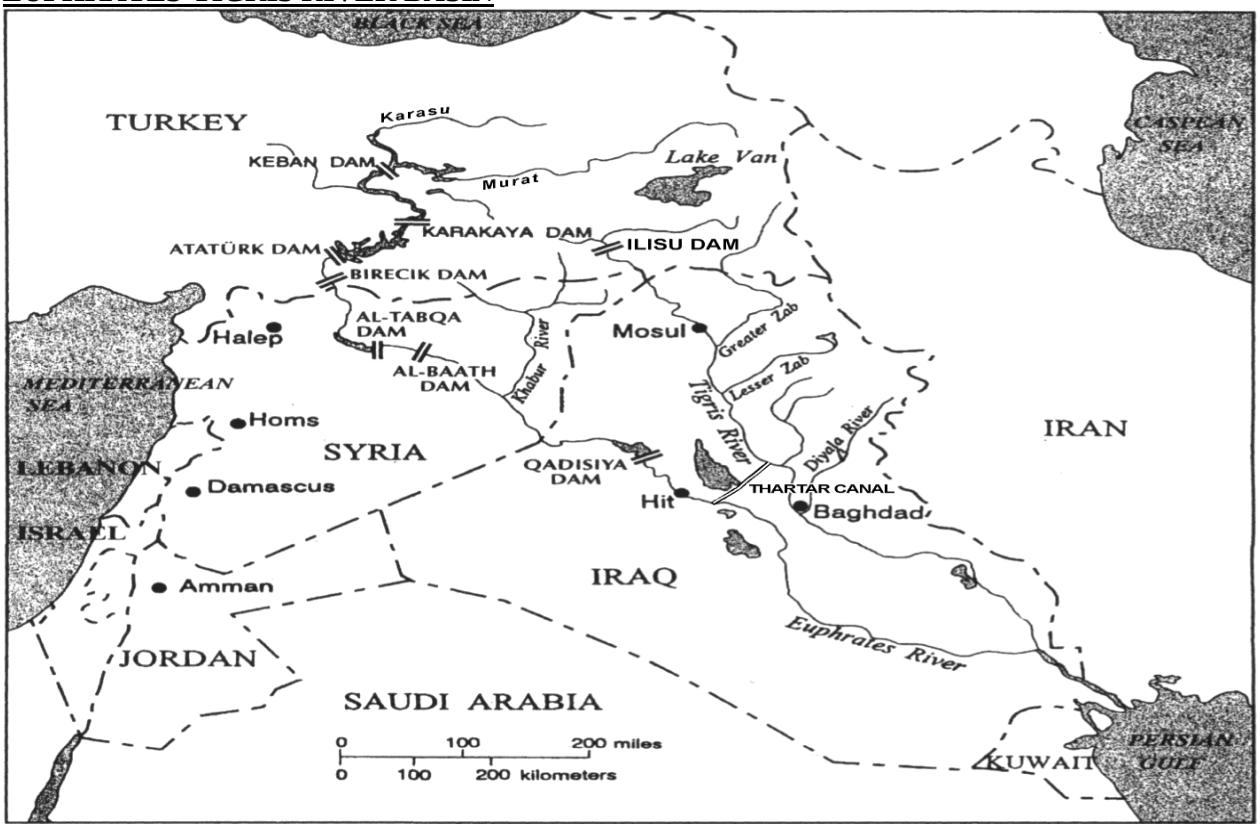
EUPHRATES-TIGRIS RIVER BASIN



Source: A. Kibaroglu et al. (2005)

1. Physical and Human Geography

A. Rivers and Tributaries (Surface Water)

The two greatest rivers of the Eurasian landscape, namely the Euphrates and the Tigris originate in a particular climatic and topographic zone (i.e., Turkey) and end up in quite a different one (i.e., Persian Gulf). The basin is characterized by high mountains to the north and west and extensive lowlands in the south and the east. They begin, scarcely 30 kilometers (km) apart from each other, in a relatively cool and humid zone with rugged 3 000 meter (m) high mountains, visited by autumn and spring rains, and winter snows. From there, the two rivers run separately onto a wide, flat, hot, and poorly drained plain. They continue more tranquilly through the plateaus of northern Syria and Iraq, where they cut deep beds in rocks so that their courses have remained stable over the millennia. In their middle courses, they diverge hundreds of kilometers apart, only to meet again near the end of their journey and discharge together into the Persian Gulf. In that section they descend from elevations of about 400 m to little over 50 m above sea level where they enter the alluvial plain. The great alluvium-filled depression, Shatt Al-Arab, the combined area of the lakes and swamps has a length of 180 km and constitutes the combined delta of the Euphrates-Tigris river basin.

In conformity with the expert judgments of geographers, the Euphrates and the Tigris rivers can be considered as forming one single transboundary watercourse system. They are linked not only by their natural course when merging at the Shatt Al-Arab, but also as a result of a man-made Thartar Canal which links the Tigris to the Euphrates through the Thartar Valley in Iraq.[1]

[1] A. Kibaroglu (2002) *Building a Regime for the Waters of the Euphrates-Tigris River Basin*, London, The Hague, Kluwer Academic Publishers.

Euphrates

The Euphrates originates in the eastern highlands of Turkey, between Lake Van and the Black Sea, and is formed by two major tributaries, the Murat and the Karasu. It enters the Syrian territory at Karkamis, downstream from the Turkish town of Birecik. It is the joined by its major tributaries, the Balik and Khabur, which also originate in Turkey, and flows southeast across the Syrian plateaus before entering the Iraqi territory near Qusaybah.

Of the Euphrates Basin 28 percent lies in Turkey, 17 percent in Syria, 40 percent in Iraq, 15 percent in Saudi Arabia, and just 0.03 percent in Jordan. The Euphrates river is 3 000 km long, divided between Turkey (1 230 km), Syria (710 km), and Iraq (1 060 km).[2]

Tigris

The Tigris, also originating in eastern Turkey, flows through the country until the border city of Cizre. From there it forms the border between Turkey and Syria over a short distance and then crosses into Iraq at Faysh Khabur. The Tigris river is 1 850 km long, with 400 km in Turkey, 32 km on the border between Turkey and Syria and 1 418 km in Iraq. Of the Tigris Basin 12 percent lies in Turkey, 0.2 percent in Syria, 54 percent in Iraq and 34 percent in Iran.

Within Iraq, several tributaries flow into the river coming from the Zagros Mountains in the east, thus all on its left bank. From upstream to downstream there are:

- Greater Zab, which originates in Turkey. It generates 13.18 billion cubic meters (BCM)/year at its confluence with the Tigris; 62 percent of the total area of this river basin of 25 810 km^2 is in Iraq;
- Lesser Zab, which originates in Iran and which is equipped with the Dokan Dam (6.8 BCM). The river basin of 21 475 km^2 (of which 74 percent is in Iraqi territory) generates about 7.17 BCM/year, of which 5.07 BCM of annual safe yield after construction of the Dokan Dam;
- Al-Adhaim or Nahr Al Uzaym, which drains about 13 000 km^2 entirely in Iraq. It generates about 0.79 BCM/year at its confluence with the Tigris. It is an intermittent stream subject to flash floods;
- Diyala, which originates in Iran and which drains about 31 896 km^2, of which 75 percent in Iraqi territory. It is equipped with the Derbendi Khan Dam and generates about 5.74 BCM/year at its confluence with the Tigris;
- Karkheh, the main course of which is mainly in Iran and which, from a drainage area of 46 000 km^2, brings about 6.3 BCM yearly into Iraq, namely into the Hawr Al Hawiza during the flood season, and into the Tigris River during the dry season.[3]

The Shatt Al-Arab is the river formed by the confluence downstream of the Euphrates and the Tigris and it flows into the Persian Gulf after a course of 180 km. The Karun River, originating in Iranian territory, has a mean annual flow of 24.7 BCM and flows into the Shatt Al-Arab just before it reaches the sea, bringing a large amount of freshwater.

The mean annual flow of the Euphrates is 32 BCM/year of which about 90 percent is drained from Turkey, whereas the remaining 10 percent originates in Syria. As for the Tigris, the average total discharge is determined as 52 BCM/year, of which approximately 40 percent comes from Turkey, whereas Iraq and Iran contribute 51 percent and 9 percent, respectively. Estimates for the total flow of the Tigris-Euphrates and their tributaries vary between 68 BCM and 84.5 BCM.

[2] *See* FAO (2008) *Water Reports 34, Irrigation in the Middle East Region in Figures*, Aquastat Survey.
[3] Ibid.

Euphrates Basin area: 444,000 km^2; mean annual discharge 32 BCM		
Riparian position	**Basin area (percent of total) Contribution to annual discharge**	**Main water uses**
Turkey upstream	146,520 km^2 (33 percent) 28.922 BCM (90 percent)	irrigation, hydropower, flood control
Syria downstream	84,360 km^2 (19 percent) 3.213 BCM (10.0 percent)	irrigation, hydropower
Iraq downstream	204,240 km^2 (46 percent) 0.0 BCM (-)	Irrigation, hydropower, inhabitants of marshes

Tigris Basin area: 387,000 km^2; mean annual discharge 52 BCM		
Riparian position	**Basin area (percent of total) Contribution to annual discharge**	**Main water uses**
Turkey upstream	46. 512 km^2 (12 percent) 20.840 BCM (40 percent)[4]	irrigation, hydropower
Syria - border with Turkey / Iraq	776 km^2 (0.2 percent) --	
Iraq downstream	209.304 km^2 (54 percent) 26.571 BCM (51 percent)	irrigation (diverts water through Tharthar Canal to Euphrates), hydropower
Iran - upstream on one tributary	131.784 km^2 (34 percent) 4.689 BCM (9 percent)	Irrigation, hydropower

[4] According to some other publications such as http://www.fao.org/nr/water/aquastat/basins/euphrates-tigris/index.stm: Turkey provides 51 percent, Iraq 39 percent, and Iran 10 percent of the annual water volume of the Tigris.

B. Groundwater[5]

In riparian countries, groundwater is mainly used for irrigation and is supplied from wells which far exceed the officially approved number.[6] Turkey and Syria share a transboundary groundwater resource system, namely the Ceylanpinar aquifer and Ras El Ain karstic springs which are found in the Urfa-Harran and the Ceylanpinar plains in south-eastern Turkey and in the Lower Balikh and Lower Khabour basins in Northern Syria. The Ceylanpinar aquifer is a karstic carbonate aquifer. The Khabour river, a tributary of the Euphrates, is fed by the Ras El Ain springs which receive their main discharge from groundwater resources in the Ceylanpinar-Harran-Sanliurfa plains in Turkey. The Ras El Ain karstic springs have an average discharge of 38.66 m^3/s. In other words, precipitation that falls in Turkey is a major source of the aquifer's recharge. According to a World Bank study, "rapid groundwater extraction both in Turkey and in Syria from the transboundary aquifer system (i.e. Ras El Ain) has reduced the spring flow discharges to the (Khabour) river [...] Overuse has caused a decline of the flow rate from a long-term average of 50 m^3/s to a few m^3/s at present and down to zero during drought years, as in 2000."[7]

C. Population

The waters of the Euphrates and Tigris stand to be significant and strategic for the major riparians: **Iraq** derives the majority of its fresh water from the two rivers. Although the Euphrates basin is one of seven river basins in **Syria**, it is strategically the most important because of its existing and potential uses for agricultural and hydropower purposes. The Euphrates-Tigris (ET) basin is one of 25 basins in **Turkey**, but accounts for nearly one third of the country's surface water resources and one fifth of its irrigable land. Hence, when "population" is considered one should not focus only on the population living in the basin but should also consider population projections and growth rates at the country level simply because of the fact that benefits from water resources development in the basin, that is to say, hydropower generation and agricultural development, turn out to be benefits created for most of the nation.

From the 1940s to the present day the population in all of the riparian countries have increased by three to five-fold, and by 2025, in the cases of Iraq and Syria, they are likely to be double again. Even in Turkey almost 2 percent annual growth rate is postulated, especially in southeast (Euphrates-Tigris basin) Turkey, where some provinces (e.g. Diyarbakir and Sanliurfa) are expanding at the fastest rate.

On the other hand, the survey by the ESCWA-BGR calculates that "the overall ET basin is home to around 54 million people in Iran, Iraq, Syria and Turkey.[8] The Euphrates Basin has an estimated population of about 23 million, of which 44 percent (10.2 million) lives in Iraq, 25 percent (5.69 million) in Syria and 31 percent (7.15 million) in Turkey.[9] The Tigris Basin comprises a total population of

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[5] For further information on the hydrogeology of the basin *see* UN-ESCWA and BGR, "Chapter 1 Euphrates River Basin", *Inventory of Shared Water Resources in Western Asia* (2013) p. 61. http://waterinventory.org/sites/waterinventory.org/files/chapters/Chapter-01-Euphrates_River-Basin-web_0.pdf Also, *see* UN-ESCWA and BGR, "Chapter 3 Tigris River Basin", *Inventory of Shared Water Resources in Western Asia (*2013) p. 112. http://waterinventory.org/sites/waterinventory.org/files/chapters/Chapter-03-Tigris_River-Basin-web_0.pdf

[6] A. Kibaroglu, Klaphake A, Kramer A, Scheumann W, Carius A (2005) *Cooperation on Turkey's transboundary waters*. Research report, German Federal Ministry for Environment, Nature Conservation and Nuclear Safety, Berlin.

[7] World Bank (2001) *Syrian Arab Republic Irrigation Sector Report*. Report No. 22602-SYR. Washington, D.C.: Rural Development Department, Water, and Environment Group, World Bank.

[8] *See* UN-ESCWA and BGR, "Chapter 1 Euphrates River Basin", *Inventory of Shared Water Resources in Western Asia (*2013) p. 54. http://waterinventory.org/sites/waterinventory.org/files/chapters/Chapter-01-Euphrates_River-Basin-web_0.pdf Also, *see* UN-ESCWA and BGR, "Chapter 3 Tigris River Basin", *Inventory of Shared Water Resources in Western Asia* (2013) pp. 108-109. http://waterinventory.org/sites/waterinventory.org/files/chapters/Chapter-03-Tigris_River-Basin-web_0.pdf

[9] The ESCWA-BGR study compiled that information through the sources:
(a) The population estimate for the area of the basin situated in Turkey is based on a 2010 census and includes populations living in the Turkish provinces of Adiyaman, Agri, Bingol, Elazig, Erzincan, Erzurum, Gaziantep, Malatya, Mardin, Mus, Sanliurfa, Sivas and Tunceli (Turkstat, 2010).
(b) The population estimate for the area of the basin located in Syria is based on a 2010 assessment and includes populations living in the Syrian governorates of Aleppo, Deir ez Zor, Hama, Hasakah, Homs and Raqqah (Central Bureau of Statistics in the Syrian Arab Republic, 2005).

approximately 23.4 million inhabitants, of which more than 18 million live in Iraq, 1.5 million in Iran and 3.5 million in Turkey. Only 50,000 people reside in the Syrian part of the basin.[10]

D. Land Use

More than 90 percent of the river basin is classified as arid land. Forests cover 1.2 percent of the total land area (more than 900,000 km2), while agricultural crops cover 25.4 percent and grasslands 47.7 percent.[11] Forests were once more dense and widespread, but centuries of exploitation – aggravated by environmental and economic conditions and a history of conflict – have decreased their extent and affected their composition. Fifty endemic tree species are under threat of extinction. Deforestation is also having an impact on the quality of water flowing through the watershed or stored in the water table.[12]

E. Economy

Following struggles for independence and liberation, and nation-building efforts in the first half of the twentieth century, the major riparians of the ET basin further consolidated their regimes after the 1960s, and they paid more systematic attention to socioeconomic development based on large scale water and land resources development which eventually brought them in odds with each other in the regional context.

Turkey had long been dependent on oil imports. Having been hard hit by the oil crises of the 1970s, the government embarked on a program of indigenous resource development, with particular emphasis on hydropower, with the aim of minimizing the national economy's dependency on imported oil. In this context, Turkey implemented the Lower Euphrates Project, initially a series of dams designed to increase hydropower generation and expand irrigated agriculture. Subsequently, in the late 1970s, the Lower Euphrates Project evolved into a larger, multi-sectoral development project, taking in the Tigris waters as well and known as the Southeastern Anatolia Project (GAP, its Turkish acronym), which included 21 large dams, 19 hydropower plants and irrigation schemes extending to 1.7 million hectares of land.

The **Syrian** economy has traditionally been dominated by agriculture. Exploration for oil did not begin until the early 1980s. Even though oil made a significant contribution to export earnings in the following decades as world oil prices fluctuated, Syria focused on agricultural development with the aim of achieving food self-sufficiency. These considerations were reinforced by political goals, which, under the ruling Baath Party, placed the emphasis on the development of rural areas and the organization of peasants as a political power base. Hence, in this context, Syria launched the Euphrates Valley Project under the Baath Party. The government set a number of objectives to be met by the Project: irrigation of an area as large as 640,000 hectares, construction of the large, multi-purpose Tabqa or Al-Thawra Dam to generate the electricity needed for urban use and industrial development, and regulation of the flow of the

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(c) The population estimate for the area of the basin situated in Iraq is based on a 2009 assessment and includes populations living in the Iraqi provinces of Anbar, Babil, Karbala, Najaf, Ninewa, Qadisiyah and Muthanna (Central Organization for Statistics in Iraq, 2010).

[10]The ESCWA-BGR study compiled that information through the following sources:

(a) The population estimate for the area of the basin situated in Turkey is based on a 2010 census and includes populations living in the Turkish provinces of Batman, Diyarbakir, Hakkari, Siirt, as well as parts of the provinces of Bitlis, Mardin and Van (Turkstat, 2010).

(b) The population figures for the area of the basin situated in Syria is based on a 2010 estimate and only covers parts of Hasakah Governorate (Central Bureau of Statistics in the Syrian Arab Republic, 2005).

(c) The population figures for the area of the basin located in Iraq is based on a 2009 estimate and includes populations living in the following governorates: Arbil, Baghdad, Diyala, Dahuk, Kirkuk and Sulaymaniyah. Parts of Basrah, Maysan, Ninewa, Salah ad Din and Wasit Governorates are also included . (Central Organization for Statistics in Iraq, 2010).

(d) The basin population estimate for Iran's share of the Tigris Basin is based on a 2006 assessment and includes populations living in the province of Ilam, and parts of Kermanshah and Kurdistan Provinces (Statistical Center of Iran, 2006).

[11] *See* FAO (2007) People, forests and trees in West and Central Asia: outlook for 2020. Main report of the Forestry Outlook Study for West and Central Asia. FAO Forestry Paper No. 152. Rome.

[12] H.M. Kangarani and Shamekhi T. (2007) "Policy proposals for integrating forest, water and people in the Tigris and Euphrates watershed" *Unaslyva, an International Journal of Forestry and Forest Industries*, FAO, Vol 58, No.4, pp. 30-33.

Euphrates to prevent seasonal flooding.[13] At that time, Syria focused almost exclusively on the Euphrates, prioritizing the completion of the Euphrates Valley Project. As Syrian technocrats eventually encountered technical and social difficulties in reclaiming land in the Euphrates Valley, their attention turned to north-eastern Syria in the late 1990s, where it was possible to expand the amount of irrigated land with the waters to be pumped from the Tigris.

Since 1958, **Iraq** has changed from being mainly an agricultural country exporting wheat, rice and other crops to an oil-producing, semi-industrial nation forced to import most of its own food. Yet after the Iraqi government nationalized the oil companies in 1972 and began to receive more income from oil, the focus also turned to agricultural production. This led to an expansion of irrigated areas, with the aim of achieving food security for the Iraqi people. The Baath Party, which came to power under Saddam Hussein's presidency in 1968, adopted the slogan "food security for the Iraqi people," which was to be accomplished through the development of irrigation. To that end, the "Revolutionary Plan" was developed. The Higher Agriculture Council, attached to the presidency, the Soil and Land Reclamation Organization, attached to the Ministry of Irrigation, and many other new departments were established to carry out studies, to create designs and to construct and maintain water projects.

In contemporary context, Turkey's largely free-market economy has been growing steadily (9 percent with $789.3 billion GDP in 2012) despite the drop in the last couple of years. On the other hand, its dependence on imported oil and gas continues in enormous rates (97 percent) to meet its energy needs. Thus water resources development for hydropower and other purposes particularly in the ET basin still stands as a strategic objective. Despite the severe domestic security as well as structural problems, Iraqi economy has grown significantly (8.4 percent with $209.6 billion in 2012) in the last decade. Thus, Iraqi (both central and regional-KRG) governments are eager to continue water resources development in the ET basin. Despite modest economic growth ($64.7 billion in 2011) and reform prior to the outbreak of unrest, Syria's economy continues to suffer the effects of the ongoing conflict that began in 2011. The economy further contracted in 2012 because of international sanctions and reduced domestic consumption and production, and inflation has risen sharply. Hence, it is expected that once the peace is restored in Syria urgent attention will need to be paid to the efforts of reconstruction and rehabilitation of existing domestic water supply and sewage systems as well as irrigation and energy infrastructure possibly delaying further expansion and development in the ET basin.

2. Hydrology

A. Hydrological characteristics (pre- and post engineering)

From their headwaters to the confluence, the discharge patterns of both the Euphrates and Tigris exhibit remarkable dynamics that reflect contribution of runoff from hydrologically different regions, diversion of irrigation water, natural distributaries in the lower parts of the basin and, more recently, the attenuation of the hydrological regimes due to embankment dams that have been built in the main streams and some of their tributaries.[14] Historically, runoff in the rivers had been characterized by pronounced spring floods. These floods had both positive and negative implications. They fertilized agricultural land with sediments from the upper catchment. They also threatened agriculture and human livelihood whenever flood seasons produced extreme events. After the first large dams were finished, hydrologic dynamics changed drastically.

It is notable that the floods that occurred until the early 1970s did not repeat after the construction of the Keban (Turkey) and Al Tabqa (Syria) dams. From the late 1970s until the early 1990s, the flow regime of the Euphrates was clearly smoothed, peak floods were reduced and low flows were less drastic due to beneficial reservoir operation. Water was stored in times of abundance, potential flood events where thus mitigated, especially in springtime. Water was released in times of large demands, e.g. during dry spells in summer. The filling of the Atatürk Dam finalized this phase of positive impacts of water

[13] H. Meliczek (1987) "Land Settlement in the Euphrates Basin of Syria," in: *Land Reform: Land Settlement and Cooperatives*, Food and Agriculture Organization Publications, Rome, Italy.

[14] J. Cullmann (2013) "Hydrology" in Kibaroglu et al., *Water Law and Cooperation in the Euphrates-Tigris Region*, Boston: Brill, pp. 183-189.

management.[15] Until 2000, low flows were extreme and the overall flows were drastically reduced. The difference in mean monthly flows before and after the construction of the big dams is about 50 percent. This share of the water is diverted in Turkey, Syria and Iraq and no longer makes it to the lower reaches of Euphrates. This hydrological condition is amongst the causes of serious water shortage and water quality problems in Iraq. Development of hydrodynamics in the Tigris exhibits parallels to the situation of the Euphrates. The flooding had been addressed as early as the mid-1950s, when management of the Samarra-Tharthar infrastructure started. The river shows amelioration of its low flow situation in recent years. This is a positive result of water management in the Tigris, especially on Iraqi territory, as far as Samarra-Tharthar is concerned.[16]

For an integral assessment of the potential benefit of water management it would be necessary to conduct a multi-objective optimization exercise that integrates all existing infrastructure. Total abstraction rate from the Tigris is less than for the Euphrates. When comparing the situation before and after 1960, it is noted that flow reduction is about one third of the total volume. However, overall water abstraction is, like in the Euphrates, a serious issue for the Tigris.[17]

B. History of water resources engineering and planned projects (supply, conservation, restoration)

The Euphrates has two main headwaters, the Karasu (Western Euphrates) and the Murat (Eastern Euphrates), that rise in the mountains in eastern Turkey and flow eastwards until they join at the **Keban Reservoir** that was created by the construction of the **Keban Dam** in the early 1970s. From there, the combined Euphrates flows through the southeastern Taurus Mountains. Some 40 km downstream of the Keban Dam, the Euphrates enters the **Karakaya Reservoir** receiving smaller contributions from the Tohma tributary. Further downstream, the Euphrates and Kahta Rivers form Lake Atatürk, Turkey's largest artificial reservoir that is impounded by the world's sixth largest dam. Consequently, the construction of these three major dams, which were originally planned to be a part of a Lower Euphrates Project initiated the into a larger, multi-sectoral development project, taking in the Tigris waters as well and known as the GAP. Moreover, downstream of the **Atatürk Dam** two smaller dams (**Birecik and Karkamis**) were also built in the 1990s on the river before the Euphrates crosses into Syria at Karkamis.[18]

In Syria, the river is joined by the Sajur River on the right bank of the **Tishreen** Reservoir before it enters Lake Al Assad, Syria's largest reservoir with a storage capacity of 11.7 BCM and a surface area of about 610 km², impounded by Al **Tabqa Dam**, which is an integral part of the Euphrates Valley Project under the Baath Party. Downstream of the Al Tabqa Dam, power is generated by means of the smaller **Al Baath dam** 0.09 BCM. The Euphrates then flows southeast across the Syrian semi-desert plateau where its waters are supplemented by the Balikh and the Khabur Rivers, both rising in the Syrian-Turkish border region. The Khabur is the largest and last permanent tributary of the Euphrates. Further downstream, the Euphrates gains no additional natural inflow.[19]

The Euphrates crosses the Iraqi border east of Abu Kamal and narrows to an alluvial strip before it enters Lake Qadisiyah formed by the **Haditha Dam**. Below Hit the river begins to widen and enters the large alluvial Mesopotamian Plain at **Ramadi**. From there on, the Euphrates loses parts of its water to a series of depressions and both natural and man-made diversions and abstractions. The **lakes Habbaniyah and Razazah** are situated south of Ramadi. North of Ramadi is **Tharthar Canal**, another depression that drains the Wadi Tharthar. The Tharthar Canal, which connects the Tigris to the Euphrates in the northwest of Baghdad, is the cornerstone of Iraq's water development system. With a surface area of 2,710 km2 the Tharthar Canal's vast total capacity is twice that of the Atatürk Dam and as much as the live capacity of the Aswan Dam. It is filled by diverting water from the Tigris at the Samarra Dam to protect Baghdad against the dangers of flooding. Moreover, with the Tharthar Canal, Iraq has already been able to alleviate water shortages within the Euphrates basin by diverting the Tigris water (where Iraq has a surplus) into

[15] Ibid.
[16] Ibid.
[17] Ibid.
[18] Cullmann, op.cit., pp.179-80.
[19] Ibid.

Lake Tharthar and then into the Euphrates when there is not enough water to feed the dependent irrigation projects. Taking into consideration the constraints of water salinity in the Tharthar Canal and the amount of water that can be saved and transferred from the Tigris to the Tharthar Lake reservoir, it may be assumed that about 6 BCM of water could be transferred annually from the Tharthar reservoir to the Euphrates river.[20]

Between Musayib and Hindiyah, the river splits into two branches, Hillah and Hindiyah. The **Hindiyah Barrage** regulates the flow into both branches and diverts excess water from the Euphrates to Lake Razazah. The Hillah branch divides into numerous channels and allows for irrigation of semi-arid areas to the east and south, while the Hindiyah branch forms the border between the desert areas in the west and the Mesopotamian Plain in the east and carries the main flow.[21]

Downstream of Nasiriyah, the Euphrates intersects the Main Outfall Drain (also called the **Third River**), a 565 km long canal that drains large parts of the Mesopotamian Plain (land between the Euphrates and Tigris Rivers) and the southern parts of the Mesopotamian Marshes into the Persian Gulf. From there, the river meanders in an easterly direction and tangles into many channels, some of which flow towards Lake Hammar and the Hammar marshes while the remainder join the Tigris near Qurnah.[22]

The maximum storage capacity of the major dams and reservoirs (>144BCM) on the Euphrates exceeds the natural annual volume of the river (32 BCM) by four to five times.[23] The three major riparians have already completed a large portion of the planned dams (and barrages) on the Euphrates. This is not the case for the planned irrigation projects (see part 3).

The Tigris is the second largest river in southwest Asia and rises in the Anti-Taurus Mountains of southeastern Turkey from Lake Hazar (elevation 1150m). Impounded by the **Kralkizi** and **Dicle** dams in its headwaters, the Tigris flows southeast crossing the agriculturally important Diyarbakir province of Turkey. It is fed by a number of smaller tributaries with the Batman and Botan Rivers being the two largest. Downstream of the Turkish city Cizre, the Tigris flows along the border between Turkey and Syria for 32 km and receives the waters of (Little) Khabur at the border with Iraq. Approximately 50 km northwest of Mosul, the **Mosul Dam** banks the river and forms the largest reservoir in the region. Downstream of Mosul, the Tigris flows south and the two largest tributaries join the Tigris on its left bank: the Greater Zab and Lesser Zab Rivers that originate from the Turkish and Iranian Zagros Mountains, respectively.[24]

On the Tigris, existing storage totals more than double (116.5 BCM) the average annual flow (52 BCM) of the river. Both Turkey and Iraq still have plans to build large dams on the Tigris. The **Ilisu Dam** Project of Turkey, which has been under construction since 2010 has a storage capacity of 10.4 BCM and with hydropower capacity of 1,200 MW. The Project also includes the planned downstream Cizre Dam, which will work in parallel with the Ilisu Dam. Iraq has been building a series of dams on the Tigris and its tributaries, namely the Badush on the Tigris; Bekhme and Mandawa Dams on the Greater Zab and the Taq Taq Dam on the Lesser Zab. Syria is a minor Tigris riparian as the river defines only a short distance of the Syrian-Turkish border. The country only plans to exploit water resources for small-scale agricultural activity and domestic use.[25]

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[20] Ibid.
[21] Ibid.
[22] Iraqi Ministries of Water Resources, Municipalities and Public Works, and Environment, *"New Eden: Master Plan for Integrated Water Resources Management in the Marshlands Area* (2005) 37 et seq., available at: www.iraqfoundation.org/edenagain/publications/pdfs/New%20Eden%20Master%20Plan%20-%20INTERIM%20REPORT%202005%20-%20REDUCED.pdf.
[23] *See* UN-ESCWA and BGR, "Chapter 1 Euphrates River Basin", *Inventory of Shared Water Resources in Western Asia* (2013) p. 62. http://waterinventory.org/sites/waterinventory.org/files/chapters/Chapter-01-Euphrates_River-Basin-web_0.pdf
[24] Ibid.
[25] See UN-ESCWA and BGR, "Chapter 3 Tigris River Basin", Inventory of Shared Water Resources in Western Asia (2013) p. 115.

Restoration of the Mesopotamian Marshlands

The area along the confluence of the Tigris and the Euphrates Rivers in southern Iraq was once home to the largest wetland ecosystem in Western Asia. However, by 2002, over 85 percent of the Mesopotamian Marshes had been destroyed as a result of heavy damming and massive drainage projects in the second half of the 20th century. In the early 1990s, the Iraqi Government embarked upon a large scale water diversion scheme designed to drain the southern marshes. In 2002, the marshes had shrunk to 14 percent of their original size. Only 35 percent of the Haweizeh Marshes remained, while the Central and Hammar Marshes had been almost completely drained. After the fall of Saddam Hussein's regime, locals began to destroy dikes. This was followed by joint restoration efforts by the Iraqi Government, UN agencies and other donors. Record precipitation in Turkey also contributed to the success of the initiative. By 2006, more than half of the original marshland area was flooded again. Today the damming of the Karkheh River in Iran is seen as a critical challenge, as the river directly feeds into the marshes. The construction of a levy along the Iran-Iraq border poses an additional threat to the area as it runs through the Haweizeh Marshes and disrupts natural flow in the ecosystem. Despite all the negative developments over recent decades, experts are hopeful and claim that the marshes have shown astonishing resilience to past droughts and diversions and can be restored to their natural state.[26]

3. Water supply and demand

A. Agriculture

Agriculture is by far the dominant sector as far as water consumption is concerned in the ET basin. It accounts, in average, for more than 70 percent of water allocated and used in the riparian countries. In Iraq, in 2000, total water allocated for agricultural purposes was 79 percent, 6.5 percent for domestic supplies and 14.5 percent for industrial use.[27] In Turkey, in 2003, the total water allocated for irrigation was 74 percent, 15 percent for domestic supplies and 11 percent for industrial purposes.[28] In the early 2000s, agriculture received about 89 percent of the water resources in Syria whereas domestic and industrial uses received 8 and 3 percent, respectively.[29]

However, agriculture's contribution to Gross National Product (GNP) has been declining in all riparian economies.[30] Yet, a significant portion of the labor force is still employed in this sector. Moreover, food security is still a prevailing approach particularly in the midst of growing global food crisis. Accordingly, in official contention, the achievement of food security depends on secure water supplies and the expansion of irrigated surfaces.

In addition to these political, economic and social reasons, there are physical facts on the ground for the expansion of irrigation: the evaporative demand is very high and crops require intensive irrigation because of low annual rainfall and hot and dry summers in the region. In this respect, the total area equipped for irrigation in the ET basin is estimated to be around 6.5–7 million hectares (ha), of which Iraq accounts for approximately 53 percent, Iran for 18 percent, Turkey for 15 percent and the Syria for 14 percent. Agricultural water withdrawal is approximately 68 BCM.[31]

Major irrigation projects in the ET basin:

By the end of 1960s, the development of irrigated agriculture in **Iraq** far surpassed the development in Syria and Turkey. During this period, Iraq was irrigating over five times as much land in the river basin as the Syria and nearly ten times as much as Turkey. To continue its efforts to use the water of these rivers efficiently and to provide irrigation water for the land between the Euphrates and the Tigris

[26] See UN-ESCWA and BGR, "Chapter 3 Tigris River Basin", Inventory of Shared Water Resources in Western Asia (2013) p. 119.
[27] See FAO (2008) Water Reports 34, Irrigation in the Middle East Region in Figures, Aquastat Survey, p. 203.
[28] FAO (2008) op. cit., p. 358.
[29] M. Daoudy (2005) *The Water Divide between Syria, Turkey and Iraq, Negotiation, Security and Power Asymmetry*, CNRS Editions (Paris).
[30] FAO (2008) op. cit., pp. 67, 202, 344, 357.
[31] FAO (2008) op. cit., p. 68.

rivers, Iraq began constructing in the 1960s a 565 km long canal, the Third River (also called Saddam River), between the Euphrates and Tigris, which was completed in 1992. In 1991 a large irrigation project, the North Al-Jazeera irrigation project, was launched in northern Iraq in order to serve approximately 60 000 ha by using a linear-move sprinkler irrigation system with water stored by the Mosul Dam. Another irrigation project, the East Al-Jazeera irrigation project, involved the installation of irrigation networks on more than 70 000 ha of previously rainfed land near Mosul. These projects were part of a scheme to irrigate 250 000 ha in the Al-Jazeera plain. At present it is estimated that the irrigated areas cover 2.8 million ha in Iraq in the ET basin.

In 1977, **Turkey** launched the Southeastern Anatolia Project (GAP) which is a large-scale and multi-sectoral regional development project. The project area includes 41.5 percent of the total watersheds of the Euphrates and Tigris rivers within Turkey. The total project area is 75 358 km2, of which 42.2 percent is cultivated. When fully developed, GAP will provide irrigation for 1.7 million ha of land of which 377 672 ha is currently operational.

Syria's Euphrates Valley project included the objective, among others, of expansion of the region's irrigated area to 640 000 ha. The project comprised six irrigation districts which were all centrally supervised by the General Authority for the Development of the Euphrates Basin. However, after the initial plan failed, the government reduced the irrigated area objectives to 370 000 ha. The problems encountered included high gypsum levels in the soil and salinization caused by intensive irrigation. Official data states that 206 987 ha were irrigated by the Euphrates River in 2010 in addition to 59 550 ha from the Khabour and Jagh Jagh Rivers, amounting to almost 270 000 ha. Moreover, in mid-2010, Syria launched the first phase of an irrigation project on the Tigris River. The water is to be used to irrigate approximately 150 000 ha of land in Hasakah Governorate in the upper part of the Khabour Basin.[32]

B. Cities and Industry

In Syria, Euphrates supplies drinking water to the governorates of Deir ez Zor and Raqqah as the major population centers. Since 2006, Aleppo also draws its water from the Euphrates, with a pipeline running west from Lake Assad and supplying cities and villages along its route.[33] The combination of rapid urbanization (4.5 percent) and population growth (2.4 percent) has steadily increased the demand for domestic water. Urbanization growth rate is 6,9 percent in 2012 in the GAP region. Facing the increasing demand of domestic water in the GAP provinces, DSI, major water development agency, has finalized a series of projects for drinking water supply providing 518 million m3/year water to the nine provinces in the GAP region which constitute 10 percent of Turkey's population. Yet, only 53 percent of the domestic water supply projects could have been realized in the GAP region.[34]

As regards to industrial water use, in Iraq 14.5 percent of total water was allocated for industrial use in 2000, in Turkey 11 percent of total water was allocated for industrial purposes in 2003; and in Syria 3 percent of total water was allocated for industrial purposes in 2003.

In the near future, it is envisaged that most, if not all, sectoral water allocations in the region will involve reducing water consumption in the agricultural sector and significant reallocation to other sectors. This reallocation will have a substantial impact on the domestic and industrial sectors that could lead to increases in the gross domestic product (GDP), provide more water for rural communities, and create more jobs within the industrial sector, thereby helping to combat unemployment. Agriculture will therefore remain to be the main focus of national water policies, since it will be greatly affected by the reduction of water available to it. Better management of water in agriculture, including changing crop patterns and the adoption of modern irrigation technologies, will help agriculture deal with the reduction in its water share.[35]

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[32] *See* UN-ESCWA and BGR, "Chapter 3 Tigris River Basin", *Inventory of Shared Water Resources in Western Asia,(* 2013) p. 65. http://waterinventory.org/sites/waterinventory.org/files/chapters/Chapter-03-Tigris_River-Basin-web_0.pdf

[33] Ibid.

[34] GAP'ta Son Durum, GAP-BKI, 2013.

[35] ESCWA (2003) Sectoral Water Allocation Policies in Selected ESCWA Member Countries, An Evaluation of the Economic, Social and Drought Related Impact, United Nations New York, p. 2.

C. Hydro-power

Iraq

Hydroelectric power (HEP) generation is about 17 percent of current electrical energy production in Iraq.[36] The dams and HEP plants on the Euphrates, the Tigris and its tributaries almost entirely account for HEP generation in the country. To illustrate: Al Qadisiyah Dam (660 MW); Adhaim Dam (39 MW), Badush Dam (170 MW), the planned Bekhme Dam (1500 MW), Darbandikhan (249 MW), Dukan (400 MW), Haditha Dam (660 MW), and Mosul Dam (320 MW) provide hydro-power production in the country. Existing power plants have been neglected for over decades and a number of new projects were suspended in the aftermath of the Gulf War. The volume and timing of water entering Iraq from neighboring countries is a significant factor in hydropower production.[37]

Syria

The major development plan for the Euphrates in Syria consisted of the construction of three dams, namely the Tabqa Dam (1975), the Al-Baath Dam (1988) and the Tishrine Dam (1999), all of which are in operation. At the heart of national plans lies the Tabqa or Al-Thawra dam (*Revolution*, in Arabic) with an overall storage capacity of 14 100 Mm^3 and a hydro-power production of 800-1100 MW. The Tabqa Dam, has contributed up to 60 percent of Syria's energy production.[38] Syria has had development plans for the Khabur river, which is a tributary of the Euphrates but treated separately from the Euphrates. Three dams will irrigate 375 000 ha, utilizing 1.6 BCM/y, and produce 28 MW power.

Turkey

In Turkey, work on a major hydroelectric dam on the Euphrates at Keban was initiated in 1963 and brought on line in 1975. By regulating river flow patterns, the Keban Dam set the stage for large-scale developments in the upper Euphrates. GAP consists of a combination of 13 independent but related major irrigation and hydropower schemes with a total capacity of 7500 MW, which involves the construction of 22 dams and 19 hydroelectric power plants on the Euphrates and Tigris and their tributaries. The overall objective of the mega-development project is to produce 27 367 GWh of hydroelectricty annually, which can be transmitted to the major population centers in Turkey. Altogether 14 dams and seven hydropower plants, including major water control facilities such as the Keban (1360 MW), Karakaya (1800 MW), Atatürk (2450 MW), Birecik (672 MW), Karkamis (189 MW), Kralkizi (94 MW), Batman-Silvan (198 MW) and Dicle (110 MW) dams, are already in operation. Ilisu Dam with a significant hydropower potential (1200 MW) is under construction and the final design for the Cizre dam (240 MW) has been completed. At present, 80 percent of the hydropower potential is under operation.

Iran

Iran completed its largest hydropower and irrigation development project, the Dez Dam (520 MW), on a tributary of the River Karun in 1962. Within the last decade, Iran has embarked on a multi-billion-dollar water management scheme on the River Karun, which runs to the Shatt-al-Arab delta. Affecting Mesopotamian marshlands, the Karun river development project has ecological consequences. In 2001, Iran inaugurated its largest water reservoir on the River Karkheh, which is intended to irrigate 320 000 ha of land. Also planned is a 540-km pipeline from Karkheh Dam to supply 250 million m3 of fresh water to Kuwait annually.[39]

D. Environment

The water quality of the Tigris is presumably good, including water originating in both Turkey and Iraq. Water quality degrades downstream, with major pollution inflows from urban areas such as Baghdad due to poor infrastructure for wastewater treatment. The Tigris is, so far, much less affected by salinization. Its headwaters have a salinity of 275 ppm, and at present no rise in the Tigris's salinity upstream from where

[36] See FAO (2008) Water Reports 34, Irrigation in the Middle East Region in Figures, Aquastat Survey, p. 203.
[37] United Nations Development Group (UNDG) (2005) *The National Water Master Plan –Phase 1 Water Resources Assessment*.
[38] M. Daoudy (2005).
[39] D. Altinbilek (2004) "Development and Management of the Euphrates-Tigris Basin," *Water Resources Development*, Vol. 20, No 1.

it enters Iraq is documented. The salinity rises to 1,000 ppm at Baghdad and stays on this level until Kut (ca. 200 km downstream of Baghdad). At Ali al-Sharki (150 km downstream of Kut) the river's salinity reaches its highest level with 2,250 ppm.[40]

The water quality of the Euphrates entering Iraq is less than that of the Tigris, as it is currently affected by the return flow from irrigation projects in Turkey and Syria and is expected to get worse as more lands come under irrigation. Overall, one can conclude that current salinity levels are in the range of 300 ppm at the Syrian-Turkish border, 600-800 ppm at the Iraqi-Syrian border, and 2,000-3,500 ppm in southern Iraq near the confluence with the Tigris River.[41] In addition to increasing salinity, intense agricultural activities and the dumping of untreated sewage in the Euphrates and its tributaries have contributed to other forms of pollution in all three riparian countries. These include increasing nutrient levels and coliform bacteria counts in the river. Euphrates characteristics such as the high rate of evaporation, sharp climatic variations, the accumulation of salts and sediments, poor drainage and low soil quality in the lower reaches of the river exacerbate the damaging effects of pollution from human activities.[42]

The quality is further degraded as flood flows are diverted into off-stream storage in Tharthar and later returned to the river system. Salts in Tharthar are absorbed by the water stored there. The quality of water in both the Euphrates and Tigris is further degraded by return flows from land irrigated in Iraq as well as urban pollution. The amount and quality of water entering southern Iraq from Iranian territory is largely unknown, although it is clear that flows are impacted by irrigation return flow originating in Iran.[43]

The deterioration of water quality and the heavy pollution from many sources are becoming serious threats to the ET basin. One problem is the lack of any effective water monitoring network so that it is difficult to take measures to address water quality and pollution as it is impossible to identify the causes. Hence, the rehabilitation and reconstruction of the water monitoring network have becoming urgent to ensure water security.[44]

The quantity and quality of water entering the Gulf is also an issue to be addressed since fisheries are an important food source for the region. Other environmental issues to be taken into account are the impact of water management and changed flow regimes on migrating fish and terrestrial species and on the viability of riverine and floodplain ecosystems throughout the Tigris and Euphrates basins.[45]

E. Water budget

While many innovations may affect the water supply and the use within the next three decades, the full development scenario in 2040 indicates a water deficiency in the Euphrates basin (Table below). The projections by various authors indicate a deficiency of 2–12 BCM/y in the Euphrates at full development. It is generally agreed that there will be a surplus of 8–9.7 BCM/y for the Tigris. This picture signals a water shortage that will emerge some time after 2020. In two decades the requirements of the Euphrates branch will not be met with virgin flow of that tributary alone. Although the transfer of water from the Tigris to the Euphrates is often proposed, this may not entirely solve the water shortage in the Euphrates basin.

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[40] N. Bremer (2013) "Dams on Euphrates and Tigris: Impact and Regulation through International Law" in Kibaroglu et al., *Water Law and Cooperation in the Euphrates-Tigris Region*, Boston: Brill, pp. 145-176.

[41] These measurements are extremely alarming considering that according to WHO standards water with a salinity exceeding 1,000 ppm is unfit for human consumption. Where the salinity rises above 2,000 ppm it cannot be utilized for crop irrigation and where it exceeds 3,000 ppm, the water cannot be fed to even the more resistant livestock without danger of severe health problems for the animals. Thus, the Euphrates' water is unfit for human consumption downstream from the Syrian-Turkish border and cannot be utilized for irrigation or as drinking water for livestock downstream from Samawah (Bremer in Kibaroglu et al., 2013).

[42] *See* UN-ESCWA and BGR, "Chapter 1 Euphrates River Basin", *Inventory of Shared Water Resources in Western Asia* (2013) p. 65. http://waterinventory.org/sites/waterinventory.org/files/chapters/Chapter-01-Euphrates_River-Basin-web_0.pdf

[43] See FAO (2008) *Water Reports 34*, Irrigation in the Middle East Region in Figures, Aquastat Survey, p. 212.

[44] Ibid.

[45] Ibid.

Summary of water budgets at full development scenario (BCM/y)					
	Altinbilek (2004)	Kolars[46] (1994)	Kliot[47] (1994)	US Army Corps of Engineers[48] (1991)	Belul[49] (1996)
Euphrates					
Natural flow at Turkish– Syrian border	31.43	30.67	28.20	28.20	31.4
Net withdrawal by Turkey	—14.50	— 21.6	— 21.50	— 21.5	—12.3
Entering Syria	16.93	9.07	6.7	6.7	19.1
Inflows in Syria	2.05	9.484	10.7	4.5	3.1
Net withdrawals by Syria	— 5.5	—11.995	—13.4	— 4.3	—10.5
Entering Iraq	13.48	6.559	4.0	6.9	11.7
Net withdrawal by Iraq	—15.5	—13.0	—16.0	—17.6	—19.0
Flow into Shatt- al-Arab	— 2.02	— 6.441	—12.0	—10.7	— 7.3
Tigris					
Runoff in Turkey	18.87	18.5	18.5	18.500	19.3
Net withdrawal in Turkey and Syria	— 8.0	— 6.7	— 7.2	— 6.7	10.2
Entering Iraq	10.87	11.8	11.3	11.8	11.5
Inflows in Iraq by tributaries	30.7	30.7	31.7	30.7	31.0
Net withdrawal in Iraq	— 31.9	— 33.4	— 40.0	— 32.8	— 33.5
Flow into Shatt- al-Arab	9.67	9.1	8.0	9.7	9.0

Source: D. Altinbilek, "Development and Management of the Euphrates-Tigris Basin," *Water Resources Development*, Vol. 20, No 1 2004.

4. Governance

The current transboundary water dispute in the Euphrates-Tigris river basin was originally due to the emergence of large-scale water development projects initiated by the major riparians, namely Turkey, Syria and Iraq, in the early 1960s in competition with one another. The aim of these dam projects was to control and harness the waters of the two rivers, particularly at times of flooding and drought. At national level, other interests identified subsequently were the generation of hydropower and the provision of water for irrigation and drinking purposes. At transboundary level, however, water development projects were implemented in an uncoordinated fashion and increased the pressure on the limited supply of water in the rivers. As demand for water exceeded supply, the nationalwater authorities attempted to engage in dialogue and set up ad hoc institutions for negotiations.[50]

A. Water Negotiations and Water Rights (Laws and Regulations at Transboundary Level)

In the 1960s, the three riparians entered a new phase of their relationship over water, upon Turkey's decision to construct the Keban Dam on the Euphrates. The downstream riparians, particularly Iraq, insisted on guaranteed flows (350 m^3/s at minimum) to be released by Turkey during the impounding period. Hence, a first meeting was held in June 1964 with Turkish and Iraqi experts attending. At the end

[46] J. Kolars (1994) "Managing the Impact of Development: The Euphrates and Tigris Rivers and the Ecology of the Arabian Gulf-A Link in Forging Tri-Riparian Cooperation," *Water as an Element of Cooperation and Development in the Middle East*, All Ihsan Bagis, editor. (Ankara: Ayna Publications and the Friederich Naumann Foundation in Turkey: Ankara.) pp. 129-154.
[47] N. Kliot (1994) *Water Resources and Conflict in the Middle East* Routledge, London, p. 100.
[48] U.S. Army Corps of Engineers (1991) 'Profile: Tigris-Euphrates River' in U.S. Army, *Water in the Sand*, p. 2.
[49] M. L. Belül(1996) *Hydropolitics of the Euphrates-Tigris Basin* M.Sc. Thesis submitted to the Graduate School of Natural and Applied Sciences, Middle East Technical University, June 1996.
[50] A. Kibaroglu and W. Scheumann (2013) "Evolution of Transboundary Politics in the Euphrates-Tigris River System: New Perspectives and Political Challenges," *Global Governance: A Review of Multilateralism and International Organizations* 19 pp. 279-305.

of negotiations, Turkey guaranteed to undertake all necessary measures to maintain a discharge of 350 m^3/s immediately downstream from the dam, provided that the natural flow of the river was adequate to supply this discharge. This was communicated to Syria and Iraq the same year. Moreover, during this meeting, Turkey proposed the establishment of a Joint Technical Committee (JTC), which would inspect each river to determine its average yearly discharge. The JTC would determine the irrigation needs of the three countries through joint field studies and would be authorised - by calculating the needs of the riparians for present and future projects - to prepare a statement of the main principles and procedures in order to facilitate an agreement on water rights.[51]

Following this first technical meeting between Turkey and Iraq, a few more ad hoc meetings were held. Among these the most notable one - the first tri-partite negotiation - was held in Baghdad in 1965 where the three delegations exchanged technical data on the Haditha (Iraq), Tabqa (Syria) and Keban (Turkey) dams. In line with a Turkish proposal, Syria suggested that it would be beneficial to commission a JTC study of the water requirements of the irrigable lands, and subsequently to examine the possibility of covering possible shortages of water supplied by the Euphrates by diverting a part of the Tigris River's water to the Euphrates. Iraq strongly opposed this proposal and insisted on negotiating only on the waters of the Euphrates.[52]

B. Joint Technical Committee: An Institutional Platform at Transboundary Level

During the 1970s, delegations from the three countries gathered on several occasions to exchange information about technical issues relating to the reservoirs. No agreement was reached, and Turkey and Syria unilaterally determined the impounding programmes for their reservoirs. In the early 1980s, the Turkish development plans created a new demand for cooperation. This time Iraq proposed the formation of a permanent Joint Technical Committee. At the end of the first meeting of the Joint Economic Commission between Turkey and Iraq in 1980, a JTC was established which Syria joined in 1983, whereupon Turkey, Syria, and Iraq held sixteen meetings up to 1993.[53]

The mandate given to the JTC was defined as determining the methods and procedures, which would lead to a definition of a reasonable and appropriate amount of water that each country would need from both rivers. The main items on the JTC's agenda were the exchange of hydrological and meteorological data, the sharing of information on progress achieved in the construction of dams and irrigation schemes in the three countries, and the discussion of initial plans for the filling of the Karakaya and Ataturk reservoirs.

However, after sixteen meetings, the JTC could not fulfil its mandate, and the talks became deadlocked. The major issues that led to the deadlock related to both the subject and the object of negotiations: whether the Euphrates and the Tigris could be considered a single water system, or whether the discussions should be limited to the Euphrates.[54] The wording of the JTC's final objective, i.e. reaching common terminology, was also problematic: whether to formulate a proposal for the *'sharing'* of *'international rivers'*, or to achieve a trilateral regime to determine the *'utilisation of transboundary watercourses'*. Iraq and Syria consider the Euphrates an *international* river and insist on an immediate sharing agreement under which its waters would be shared on the basis of each country's stated water needs. On the other hand, Turkey regards the Euphrates and Tigris as forming a *single transboundary river basin* where the waters should be *allocated* according to the identified needs.

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[51] A. Kibaroglu and W. Scheumann (2011) "Euphrates-Tigris River System: Political Rapproachement and Transboundary Water Cooperation", in: A. Kibaroglu et al. (eds), *Turkey's Water Policy: National Frameworks and International Cooperation*, Heidelberg: Springer, pp. 277–301.

[52] Ibid.

[53] A. Kibaroglu (2002) *Building a Regime for the Waters of the Euphrates-Tigris River Basin*, : Boston: Kluwer Law International, pp. 259–260.

[54] The Turkish side regards the Euphrates and Tigris as one river system because both rivers form the Shatt al-Arab watercourse. This opinion is reinforced by the existence of the Thartar Canal, which was built by Iraq: it connects the Tigris with the Euphrates and diverts water from the Tigris to the Euphrates. This view is, so far, not shared by Iraq and Syria. With respect to these contradicting views, Article 2a of the UN Water Convention reads as follows: "'Watercourse' means a system of surface and groundwaters constituting by virtue of the physical relationship a unitary whole and normally flowing into a common terminus."

The JTC meetings, at which claims and counter-claims concerning the use of the rivers and the nature of customary international water law were voiced, did not make an effective contribution to the settlement of the regional water dispute. The JTC did not provide a platform for delineating the co-riparians' priorities and needs as a basis for addressing regional water problems such as shortages and contamination of regional waters as well as the severe impacts of droughts. In this respect, water use patterns and the riparians' related legislation and institutional structures never had a chance of being discussed at the JTC meetings. National management and allocation policies and water management practices within the riparian countries simply could not be debated during those negotiations.[55]

C. Bilateral Treaties for Water Allocation

Although basin-wide agreement was not reached over procedures or over water quotas, in 1987 and 1990, two bilateral accords were concluded which were largely products of the then prevailing political atmosphere. They were, however, not the results of JTC negotiations, but were initiated at the highest political levels. Both are acknowledged as interim agreements by all riparians.

a. The Protocol of 1987 between Turkey and Syria

The Turkish-Syrian Joint Economic Commission meeting on 17 July 1987 had an important outcome regarding negotiations on the water issue. The Protocol of Economic Cooperation signed by Turkey and Syria at the end of the meeting included provisions for water. It is important to note that the Protocol was regarded as a temporary arrangement. The text of article 6 of the Protocol reads as follows:

> During the filling up period of the Atatürk dam reservoir and until the final allocation of the waters of Euphrates among the three riparian countries the Turkish side undertakes to release a yearly average of more than 500 m3/sec at the Turkish-Syrian border and in cases where monthly flow falls below the level of 500 m3/sec, the Turkish side agrees to make up the difference during the following month.[56]

b. Water Allocation Agreement between Syria and Iraq: The Protocol of 1989

Syria and Iraq perceived the interruption to the flow of the Euphrates due to the impounding of the Atatürk Dam as the beginning of many such interruptions that would be the consequence of the envisaged projects within the framework of GAP. Hence, the thirteenth meeting of the JTC, held in Baghdad on 16 April 1989, provided the occasion for a bilateral accord between Syria and Iraq, according to which 58 % of the Euphrates water coming from Turkey would be released to Iraq by Syria.[57]

D. Emergence of Cooperation Frameworks (1990s-onwards)

Beginning in the late 1990s, however, the opportunity for a lasting solution over the Euphrates and Tigris rivers has been an emerging trend as cooperation, mainly in the security domain, has intensified between two of its major riparian states, Turkey and Syria. It is important to note that, in 1998, Turkish-Syrian relations became very tense when Turkey threatened Syria with all appropriate measures if it continued to support the PKK, the Kurdish separatist terrorist organization. War was prevented by the mediation of Egypt and Iran. Syria decided not to risk a war and expelled the PKK leader, who was subsequently captured in February 1999. This event paved the way for the conclusion of the Turkish-Syrian Ceyhan Security Agreement in October 1998[58], which marked the beginning of a new era that is based on more cooperative initiatives of interest to both sides. One of the first initiatives was a joint communiqué signed between Southeastern Anatolia Project Regional Development Administration (GAP RDA) from Turkey and the General Organization for Land Development (GOLD), under the Syrian Ministry of Irrigation, in

[55] Kibaroglu and Scheumann, op.cit., (2013) p. 287.

[56] Para. 6 Protocol on Matters Pertaining to Economic Cooperation between Turkey and the Syrian Arab Republic (signed and entered into force 17 July 1987) *UNTS* Vol. 1724 No. 30069.

[57] Para. 1 Joint Minutes Concerning the provisional Division of the Waters of the Euphrates River (Iraq-Syria) (signed 17 April 1989), available at: <http://faolex.fao.org.>.

[58] *Hurriyet*, 21 October 1998.

2001.[59] GAP-GOLD cooperation is based on the common understanding of the sustainable utilization of the region's land and water resources through conducting joint rural development and environmental protection projects, joint training programs, expert and technology exchanges, and study missions. Syrian and Turkish delegations paid visits to each other's development project sites. During these contacts they had opportunities to exchange experiences pertaining to the positive and negative impacts of the decades' old water and land resources development projects. Unlike the technical negotiations in the 1960s, the GAP-GOLD dialogue included diversified issues such as urban and rural water quality management, rural development, participatory irrigation management and agricultural research.[60] Even though the dialogue between these two leading institutions has not resulted in concrete project implementation or regular exchange programmes, it has served as a semi-formal consultation mechanism and paved the way for initiatives taken by other government departments and agencies in 2008 and 2009 with the similar objective of solving transboundary water problems within a broader framework of political, economic and social development.

E. New Perspectives on Transboundary Water Issues: New water protocols (Key Decisions)

In 2008 and 2009, the governments of Turkey, Syria and Iraq embarked upon cooperative foreign policy initiatives. The political reasons behind these initiatives can be analyzed at contextual, regional, bilateral and domestic levels, the analysis of which is beyond the focus of this report.[61] However, the political will expressed and sealed at the highest levels has also reflected on cooperative initiatives related to transboundary water development and management in the Euphrates and Tigris region.

In this context, Turkey and Iraq signed the Joint Political Declaration on the Establishment of the High-Level Strategic Cooperation Council (HSCC) on 10 July 2008.[62] On the other side, a similar bilateral HSCC was created between Turkey and Syria on 22 December 2009. Broadening the scope of the cooperation agenda to take in sectors of socio-economic development, including water, and simultaneously fostering a situation of regional interdependence were in fact the main aims underlying the establishment of both the Turkish-Syrian and Turkish-Iraqi HSCCs. The comprehensive and strategic nature of the HSCCs resulted in an innovative approach to transboundary water issues in that the water and diplomatic bureaucracies were empowered to draft and sign a series of memorandum of understandings (water protocols) addressing problems associated with water development, management and use.

Among the forty eight Memorandum of Understandings (MoU) which were signed between Turkey and Iraq on 15 October 2009, one was on "water". With that protocol the two sides agreed to exchange hydrological and meteorological information as well as exchanging expertise in these fields. Both sides also emphasized utilization and management of regional water resources in an efficient manner.

On December 23 and 24, 2009 Turkey and Syria signed fifty MoUs at the first meeting of the HSCC in Damascus including four, which are related to regional waters, namely the Euphrates, Tigris and the Orontes.[63]

a. The Memorandum of Understanding on the Tigris Waters

Turkey and Syria signed the MoU on the Tigris under which Turkey agreed that Syria could pump 1.25 BCM of water from the Tigris annually, when the flow of water is within the average.[64] The water

[59] A joint Communiqué between the Republic of Turkey, Prime Ministry, Southeastern Anatolia Project Regional Development Administration (GAP RDA) and the Syrian Arab Republic, Ministry of Irrigation, General Organization for Land Development, 23 August 2001, Ankara, Turkey, on file with author.

[60] Kibaroglu and Scheumann, op. cit., (2011), pp.290-291.

[61] M. Altunisik and L. G. Martin, "Making Sense of the Turkish Foreign Policy in the Middle East under AKP", *Turkish Studies* 12 (2011).

[62] See <http://www.mfa.gov.tr/data/DISPOLITIKA/Bolgeler/ortadogu/irak/Ortak%20Siyasi%20Bilirge%20%C4%B0ngilizce.pdf.>.

[63] The Memorandum of Understanding Between the Government of the Republic of Turkey and the Government of the Syrian Arab Republic for the Construction of a Joint Dam on the Orontes River Under the Name 'Friendship Dam', (23 December 2009) (published in Turkish on the Turkish Grand National Assembly website), on file with the author.

withdrawals are arranged according to monthly flows, and it is indicated that pumping will be done when time and place allows.[65] This MoU may enable Syrian authorities to expand irrigation in the north-eastern Syria by pumping water from the Tigris river, which forms the boundary between Turkey and Syria and between Syria and Iraq. From the Turkish point of view, achieving an agreement with Syria about the use of the Tigris waters is real progress in terms of developing a regional understanding on transboundary waters which includes both Euphrates and Tigris waters.

b. Memoranda of Understandings on Water Efficiency, Drought Management and Quality Remediation

Two more MoU signed between Turkey and Syria include issues which have only recently entered the agenda of transboundary water negotiations among the concerned technocrats and diplomats.[66] In this respect, it is interesting to note that within a framework of an official agreement the parties have dealt, for the first time, with the protection of environment, management of water resources quality, and scrutinized the issues of water efficiency, drought management and flood protection in tackling with the negative impacts of climate change. As opposed to the bilateral agreement concluded in 1987 on sharing the waters of the Euphrates, these MoUs have focused on how the riparian states use, manage, protect and develop the diminishing water resources of the Euphrates and Tigris rivers. The parties no longer adopted only reserved and rigid positions about their water shares and rights, but openly discussed new and efficient methods and procedures to manage water supply and demand for agricultural, industrial and domestic uses. Hence, the issues covered in the MoUs are diversified, ranging from various ways of supply management such as cloud seeding (artificial rain) to increase precipitation, installation of early flood warning systems and flood protection measures, agricultural practices with drought resistant crops; to various ways and means of demand management such as sharing of knowledge and experience on modern irrigation techniques, prevention of water loss in domestic water supply; organization of training programs on the operation of dams and efficient utilization of water resources; sharing knowledge and technology pertaining to waste water storage and reuse of treated waste water in agriculture and industry; cooperation on the development of land use techniques to increase saving of soil water.

The general approach and the content of the MoUs also display the fact that Turkey's firsthand experience with the European Union's water policy and water management approach is broadly translated to the envisioned principles in the MoUs. Hence, the Turkish bureaucracy of the Ministry of Environment and Forestry (MoEF)[67], in particular, is interested in implementing these MoUs as, in their contention, implementation of them would be a useful practice for the implementation and extension of the new water legislation in Turkey.[68] In this respect, the 'river basin level' water management approach, which is adopted from the European Union water legislation, namely the EU Water Framework Directive (2000) would be practiced not only at the national river basins of Turkey but at the transboundary river basins

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[64] The Memorandum of Understanding Between the Government of the Republic of Turkey and the Government of the Syrian Arab Republic on Establishment of a Pumping Station in the Territories of Syrian Arab Republic for Water Withdrawal From the Tigris River, December 23, 2009, (published in Turkish at the Turkish Grand National Assembly website) on file with the author.

[65] In 2002, a bilateral agreement between Syria and Iraq was signed concerning the installation of a Syrian pump station on the Tigris river for irrigation purposes. The quantity of water drawn annually from the Tigris river, when the flow of water is within the average, will be 1.25 BCM with a drainage capacity proportional to the projected surface of 150,000 ha. Personal communication with the Turkish officials at the Ministry of Foreign Affairs and State Hydraulic Works (DSI, Turkish acronym), January 2010.

[66] Memorandum of Understanding between the Government of the Republic of Turkey and the Government of the Syrian Arab Republic in the Field of Efficient Utilization of Water Resources and Combating Drought (23 September 2009); Memorandum of Understanding between the Government of the Republic of Turkey and the Government of the Syrian Arab Republic in the Field of Remediation of Water Quality (23 December 2009), (published in Turkish at the Turkish Grand National Assembly website) on file with the author. "

[67] Since June 2011, the Ministry of Environment and Forestry has been reorganized and renamed as the Ministry of Forestry and Water Affairs, Turkey. See <http://www.ormansu.gov.tr>.

[68] A series of laws and by- laws have been adopted in Turkey since mid 2000s, which are related to environmental protection and water quality management in domestic, agricultural and industrial sectors. This legal reorientation is basically guided by the European Union water legislation within the framework of accession partnership process.

such as the Euphrates and Tigris. Moreover, adopting common standards for measuring (gauging) water resources quantity and monitoring of the transboundary water quality are also one of the main objectives of the MoEF particularly as relates to their cooperation with Syria and Iraq. In this context, one of the main aims of the Turkish bureaucracy is to establish environmental quality standards and to implement polluter pays and cost recovery principles at the transboundary level as the relevant MoU[69] stipulates.

F. ETIC: the Non-governmental Network[70] (Role of Stakeholders)

Another significant development in the region is the Euphrates-Tigris Initiative for Cooperation (ETIC) established in May 2005 by a group of scholars and professionals from the three major riparian countries. The overall goal of the initiative is to promote cooperation among the three riparians to achieve technical, social and economic development in the Euphrates-Tigris region. The composition and the role of ETIC remarkably fit the epistemic community theory and its role in institutional bargaining. Epistemic communities are a "network of professionals with recognized expertise and competence in a particular domain and an authoritative claim to policy-relevant knowledge within that domain or issue-area."[71]

The ETIC is a track-two effort, meaning that it is voluntary, non-official, non-binding, non-profit seeking and non-governmental. It is not affiliated with any government, but it aims to contribute positively to efforts, official and unofficial, that will enhance the dialogue, understanding and collaboration among the riparians of the Euphrates-Tigris region. As a multi-riparian initiative, ETIC has been unique in that it looks beyond water rights, *per se*, to themes related to environmental protection, development and gender equity, water management, governance, and grass-roots participation in a holistic, multi-stakeholder framework.

The ETIC members contend that awareness of socio-economic development is compulsory to understand the real dynamics of the region. Hence, the vision of the ETIC is defined by the founders as "quality of life for people in all communities, including rural and urban areas, is improved, and harmony among countries and with nature in the Euphrates-Tigris region is achieved" to promote cooperation for technical, social and economic development in the Euphrates-Tigris region. In line with its vision and overall goal, ETIC prepares and implements joint training and capacity building programs as well as research and projects with an aim to respond to the common needs and concerns of the people in the region. In conducting these activities ETIC has built partnerships with the international organizations, NGOs and with the universities.

G. Analysis

Throughout the evolution of their transboundary water policies, the goal pursued by each riparian has not changed: Turkey has been keen to determine what is needed and how resources should be allocated, while Iraq and Syria have adopted the same line of reasoning, that a sharing agreement should be concluded on the basis of a declaration of riparian rights. Yet there has been a change in what is done and how it is done in the region since the early 2000s. The high-level contacts have produced a framework for regional cooperation of which water is an integral component. Issues of mutual concern, such as drought management, efficient management of resources and the improvement of water quality, have come to the fore during the transboundary water talks. Moreover, new instruments of statecraft, namely the environmental bureaucracies, and non-governmental entities, such as the ETIC, have begun to play key roles in shaping the water cooperation agenda.

However, thorough analyses reveal that the change involving various cooperative initiatives is more closely and intimately related to the change in overall political relations, with decisions being taken at the highest level. It cannot be denied, therefore, that the overarching problem of deteriorating political

[69] The Memorandum of Understanding between the Government of the Republic of Turkey and the Government of the Syrian Arab Republic in the Field of Remediation of Water Quality.

[70] This section is mainly drawn from A. Kibaroglu (2008) "The Role of Epistemic Communities in Offering New Cooperation Frameworks in the Euphrates-Tigris Rivers System", *Journal of International Affairs* 61, 191.

[71] P. M. Haas (1992) "Introduction: Epistemic Communities and International Policy Coordination", *International Organization* 46, 1.

relations in the region may have a counter effect on the development of transboundary water cooperation. As political will fades, particularly in Turkish-Syrian relations, technocratic and diplomatic bureaucracies are encountering serious difficulties in implementing the new water MoUs. They are closely linked to decision-making at the highest level. But it should also be noted that, since the early 2000s, contacts have been made, existing networks have been revitalized, and new ones have been created. Thus a partial institutionalization of water cooperation had already begun before it was abruptly halted in 2011 as overarching bilateral political relations worsened. When it has a chance to resume, transboundary water cooperation should start from a variety of perspectives and issues, which may again provide opportunities for regional cooperation.

5. Problems/challenges

A. Political problems

The biggest challenge now is to coordinate water resources management and establish transboundary water cooperation in the midst of current state of affairs in the region. Overarching political problems, namely the Syrian internal conflict (civil war) and the deterioration of bilateral political relations between any pair of the riparians constitute disabling political background for the implementation of efficient and equitable water policy in the Euphrates-Tigris river basin.

B. Institutional deficiencies

The ratification procedures and implementation of the recent (2009) bilateral MoUs could not be achieved mainly because of strained political relations. However, even in the case of restoration of peace and stability in the region, there would still be the danger of inadequate implementation of the MoUs in mobilizing relevant actors and actions to implement benefit sharing projects and distribute the benefits equitably. Hence, the success or the failure of possible cooperation between the riparians will be tested through the systematic analyses of the changes in the socio economic status of regional people: whether their social and economic statuses are better off in terms of increasing income levels and distribution of the benefits fairly.

Moreover, there has been an enduring problem of lack of coordination in transboundary water management in the basin. That is to say, analysis of national water policy and management demonstrate the fact that riparians have developed complex national water management systems; and there are institutional and legal incompatibilities. Hence, successful implementation of water protocols and treaties would mainly depend upon the institutional capacity of the riparians as well as proper coordination of water policy.

Furthermore, with Syria experiencing significant internal unrest and Iraq recovering from two decades of sanctions and war, water resource management capacities in both countries are considerably diminished.[72] On the other hand, Turkey's water policy has been evolving since the early 1990s which shaped up in a more complex legal and organizational framework, and demonstrating only a partial progress in water resources protection and public participation in water policy-making process.

C. Shortcomings and loopholes in existing transboundary water sharing treaties

The existence of the two historical and legally binding treaties (1987 Protocol between Turkey-Syria and the 1990 Protocol between Syria and Iraq), both relating only to the Euphrates, could not be accepted as evidence of cooperation. Both were bilateral and predominantly concerned with water quantity issues. Under the framework of these bilateral treaties, the riparians could not agree on more comprehensive forms of cooperation that would adopt an integrated approach to the various aspects of water use and needs (quality, quantity, flood protection, preservation of ecosystems and prevention of accidents) and might potentially facilitate negotiations by linking water management issues. The agreements lacked effective organisational back-up, at least in the form of joint monitoring. Most critically, both treaties failed to address fluctuations in flow, meaning that they contained no clauses referring to the periods of

[72] D. Michel et al. (2012) *Water Challenges and Cooperative Response in the Middle East and North Africa*, The Saban Center at Brookings, p. 14

drought and flooding which frequently occur in the basin and cause drastic changes in the flow regime, requiring urgent adjustment to the use of the rivers.

D. Climate change impacts

Future climate change projections indicate substantial reductions in the runoff of Tigris and Euphrates rivers. According to a high emissions scenario (SRES A2) simulation, the surface runoff in these basins will decrease by 23.5 percent and 28.5 percent for Euphrates and Tigris basins respectively by the end of the present century (these figures are calculated for the Turkish portions of these basins). The same simulation reveals that there will be little snow cover in the headwaters of these rivers in the late 21st century as the increase in regional temperatures will cause precipitation to fall as rain mostly (not as snow). The decreases in the surface runoff are primarily related to decreases in the precipitation, however, higher evapotranspiration rates in response to increased temperatures also play a role as they increase the water loss into the atmosphere.[73]

In addition to reductions in the runoff, which has not been observed in the historical observations, the peak flows in the future hydrographs will be observed earlier (similar shifts have been already detected in historical observations). The aforementioned high emissions scenario simulation indicates that the temporal shift to earlier will be about 4-5 weeks. Needless to say, these are statistically significant shifts.[74]

Both changes, i.e. runoff reduction and temporal shifts to earlier, may have important implications for the future of the basin. There will be less water available for irrigation, energy production, and domestic and industrial use. Less water in the rivers will also increase the stress on the ecosystems along the rivers. The 2008 severe drought in the basin convey important messages about what could happen in this area in the future. Such events, which could be more frequent and intense in the future, could threaten the water availability and food security, and may cause conflicts in the region.[75]

E. Environmental problems

In the 1960s and 1970s dams were seen as a good investment due to the possibility to generate energy without emitting carbon. It was not until the 1990s that the adverse social and ecological impacts of large dams and HEPP became a point of concern in the basin. The dams stabilized natural flow fluctuations, altering the natural flow regime of the river. Such a stabilization of a river's flow seemed beneficial, since it enhanced the overall usability of the river. Naturally occurring floods have been, however, important for maintaining a river's profile because of the large amounts of sediment they move and deposit. Reduced flooding, therefore, caused sediments to build up, reduced water depth and smothered habitats. With the rising of environmental concern and with an aim to catch up with international concern for sustainable development, the three major riparians established the ministries of environment and adopted related legislation, i.e. environmental impact assessment at national level though the implementation of the environmental protection measures fell short of expectations.

F. Reservoir sedimentation

Rivers contain sediment which partly accumulates in the reservoirs. Depending on sediment loads and a reservoir's storage capacity, the accumulation reduces, over time, its safe yield, i.e. the annual runoff of a river which can be utilized for electricity generation, irrigation and flood control. If an upstream reservoir serves as a sediment trap for those downstream, it increases the life time over which they provide services; it reduces maintenance requirements in irrigation channels because less sediment deposits therein. In addition, water quality improves downstream with less sediment contents. The Turkish Keban Dam has positive flood control effects for the downstream countries, in particular, for Iraq. Positive effects on flood control increased with the construction of the Karakaya and Atatürk dams, which also serve as sediment

[73] D. Bozkurt, Sen, O.L. (2013) "Climate change impacts in the Euphrates-Tigris Basin based on different model and scenario simulations," *Journal of Hydrology*, 480, 149-161.

[74] O.L. Sen, A. Unal, D. Bozkurt and T. Kindap (2011) „Temporal Changes in Euphrates and Tigris Discharges and Teleconnections," *Environmental Research Letters*, 6, 024012, doi:10.1088/1748-9326/6/2/024012.

[75] I. Yücel, A. Güventürk, and O.L. Sen (2014) „Climate change impacts of snowmelt runoff for mountainous transboundary basins in eastern Turkey," *International Journal of Climatology*, (in press). DOI: 10.1002/joc.3974

traps.[76] However, the deforested Turkish watershed of the Euphrates has negative effects on sedimentation rates, and estimates assume that yearly sedimentation in the three Turkish reservoirs, i.e. Keban, Karakaya and Atatürk, can reach a volume of 1,050 cubic meters per square kilometer. The General Directorate for State Hydraulic Works (DSI, in Turkish acronym) assumes 350 cubic meters per square kilometer for each reservoir. Annual storage loss in Keban reservoir is estimated to be 0,147 percent, and by 2006 the Keban dam lost its total storage capacity by 4,55 percent due to sedimentation.

G. Problems in irrigation water management: inefficiencies and inequities

Traditionally central water authorities have been in charge of building, operating and maintaining irrigation systems in the riparian countries. However, in Turkey, including the ET region, operation and management responsibility of 98 percent of the irrigated area equipped with irrigation facilities by DSI has been transferred to the water users, namely the irrigation associations (IA). The Turkish experience of water user associations, which was supported by the World Bank, can be shared and exchanged with other riparian countries to increase water use efficiency and the water revenue collection rate and to save water. However, both good and bad experiences should be shared. Following the transfer of irrigation schemes to the user organizations some improvements are recorded in irrigation ratios, irrigation water fee collection rates, and financial cost reduction in irrigation systems operated by the IAs. However, system performance remained almost at the same level. The participatory aspect of the transfers in particular has been questioned owing to the exclusion of irrigators from IA general assemblies and boards. The top-down approach, adopted rather than a grassroots approach generated by farmer interest and involvement, has caused fierce debate over the characterization of the associations as democratic. Critics also stress that maintenance, rehabilitation and modernization of the irrigation canals, some of which are 50 years old, cannot be accomplished due to technical, administrative and legal capacity deficiencies of the IA.

Most of the irrigation schemes in the Euphrates-Tigris region are equipped with inefficient infrastructure. For example some irrigation schemes in the region still use open channels as means of water transportation rather than solid gutters or enclosed pipes, which lose far less water through seepage and evaporation. Furthermore, large areas in the Euphrates-Tigris region are irrigated not with sprinklers or drip irrigation, but rather by so-called simple surface irrigation, which consists of indiscriminately flushing water onto fields, the result of which is inefficient use of irrigation water. The application of water-saving techniques in irrigation could help to save 20–30 percent of irrigation demand. The use of water-saving innovations requires higher investments and necessitates education of the farmers, which may take years to progress. Nevertheless, once the full use of water is reached, water-saving techniques become compulsory as part of a scarcity regime.[77]

The price of the irrigation water is still based on operation and maintenance costs in all irrigation schemes and it is charged on per hectare basis, differentiated according to the crop. The recovery of capital costs has been low. There is almost no volumetric pricing system in irrigation. However, unfavorable global climate and economic conditions may further increase the stress in the water sector. Agriculture consuming about two thirds of water resources will bear the burden of adjustment to water scarcity. Fast implementation of the necessary policy measures at all levels will achieve more efficient use of public resources and water. More resources can be allocated to restrict water losses from irrigation infrastructure starting from the high evaporation regions. To illustrate, in Turkey, there have been improvements in adopting more efficient water application technologies (closed pipe systems; a system of loans are given to farmers to shift to pressurized irrigation: drip and sprinkler irrigation) induced by government subsidies. The uptake of these technologies by irrigators can be further increased by shifting towards volumetric pricing practices. The determination of irrigation fees proportional to the actual amount used will increase the efficiency in the use of irrigation water.[78]

[76] W. Scheumann (1998) „Conflicts on the Euphrates: An Analysis of Water and Non-Water Issues," in Scheumann and Schiffler (eds.), *Water in the Middle East*, Springer, pp.129-30.

[77] N. Bremer (2013) "Dams on Euphrates and Tigris: Impact and Regulation through International Law" in Kibaroglu et al., *Water Law and Cooperation in the Euphrates-Tigris Region*, Boston: Brill, pp. 145-176.

[78] E. Cakmak (2010) *Agricultural Water Pricing*, OECD Study Sustainable Management of Water Resources in Agriculture, Paris.