb) to study "the possibility for exploiting the Euphrates river water". A hydro-electric dam was proposed at Youssef Basha, 8 km south of the Turkish border, at the present site of Tishrin dam. Later, in 1957 and 1958, Syria signed two agreements with the Soviet Union to carry out designs for the construction of a multi-purpose dam at Halabia-Zalabia. Four yeas later, a Swedish Company (V.B.B.) and a German Company (Lahmayer) carried out engineering designs for the construction of a dam at the Tabqa site. In 1966, the Syrian government signed a new agreement

with the Soviet Union for designing and financing the construction of a "earth storage dam" at Tabqa; the project was completed in 1975.

Development Plan Components:

The latest development plans for the Euphrates rive in Syria consist of the construction of three dams (Table 5). Two of them have already been built, the Tabqa dam (a multi-purpose dam) and the Al-Baath dam (a flow regulator dam). The third, the Tishrin dam, a hydro-electric power generating dam, is under construction. The Tabqa dam, which is the largest, is designed to produce 1.9 billion kWh/yr which will be increased to 2.5 billion kWh/yr in a second stage after raising the dam's crest by 20 m. Its reservoir will supply water to irrigate 594,000 ha divided into seven irrigation projects (Table 6). An additional 124,000 ha could be irrigated if needed water becomes available. The Tishrin dam aims to produce 1,600 kWh/yr. (Editor's Note: Some of these projects have been shelved for the time being.)

Future Water Demands:

At the completion of the planned irrigation projects, targeted for the year 2010, the water demand for various sectors in the Euphrates River basin is estimated to be 12,970 million m^3/ yr, and the bulk, 10,100 million m^3/yr, will be consumed by irrigation at an estimated annual rate of 17,000 m^3/yr.

The municipal sector in the basin and the city of Aleppo which relies in the Euphrates River of its water supply, will use 710 million m^3/yr. The Queik river (200 million m^3/yr) which once supplied the city is, as previously stated, completely exploited by Turkey during the summer months. It is expected that by the year 2010 around 7.8 million city dwellers will rely on Euphrates water for their water supply. Water consumption for the industrial sector is expected to be elevated to 300 million m^3/yr.

In the absence of a formal agreement among the Euphrates riparians for the allocation of the river's water, it is not possible to calculate an accurate water

balance of the Syrian Euphrates River basin. However taking into consideration Kolars' estimation (21,600 billion m^3/yr, including 50 million m^3/yr return flow) of the GAP (Greater Anatolia Project) project water needs in Turkey, the water balance of the Syrian Euphrates river basin could be (at the completion of the GAP project) in a critical situation with as much as a 30-40% reduction in flow.[19]

Khabour River Development Plans:

Plans for the use of the Khabour River water by Syria dates back to 1950.[20] In 1975, Syria signed an agreement with Bulgaria to conduct "studies and engineering designs for irrigation projects in the Khabour basin". Projects stemming from this agreement were begun in 1985.

Current development plans for the Khabour River envisage the construction of three dams devoted mainly to irrigation (Table 7), supplying water to the planned total estimated to be 154,000 ha. Two dams have already been built, while the largest, the Khabour dam, which is located south of Hassakeh, is presently under construction. The main objective of these dams is to store Khabour water during the autumn and winter seasons, when dammed for irrigation water is low, in order to use such water later in the spring and summer. The installed hydro-electirc capacity in the three dams will amount to 24 MW.

Future Water Demands:

Total water demands on the Khabour, after completion of the irrigation networks, expected by the year 2010, are estimated at 2,140 million m^3/yr. The irrigation sector will use 2,000 million m^3/yr (at a rate of 13,000 m^3/ha for a cropping intensity of 110%). The municipal sector will consume 106 million m^3/yr, and the industrial sector will consume 40 million m^3/yr. The population of Khabour valley has been projected to reach 1.45 million inhabitants by the year 2010.

Table 8 gives the expected future water balance of the Khabour river. It indicates that at the full completion of the planned irrigation project, 95% of water resources of the Khabour river will be consumed.

Conclusion:

Water resources development plans in Syria, which labors under the burden of limited water resources, rely mainly on the Euphrates River: around 50% of the total planned irrigated area and 95% of projected hydro-electric production are located in the Euphrates basin. So far, no formal agreement between the three riparians regarding the allocation of Euphrates water has been reached. This constitutes a major problem for Syrian economic development plans. At present, Turkey, is planning and executing large scale irrigation and hydropower projects. When the GAP project attains its full development, Turkey could then consume 60% of the annual Euphrates discharge.

Thus, at this stage, while Turkey, Syria and Iraq are still formulating large scale water development schemes, it is of primary importance for the three riparians to agree on a just and fair water allocation scheme among them. Cooperation among the riparians is also needed to deal with a serious water pollution problem of excess salinity and nitrates. Both the Euphrates River and the common aquifer which supplies the Khabour River are in danger of serious pollution resulting from wide scale introduction of irrigated agriculture in the upper Euphrates basin. Syria and Iraq will be particularly affected by this pollution.

---

[1] Editor's note: The 13 bm^3 figure claimed by Syria as its rightfu share of the river, is 47% of the flow of the Euphrates (not counting the Khabur), and is disputed by Turkey.

[2] Ministry of Irrigation, Damascus, *The Scheme of Water Resources in Four Areas of the Syrian Arab Republic*, Georgian State Institute for Design of Water Resources Development Projects, Tbilisi, 1982.

[3] Ibid.

---

[4] Wakil, Mikhail, "Analysis of Future Water Needs of the Various Sectors in Syria," *Water Internations*, (forthcoming, spring issue).

[5] Office of the Prime Minister, SAR, *Statistical Abstracts*, 1974, 1959, 1962, 1990, Central Bureau of Statistics.

[6] D'Hont, D. "Evolution recente dans l'utilisation des espaces de la moyenne vallee de l'Eupharate," *Actes du colleque de De Damas sur Techniques et Pratiques Hydor-agircoles Traditionalles en Domaine Irrigue*, Institut Fransaise d'Archeologie du Proche Orient (IFAPO), Damascus, 239-40.

[7] Juneid, G., "Planning Water Resources Use at the Watershed Level," *Proceedings of the Symposium on Water Resources Planning and Management*, Aleppo University, Syria, 1987, 221051.

[8] Hadid, B., "A Strategy for Developing Water Resources in Syria," *Proceedings. Workshop on Water Resources Development Strategy Under Drought Conditions*, Damascus, 1989, ACSAD, HS, 115.

[9] Juneid, op.cit., 221-52; Ministry of Irrigation, the General Organization of Al-Khabur Basin, *Lands Reclamation Project in Al-Khabur Basin*, Damascus, 1986; Ministry of Irrigation, General Organization for Lands Reclamation, *Statistical Absracts*, 1985, Damascus.

[10] Kerbe, J., *Climat, hydrologie et amenagement hydro-agricoles de Syrie*, These d'Etat, Universite Bordeaux III, 3 tomes, 1089 pp.

[11] Central Bureau of Statistics, Office of the Prime Minister, *Statistical Absracts*, 1959, 1962, 1974, 1990.

[12] Ministry of Irrigation, *Irrigation Project of the Khabur Basin* (State Economic Engineering Corporation, Sofia, Bulgaria), Damascus, 1975.

[13] Soumeh, G., "Actual Use of Al-Khabur River," *Proceedings of the Symposium on Water Resources Planning and Management*, Aleppo, 1987, 253-63.

[14] Finet, A., "Les pratiques de l'irrigation au XIII siecle avant notro ere en Mesopotamie d'apres les textes de Marie et code hamorabi," *Actes de colloque de Damas sur Techniques et Praqtiques Hydor-agricoles Traditionelles en Domaine Irrigue*, IFAPO, Damascus, 143-155; Durand, J., "Problemes d'eau et d'irrigation au royaume de Mari," Ibid., 102-42.

[15] Finet, op.cit.

---

[16] Watson, A., *Agricultural Innovation in the Early Islamic World*, Cambridge, 1983.

[17] Juneid, op.cit.

[18] Ministry of Irrigation, *Statistical Abstracts* 1985.

[19] Kolars, J., "Water Resources of the Middle East," *Canadian Journal of Development Studies* , Special Issue, Sustainable Water Resources Management In Arid Countries, 1992, 103-119.

[20] Soumeh, G., op.cit.

Water resources development plans in Syria : role of the Euphrates basin.

Dr. Wakil Mikhail

Faculty of Civil Engineering
Aleppo University , Syria

Abstract

In order to achieve socio-economical development and to face the growing food deficit, Syria, a traditionally agricultural country, is developing and executing water resources development plans in all the watershed basins. The objective of these plans is to increase the irrigated area from 650 000 ha (in 1962) to 1350 000 ha and to produce around 5000 kWH/yr . The major development plans are under-construction in the Syrian Euphrates basin (Euphrates and Khabour River basin) which covers 41% of the total area of the country and contains the largest land and water resource poetential : 65% of the total economically irrigable lands, 66% of the total water resources and 95% of the economically viable hydro-electric generation. The water resources development plans in this basin aims to increase the irrigated area from around 390 000 ha (in 1962) to 750 000 ha, of which 594 000 ha are depending on Euphrates River, and 155000 ha are located in Al-Khabour River valley. The water demands for different sectors, at full development of the irrigation projects, is estimated at 13000 million m^3/yr in Euphrates River basin and at 2140 million m^3/yr in Khabour River basin. At the completion of water resources development schemes , the water balance of the Khabour river will be completely satisfied . The water balance of the Syrian Euphrates River basin is depending on the in flow entering the basin from Turkey, which is so far, not formally defined between riparians. This situation affects seriously the water resources development in the basin. Thus , an agreement for the allocation of Euphrates water among the three riparians (Turkey, Syria and Iraq) is of primary importance for Syria which is more dependent on the Euphrates river than the others .

1. Introduction

1.1 Location and climate

Syria lies on the eastern coast of the Mediterranean sea, bounded by Turkey to the North, Iraq to the east, Jordan, Palestine and Israel to the south and by Lebanon and the Mediterranean Sea to the west. It has an area of some 185,000 Km^2.

The Mediterranean climate generally prevails in Syria. This climate is characterized by a rainy winter and a dry and hot summer, separated by two short transitional seasons.

The rainy season last between 5-6 months, ~~it begins in October~~, reaches its maximum in December and January, and ends in May.

~~From the environment point of view~~, Syria may be divided into two regions, (Figure 1):

- The arid region, which receives an average total annual precipitation less than 250 mm. This region constitutes 72% of the total area of Syria and covers the southern and the sourtheastern part of the country. It forms the natural extension of the Arabian steppe - desert. Annual precipitation declines in this region from Northwest of southeast where the mean annual precipitation is less than 100 mm .

The sub-desertic climate prevails in this region. This climate is characterized by infrequent rains and high evaporation rate which averages 2200 mm/yr . The air relative humidity is very low, ~~it varies~~ between 20-50 %, ~~during the year~~. The air temperature is very high, the average annual temperature ~~varies~~ between 19°C the north to 22°C in the south, and may reach 44°C in ~~the~~ summer.

This region ~~is not~~ suitable for rainfed agriculture; ~~and~~ any agriculture development in this area is not possible without the introduction of irrigation .

- 2) The semi-arid region ~~in which~~ the average total annual precipitation is more than 250 mm. ~~It~~ covers the rest of the ~~country, 60%~~ of this region receives less than 350 mm/yr. ~~and it mainly covers the northern plains of the country.~~ Along the coast the annual precipitation varies between 800-1000 mm.

Annual evaporation ranges between 1900 mm in northern plains and 600 mm in coastal plains . The annual average temperature is around 17.5 °C in the northern plains and 19°C along the coast.

Rainfed agriculture is traditionaly practiced in this region ~~mainly cereals~~. However, due to the high fluctuation of the annual precipitation, the risk of crop failure and ~~in~~satisfactory yield is high. ~~in this region~~ .

1.2. Land Use

Cultivable lands in Syria are evaluated at about 6.15 million hectars which corresponds to 33% of the total area of the country(Table 1) In 1990, around 91.5% of the cultivable lands was under crops, 12% of which ~~was~~ irrigated (693 000 ha) .

Table 1. ~~indicates that 53%~~ of the cultivable lands in Syria ~~is~~ located in Euphrates basin

1.3. Water Resources

Hydrologicaly, Syria may be divided into seven watershed basins, (Figure 2) . These are :

1. Euphrates basin and its sub-watershed Al-Khabour.
2. Aleppo (Kweiq and Jabool).
3. Orontes and its sub-watershed Al-Afrin.
4. Coastal.
5. Desert .
6. Damascus.
7. Horan.

The available water resources in Syria is estimated at about 23.5 billion m^3/yr , taking into account the Syrian share of the Euphrates river (13 billion m^3/yr) . Eight percent of this amount is underground water .

About 90% of the total water resources is located in three basins: Euphrates, Orontes , and the coastal basins (Table 2). The other four basins are either poor in water resource ,or experiencing deficit in their water balance as the case of Damascus and Aleppo basins [2], where most of the populated in Syria (40% of the total population) is clustered.

The Euphrates basin is the largest basin in Syria, it covering 41% of the total area of the country . Euphrates river and its tributary Al-Khabour are the major rivers flowing in Syria (Table 2).

The Orontes basin is the second largest basin , its water resource is evaluated at 2860 million m^3/yr of which around 20 % is generated in Lebanon.

The water resources of coastal basin is evaluated at 2600 million m^3/yr [2] , of which around 50% occurs as ephemeral water flow during intense winter rainfall storm. The agricultural sector is the major consumed of water. In 1990 approximately 90% of the consumed water (12 billion m^3) was used to irrigate 693000 ha [5] .

2. Water resources development plans in Syria

The main expansion in the irrigated areas realized so far in Syria, was achieved during the fifteen years that followed the independence (1945). The irrigated area has increased from 295000 ha in 1947 to 657000 ha in 1962. [1] . This rapid development is mainly due to the introduction of moto-pump combined with the raise of cotton price during the Korean war [6]. This expansion was primarly completed by private farmers and was located in the river valley plains and in low terraces of Euphrates, Khabour and Orontes river . Thus in 1962, all the low plains suitable for irrigation in river valleys was used up . Therefore any additional development in irrigated agriculture necessitated recourse to

large scale irrigation projects requiring important hydroulic works (dams , large irrigation networks...) and conducted by state agencies.

Starting, from 1963, the Syrian strategy for water resource development aimed to

1. exploitation of the main rivers for large scale irrigation projects .
2. construction of dams (surface earth dam) on epthemral flow streams and seasonal rivers in order to increase the country water resource avaiability .

Therefore since that date Syria developed plans to use the water of Euphrates, Khabour and Orontes rivers for irrigation and hydro-electricity generation: special emphasis has been placed on the construction of Tabqa dam on Euphrates river and on developing and improving the existing irrigation projects in the Orontes basin (123000 ha) [7] .

During the period 1965-1990 , about 125 small surface earth dams have been built on ephemeral streams and seasonal rivers, their total storing cpacity is evaluated at 410 million m^3 [8] .

Actually large (more than 500 million m^3), medium and small dams are under construction in the Syrian three main basins(Table 3.), their total storing capacity amounts 3.3 billion m^3. Medium and small dams having a total storing capacity of around 1 billion m^3 are planned to be built before the year 2000. So it is expected that before the end of this century, around 16 billion m^3 of water, which corresponds to 85% of the total surface water will be under storage in dam reservoir for irrigation purposes [7][9][10]. Thus, starting from the next century, 90% of the total surface water (including run- of river water) will be usable. At the completion ofall irrigation projects the irrigated area will amount some 1350000 ha .

3. Water resource development plans in Euphrates basin:

3.1. Hydrology of Euphrates basin

The Euphrates river rises in the mountains of the southern of Erzurum, south eastern Turkey, from rainfall and melting snow. It joined the Murat river, the largest tributary of Euphrates river, just upstream of the Keban dam. Below the Keban dams , it flows southward down to Karakaya damsite and Ataturk dam site in a steep slopes and narrow valley,

of Syria. At 175 Km from the border, it reaches Tabqa damsite, from (5) which it flows eastward .

In Syria, Euphrates is joined by Al-Sajur (100 million m^3/yr) and Al-Balikh rivers (190 million m^3/yr) , both of them rise from the southern slapes of Anatolian mountains (actually, theyare completely used in Turkey) and by Al-Khabour river .

One hundred kilometers downstream from its confluence with Al-Khabour, theEuphrates enters Iraq where is joined by Tigris river only 100 Km from the head of Shalt-Al-Arabs . The total area of Euphrates basin is 444000 sq.km of which 25% lies in Turkey , 17% in Syria, 40% in Iraq and 5% in Saudi Arabia .

The main discharge of Euphrates river at its entrance Syria (Yousef Basha Hydro metric station) is 998 m^3/sec,(average of period 1950-1069) [3] , this value diminishes progressivelyalong its water course primarily as a result of infiltration and evaporation from water surface and underground water along the river bank, thus its mean discharge at Deir -ElZor is 735 m^3/sec [1](average of the period 1930-1955).

Al-Khabour river is the largest tributary of the Euphrates river outside Turkey. It stems up from the Taurus Mountain in Turkey , though they springs of Ras El Ain are its major sources. The Khabour river basin is covering an area of 31700 km^2 of which 32.6% is in Turkey, 62.3% is in Syria and 5,1 % in Iraq. Before Hassakeh , Khabour is joined by Al-Rad river which has Jagh -Jagh river as a main confluent (200 million m^3/yr) (completely used by Turkey during summer).

The flow of Al-Khabour river is relatively stables along the year, months. Its mean natural discharge at Saouar station (81 km from its confluence with Euphrates) is 59.5 m^3/sec (average of the period 1956-1975) [4] . Recently there were some indications, that during summer, the discharges of Ras El-Ain springs diminished from 6-10 m^3/sec.which is attributed to pumping from the springs acquifer in Turkey [11].

3.2. History of water usage in Euphrates basin

The use of Euphrates river for irrigationin Syria dated since more than 6000 years. The political and socio-economical organisation development of the first ancient Kingddms of middle and low Euphrates

in Syria was relied in a well developped hydro-agricultural system. The Amorites civilisation which is contemporary to the Sumarian and Babilonian civilisation in low Mesopotamia (Mari Kingdom, 4000 -1500 B.C) has developped irrigation systems in several locations on the Euphrates river (Mari, Terga) [12] and on its tributaries Al-Balikh and Al-Khabour [13] . Aramean (Aram Nahrein Kingdom) and assyrian (1000 B.C) has acheived important hydraulic works in Al-Khabour basin (Daurin Canal) and Al-Balikh basin[12]. During the Romain era several communities has florished in Euphrates valley : Dora-Europos Pales, Serjio-Polis .... A major agricultural innovation has been acheived during the Arabo-Islamic era : the adaptation,in this semi - amid area, of tropical plants (cotton, rice, sorghum...) [14]. This has lead to the intensification of irrigation and to the excution of large- scale irrigation systems . In the XVII century, some hydraulic water lefting machines have been developped in the basin : the nasbe and later the gharraf .

The introduction of moto-pump after World-War II has lead to a rapid development of the irrigation agriculture in the basin. Thus the irrigated area has increased from 175000 ha , in 1947 , to 390000 ha in 1962 , of which 322000 ha were in Euphrates valley, [1] which consumed around 4 billion m^3/yr.

3.3. Development objectives :

Syrian Euphrates basin possess the largest potential for agricultural and economical development in the country. In fact, 65% of the total Syrian economically irrigable lands , (Table 3), 66% of the Syrian water resources and 95% of the hydro-electric generation potential, are located in Euphrates basin.

The water resource development plans in Euphrates basin envisages the construction of 6 dams on Euphrates and Khabour rivers. It is planned that at full development over than 750000 ha of land will be irrigated, which correspond to approximately 50% of the total economically irrigable area in Syria , and around 4500 million kWh of hydro-electric energy will be

produced which represents 95% of the Syrian economically viable hydropower potential .

The implementation of irrigation projects in Euphrates basin will increase the actual cropping entensity from 80% to 135% . A new cropping pattern / rotation will be applied, containing new crops: corn, alfalfa .... Thus, the actual gross agricultural production of the area will be increased by more than 4 times. This will help in reducing the country food deficit which is increasing steadily. (for example the imported wheat and wheat flour has increased from 220 000 tons in 1961 to 1436 000 tons in 1990). In addition the agricultural development of the area will promote manufacturing agro-related industry such as : cotton related industry, edibee oil, vegetable and fruit processing, milk processing .....As a result the employment opportunity will increase. It is expected that at the completion of the irrigation projects the population of the Euphrates basin will increase by 3 million inhabitants [10] .

3.4. Euphrates river development plans :

Syria began to develop plans to utilize Euphrates river water soon after its independence (1945) . In 1947 , Syria signed an agreement with a British Engineering Company (Alexander Gibb) in order to study " the possibility for exploiting Euphrates river water ". An hydro-electric dam was proposed at Youssef Basha (8 km south of the Turkish border, at the actual site of Tishrin dam). Later , in 1957 and 1958, Syria signed two agreements with the Soviet Union to carry out designs for the construction a multi-purpose dam at Halabia-Zalabia. Four years later, a Swidish Company (V.B.B.) and a German Company (Lahmayer) have carried out engineering design for the construction of a dam at Tabqa site. In 1966 the Syrian government signed a new agreement with the Soviet Union for the designing and financing the construction of " Storing earth dam " at Tabqa dam which was completed at 1975.

Development plan components

The development plans of the Euphrates river in Syria consist of the construction of three dams (table 5) . Two of them are yet constructed : Tabqa dam (a multi-purpose dam) and Al-Bath dam (a flow regulator dam) . The third dam, Tishren dam, a hydro-electric generating dam, is under construction. Tabqa dam which is the largest, aims to produce 1.9 billion kWh/yr which will be increased to 2.5 billion kWh/yr in a second stage after raising the dam crust by 20 m , and to irrigated 594000 ha divided into seven irrigation projects (table 6) . Additional 124000 ha could use irrigated if needed water could be available. Tishrin dam aims to produce 1600 kWh/yr.

Future Water demands

At the completion of the planned irrigation projects which is expected to be at the year 2010 , the water demand for different sectors in Euphrates river basin is estimated at 12970 million m^3/yr . The bulk of it, 10100 million m^3/yr , will be consumed by the irrigation sector (at an estimated rate of 17000 m^3/ha) .

The municipal sector in the basin and in Aleppo city which relies on Euphrates river water for its water supply, will use 710 million m^3/yr. Queik river (200 million m^3/yr) which once supplied the city is completely exploited by Turkey during summer. So, it expected that by the year 2010 around 7.8 millions inhabitants will reley on Euphrates water for their water supply. Water consumption of the industrial sector is evaluated at 300 million m^3/yr.

In the absence of formal agreement between riparians regarding the allocation of Euphrates river water, it is not possible to establish an accurate water balance of the Syrian Euphrates river basin. However, taking into consideration Kolars estimation [15] (21600 million m^3/yr) of the GAP project water needs (Great Anatolian project) in Turkey, the water balance of the Syrian Euphrates river basin could be (at the completion of GAP project) in a critical situation.

3.5. Khabour river development plans :

Since, 1950, Syria formulated plans to use Khabour river water [11]. In 1975 Syria has signed an agreement with Bulgaria to conduct " studies and engineering designs for irrigation projects in Al-Khabour basin". The executing works started in 1985.

Development plans components :

Actual development plans in Khabour river envisages the construction of three dams devoted mainly for irrigation purposes (Table 7) . The total planned irrigated area is evaluated at 154000 ha. Two dams are yet constructed while the largest, Al-Khabour dam, which is located south Hassakeh, is actually under construction. The main objective of these dams is to store Khabour water during autumn and winter seasons,where demand is low for irrigation water, in order to use it later in spring and summer. The installed capacity in the three dams amounts 24 MW.

Future water demands :

Total water demands, at the completion of the irrigation networks which is expected to be by the year 2010, are estimated at 2140 million m^3/yr . The irrigation sector will use 2000 million m^3/yr (at a rate of 13000 m^3/ha for a cropping intensity of 110%). The domestic and municipal sector will consume 106 million m^3/yr , the population of Khabour valley is estimated at around 1.45 million inhabitants by the year 2010. The consumption of the industrial sector is estimated at 40 millions m^3/yr.

Table (8) gives the expected future water balance of Al-Khabour river. It indicates that at the full completion of the planned irrigation project , 95 % of water resources of Khabour river will be consumed.

Conclusion :

The water resources development plans in Syria , which has a limited water resources, relied mainly on the Euphrates river : around 50% of total planned irrigated area and 95% of the projected hydro-electric production are located in Euphrates basin. So far, no formal agreement between the three riparians regarding the allocation of Euphrates water is reached, this constitutes a major problem for the syrian economical development plans. At the present time, Turkey is projecting and executing large scale irrigation and hydropower projects: The GAP (Great Anatolian Project) which, at its full development may consume 60% of the annual Euphrates discharge.

Thus at this stage, where Turkey, Syria and Iraq are formulating large scale water resources schemes, it is of primary importance for the three riparians to reach a just and fair water allocation among them. Cooperation between riparians is needed also to face the serious water pollution problem (salinity and nitrate pollution) of both the Euphrates river and the common acquifer, which will result from the wide introduction of irrigated agriculture in the Euphrates basin. Syria and Iraq will mostly be affected by this pollution.

REFERENCES

[1] Stalistical abstracts , 1974,1959,1962, 1990. Central Bureau of statistics, office of the Prime Minister , Syrian Arab Republic .

[2.] Georgian State Institute for Design of Water Resources Developments Projects, Tbilisi 1982. Sheme of water resources in four areas of the Syrian Arab Republic . Ministry of Irrigation Damascus , Syria .

[3] Kerbe J.,1980 . Climat, hydrologie et amenagement hydro-agricoles de Syrie, These d'Etat, Université Bordeaux III, 3 tomes, 1089p.

[4] State Economic Engineering Corporation, Sofia, Bulgaria , 1975. Irrigation project of Khabour Basin, Ministry of Irrigation, Damascus , Syria .

[5] Wakil M., 1992 Analysis of future water needs for different sectors in Syria ,under publication, Water International, Spring issue .

[6] D'Hont D., 1990. Evolution récente dans l'utilisation des espaces de la moyenne vallée de l'Euphrate. Acte du colleque de Damas sur : " Techniques et Pratiques hydro-agricoles traditonnalles , en domaine irrigué " p. 239-240 , IFAPO (Institut Francaise D'Archéologie du Proche Orient), Damas .

[7] Juneid G., 1987. Planning water resources use on the watershed level. Symposium on " Water resources planning and management" roceedings , p. 221-251 , Aleppo University, Syria .

[8] Hadid B., 1989. Strategy for developing water resources in Syria. Workshop on " Water resources development strategy under drought conditions ", ACSAD, HS/D.115, Damascus , Syria .

[9] General Organisation of Al-Khabour Basin, 1986, lands reclamation project in Al-Khabour basin, Ministry of Irrigation, Damascus, Syria .

[10] Statistical abstracts, 1985, General organisation for lands Reclamation, Ministry of irrigation, Damascus, Syria.

[11] Soumeh G., 1987. Actual use of Al-Khabour river. Symposium on " Water resources planning and management " proceedings, p. 253-263 , Aleppo University, Syria .

[12] Finet A., 1990. Les pratiques de l'irrigation au XIII siecle avant notre ère en Mesopotamie d'après les textes de Marie et code de Hamorabi . Acte de colloque de Damas sur "Techniques et pratique hydro-agricoles traditionnelles en domaine irrigué" p. 143-155, IFAPO , Damas, Syrie .

[13] Durand J., 1990. Problemes d'eau et d'irrigation au royaume de Mari. Acte de colloque de Damas sur " Techniques et pratiques

hydro-agricoles traditionnelles en domaine irrigué ",
p. 101-142 , IFAPO , Damas, Syrie .

[14] Watson A. , 1983. Agricultural innovation in the early Islamic World . Cambridge University Press, Cambridge, 200p.

[15] Kolars J., 1992 . Water resources of the Middle East. Canadian Journal of Development Studies, Special issue , Sustainable water resources management in arid countries, p. 103-119.

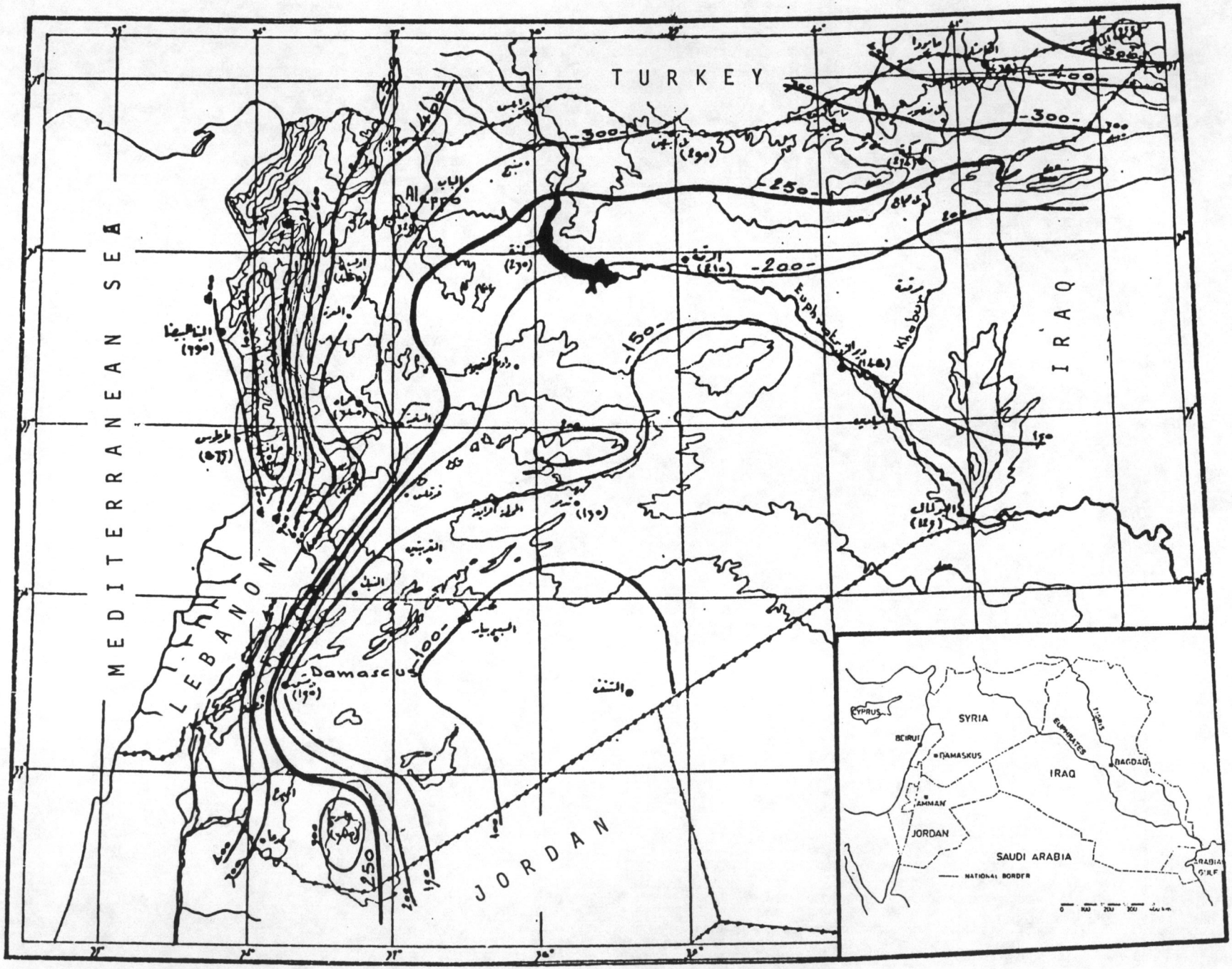

Figure 1. Isohyetal map.

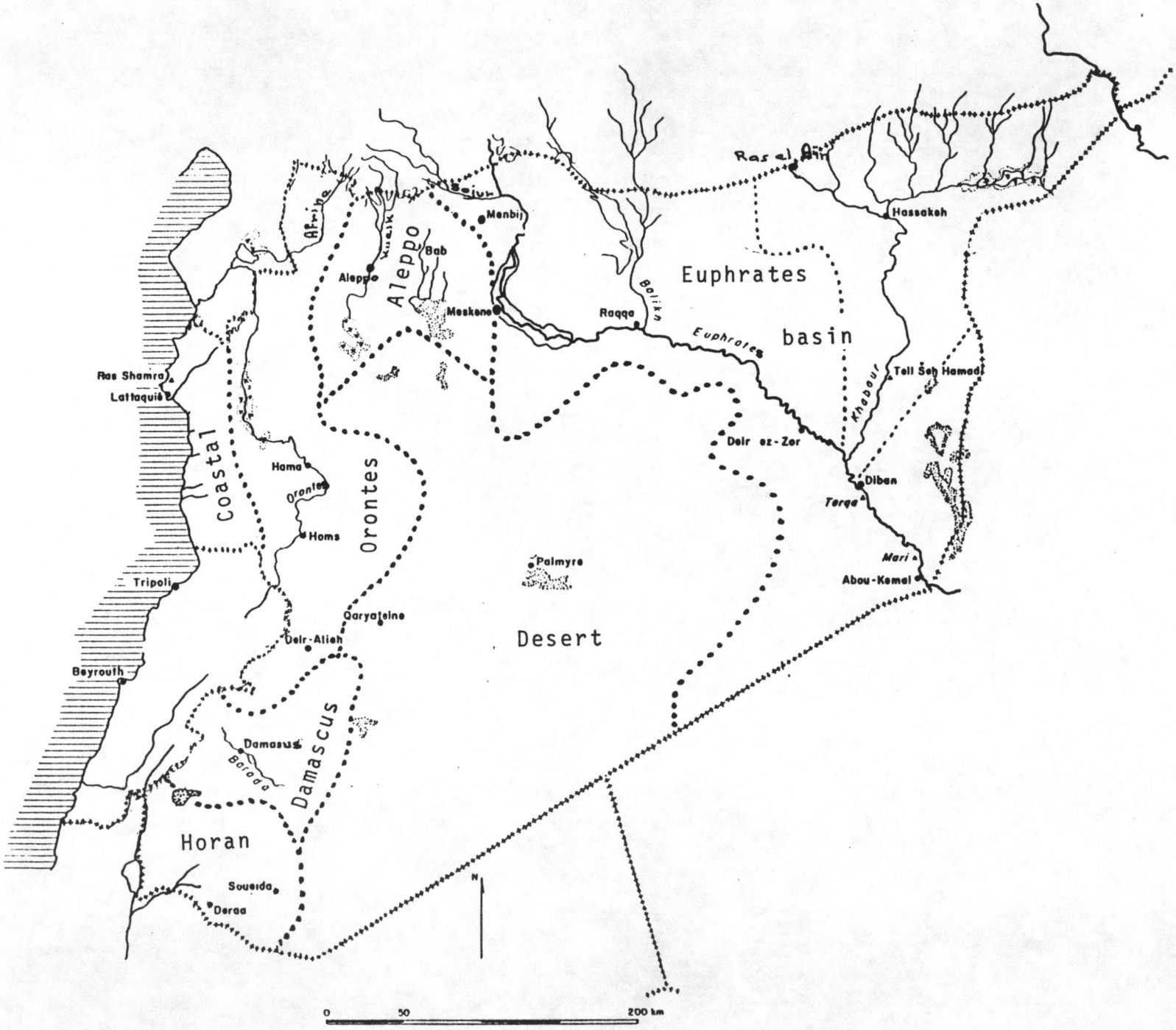

Figure 2. Hydrological basins in Syria .

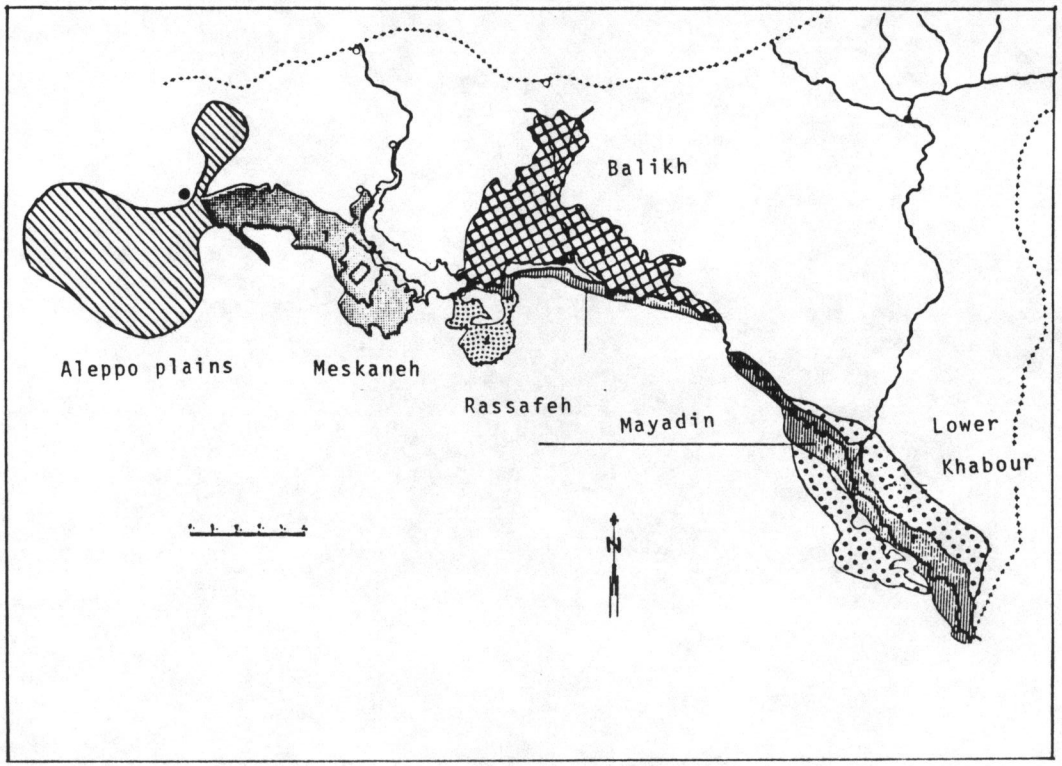

Figure 3. Planned Irrigation Projects in Euphrates river basin.

Table 1. Cultivable lands and land uses in Syria, 1990.(thousand ha)

	Syria	Euphrates basin
cultivable lands	6149	3273
cultivated		
- Irrigated	693	348
- Rainfed	4773	2762
- Follow	150	15
Uncultivated	528	152
Uncultivable lands	3777	910
Steppe and pastures	7869	3237
Fanests	723	185
Total	18518	7609

Source : Statistical abstracts (1990)

Table 2. Water resources in Syria (Million m^3/yr)

basin	Surface flow	Ground water
Euphrates river	31500*	300
Al-Khabur (sub-basin)	2065	500
Orontes	2509	356
Coastal	2386	236
Others	1985	646

Source : [2] , [3] , [1]

* At its entrance in Syria of which 13000 million m^3/yr is assumed Syrian share .

Table 3. Actual situation of water resources in Syria, 1990

(million m^3/yr)

Ground water	2030
Spring run-off	2260
Surface water :	
- Stored in dam reservoirs	13415*
- To be stored in dam reservoirs	
- Under construction	3367**
- Planned	873
- Run of - rive (direct use)	1009
- Non stored	2449

Source : [7] , [8] , [9] , [10] .

* Including Tabqa dam 11900 million m^3.

** Including Tishrin dam (hydro-electric dam) , 1800 million m^3

Table 4. Economically irrigable lands in Syria , 1990 (ha).

Basin	Irrigable	Irrigated(1990)
Euphrates river basin	729	197
Khabur sub-basin	260	151
Qrontes	237	156
Coastal	67	52
Damascus	82	75
Others	103	62
Total	1478	693

Source : [2] , [4] , [10] .

Table 5. Development plans of Euphrates river basin .

Dam	Storing capacity million m^3	Irrigations ha	Installed capacity MW
Tabqa	11900	594000	800
Al- Bath	90	-	75
Tishrein	1800	-	630
Total	13790	594000	1505

Source : [10]

Table 6. Irrigation projects in the Euphrates river basin .

Projects	Area (ha)
Al-Balikh	141000
Euphrates valley	152000
Meskaneh	84000
Aleppo	82000
Rassafeh	25000
Lower Khabour	70000
Mayadin	40000
Total	594000

Source : [10]

Table 7. Development plans of Khabur river basin.

Dam	Storing capacity million m^3	Irrigated areas ha	Installed capacity, M W
Main canal	-	52345	-
West Hassakeh	91	53195	12
East Hassakeh	232	-	4
Al-Khabour	665	48200	8
Total	988	153740	24

Source : [9]

Table 8. Estimated water balance of Khabour river at the completion of irrigation projects .

	Inflow million m^3/yr	Outflow million m^3 / yr
River natural flow	1955	
Underground water*	200	
Municipal		106
Irrigation		1998
Industrial		40
Evaporation losses		210
Return flow	300	
Total	2465	2354

* Ras El-Ain region .

August 4, 1993

FAX NO. 215 898 5756

ATTN: PROFESSOR THOMAS NAFF
SCHOOL OF ARTS AND SCIENCES
847 Williams Hall
Univ. of Pennsylvania, USA

Dear Professor Naff,

I refer to your fax of July 5, the sentence on page 5 should be as follows:

The flow of Al-Khabour river is relatively stables along the year, months. Its mean "natural " discharge at Saouar station (81 km from its confluence with Euphrates) is estimated at 59.5 m^3/sec (average of the period 1956-1975 [4] . Recently there were some indications, that during summer, the discharges of Ras El-Ain springs flow is diminished by 6-10 m^3/sec of its normal discharge which is attributed to pumping from the springs acquifer in Turkey. [11].

Regarding the tables 1,2,4,5, and the map, please send me a copy of them by fax so I can make the requested corrections.

You can fax to (514) 374-8110 or call me to (514) 731-4333

Best regards

M. Wakil

Dr. Mikhail Wakil

Dear Professor Naff.

Please do the necessary editorial corrections.
I didn't receive the list of publication
you need from AESAD.
In January, I will be in Montreal, I
will contact you,

Thank you. Nov/5/1992.

Walter Michel
M. Walter