Chapter 3

Tigris River Basin

INVENTORY OF
SHARED WATER RESOURCES IN WESTERN ASIA (ONLINE VERSION)

german cooperation
DEUTSCHE ZUSAMMENARBEIT

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Tigris River Basin

The Tigris at Baghad, Iraq, 2010. Source: Larisa Epatko.

EXECUTIVE SUMMARY

The Tigris River is the second largest river in Western Asia. Its basin is shared by four countries: Iran, Iraq, Syria and Turkey. Besides contributions from precipitation that originates in the Armenian Highlands, the Tigris is fed by numerous tributaries that rise in the Zagros Mountains in Iran, Iraq and Turkey.

The Tigris has a higher water yield than the Euphrates River. Historically, the natural annual flow of the Tigris at the Iraqi-Syrian-Turkish border was around 21 BCM. In recent years, Tigris flow volumes have been affected by large water development projects in Iraq and Turkey. The flow volume records for Kut show a significant negative trend. Water supplies to the Mesopotamian Marshlands have also dwindled over the past 40 years.

In addition to Turkey's use of the Tigris River for the Southeastern Anatolia Project (GAP), Iraq has built several dams and diversion projects on the river, centring on the Tharthar Canal between the Euphrates and Tigris. Water from the Tigris is mainly used for agriculture, with irrigation projects in all riparian countries.

Water quality in the basin is primarily threatened by rising salinity rates resulting from intensive irrigated agriculture and high evaporation rates.

Apart from historic agreements that jointly address the Euphrates and Tigris Rivers, water resources in the Tigris Basin have not received much attention at the negotiation table. There is no basin-wide agreement in place, and the Tigris River has been the subject of only one bilateral agreement.

BASIN FACTS

RIPARIAN COUNTRIES	Iran, Iraq, Syria, Turkey
BASIN AREA SHARES	Iran 19%, Iraq 56.1%, Syria 0.4%, Turkey 24.5%
BASIN AREA	221,000 km^2
RIVER LENGTH	1,800 km
MEAN ANNUAL FLOW VOLUME	26 BCM (at Kut)
MAIN DAMS	14 (max. storage capacity 116.5 BCM)
PROJECTED IRRIGATED AREA (IN BASIN)	~4.6 million ha
PROJECTED IRRIGATED AREA (OUTSIDE OF BASIN)	150,000 ha
BASIN POPULATION	23.4 million

MAIN AGREEMENTS

IRAQ - TURKEY	1946 – The Treaty of Friendship and Good Neighbourly Relations is the first legal instrument of cooperation on water between the two riparian countries. Among others, it addresses flow regulation on the Tigris and Euphrates and their tributaries and the monitoring of flow data. The parties also commit to the principle of prior notification with regards to water infrastructure projects.
IRAN - IRAQ	1975 – Agreement on the use of shared watercourses in which the signatory parties agree on the division of a number of shared Tigris tributaries.
IRAQ - SYRIA	2002 – Agreement on the establishment of a pumping station on the Tigris River in Syria, specifying project area and volume of water extracted.
SYRIA - TURKEY	2009 – The Turkish-Syrian Strategic Cooperation Council Agreement covers water issues and can be regarded as the Turkish approval of Syria's pumping project on the Tigris River.

KEY CONCERNS

WATER QUANTITY

Water use for irrigation and hydropower production is constantly increasing, with numerous operational and planned projects along the river's main course and its tributaries placing pressure on flow regimes in the basin. Periodic droughts affect water supply and may impact water allocation to different sectors in the future. There is no basin-wide agreement and no common approach or consensus on how to regard the Euphrates and Tigris Rivers (i.e whether the two rivers should be considered part of a single watercourse system or as separate basins).

While the development of new infrastructure along the river course has in general not sparked disputes among basin countries, the Ilisu Dam Project in Turkey remains controversial. Iran's damming of the Wand River has also caused tensions between Iran and Iraq.

WATER QUALITY

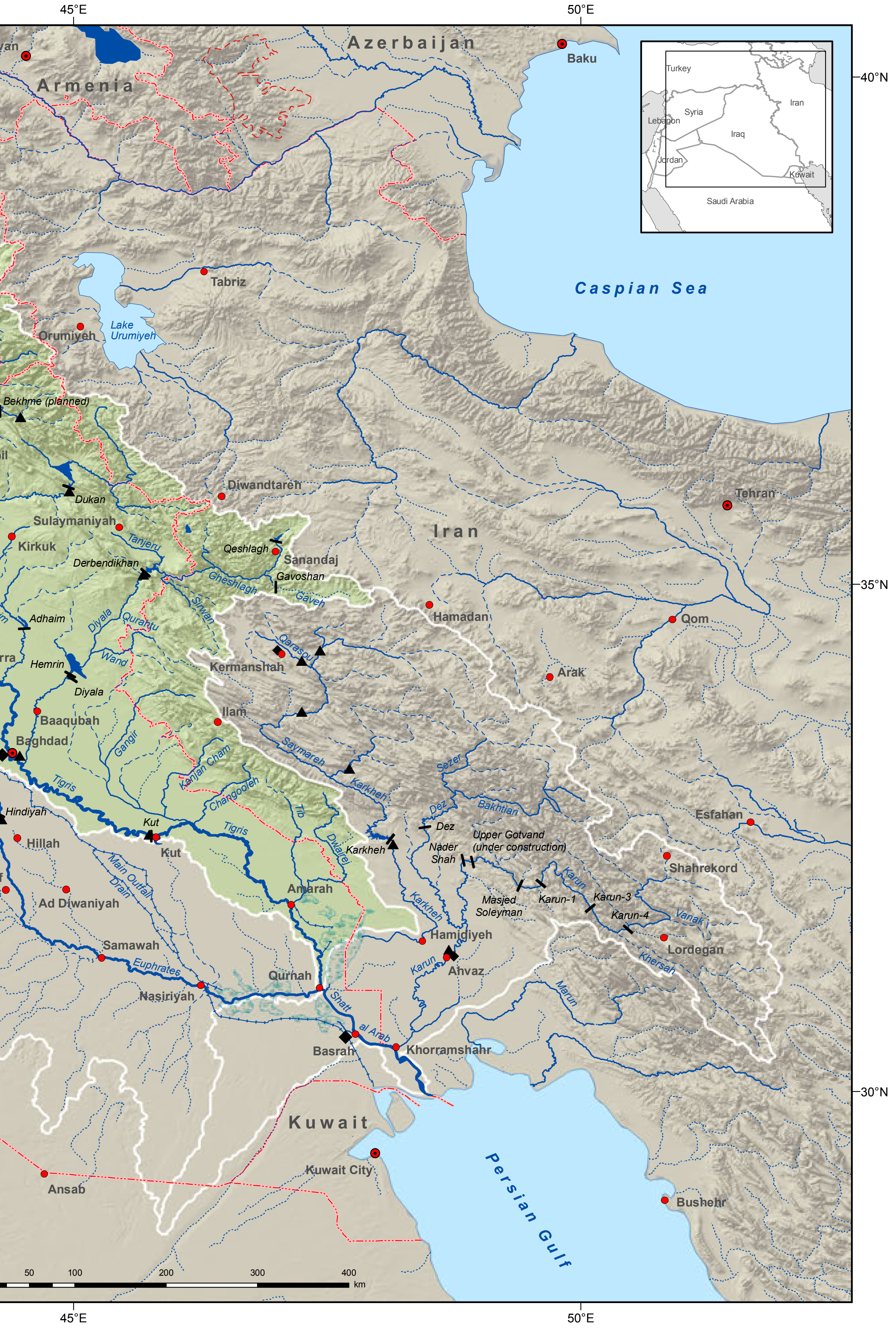
Water quality is relatively good in the upper part of the basin, but salinity levels increase in the Iraqi part of the basin.

Rising pollution from domestic and industrial sources is a cause for concern.

BIODIVERSITY

The Mesopotamian Marshes have suffered severe damage as a result of upstream damming projects in the 20th century, reducing the marshes to 14% of their original size. More than half of the original area of this unique freshwater system has recently been rehabilitated in a joint effort by the Iraqi Government and international organizations.

OVERVIEW MAP


45°E
50°E
40°N
35°N
30°N
Azerbaijan
Armenia
Baku
Caspian Sea
Tabriz
Lake Urumiyeh
Orumiyeh
Bekhme (planned)
Dukan
Diwandtareh
Tehran
Iran
Sulaymaniyah
Kirkuk
Tanjeru
Qeshlagh
Sanandaj
Gavoshan
Derbendikhan
Gheshlagh
Gaveh
Sirwan
Adhaim
Diyala
Quratu
Hamadan
Qom
Qarasou
Wand
Hemrin
Kermanshah
Arak
Diyala
Baaqubah
Ilam
Baghdad
Gangir
Saymareh
Kanjan Cham
Sezer
Tigris
Changooleh
Karkheh
Tib
Dez
Bakhtiari
Hindiyah
Kut
Tigris
Dez
Esfahan
Hillah
Kut
Duwairej
Karkheh
Upper Gotvand (under construction)
Nader Shah
Main Outfall Drain
Karun
Shahrekord
Amarah
Karun-1
Karun-3
Ad Diwaniyah
Masjed Soleyman
Karun-4
Karkheh
Vanak
Hamidiyeh
Lordegan
Samawah
Karun
Ahvaz
Khersan
Euphrates
Qurnah
Marun
Nasiriyah
Shatt al Arab
Basrah
Khorramshahr
Kuwait
Kuwait City
Ansab
Persian Gulf
Bushehr
50
100
200
300
400
km
Turkey
Syria
Lebanon
Iran
Iraq
Jordan
Kuwait
Saudi Arabia

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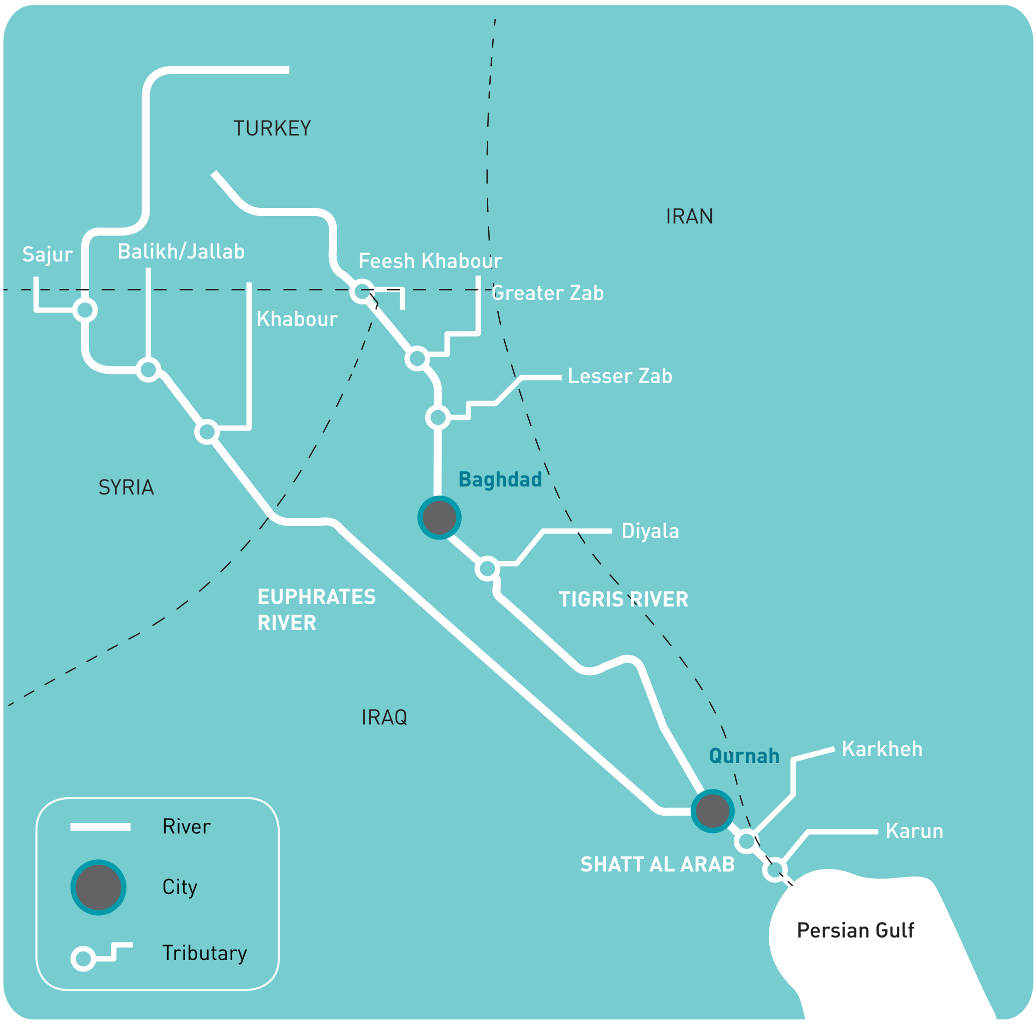
Defining the Euphrates-Tigris-Shatt al Arab Basins

The Euphrates-Tigris-Shatt Al Arab river system constitutes by far the largest surface water resource in the study area. Its combined topographic catchment covers more than 900,000 km^2 from the headwaters in the Taurus-Zagros Mountain Range to the Mesopotamian lowlands and the only outlet to the Persian Gulf, the Shatt Al Arab (Fig. 1). The overall basin is also home to around 54 million people in Iran, Iraq, Syria and Turkey. Given its importance and in order to adequately reflect the specific conditions as well as its complex hydrology, the Inventory dedicates five chapters to this river system.

The Euphrates River Basin (Chap. 1) and Tigris River Basin (Chap. 3) each have a different dynamic and set of characteristics, particularly with regard to their riparian countries, tributaries and contribution to discharge, as well as water use patterns and water quality. The shared tributaries of the Euphrates River (Chap.2) and the major shared tributaries of the Tigris River (Chap. 4) are covered in more detail in two separate chapters in order to highlight the role of these rivers and draw attention to local water issues and transboundary impacts. Chapter 4 also provides information on water use in Iran, which does not share the watercourse of the Tigris River itself but hosts important tributaries within the Tigris Basin. Finally, the Shatt al Arab River is discussed together with two additional major tributaries, the Karkheh and the Karun Rivers, which discharge directly into the Mesopotamian Marshes or the Shatt al Arab itself, and are hence neither part of the Euphrates or Tigris River basins (Chap. 5).

Figure 1. Sketch of the Mesopotamian river system

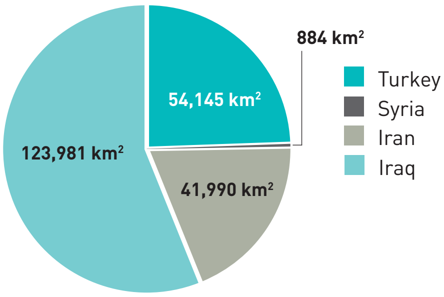


Source: Compiled by ESCWA-BGR.

Geography

The Tigris River originates in the Armenian Highlands in Turkey and flows south-east along a short stretch of the Syrian-Turkish border before entering Iraq (see Overview Map, Fig. 1). The river merges with the Euphrates River in southern Iraq to form the Shatt al Arab, which discharges into the Persian Gulf. The Tigris has four basin riparians: Iran, Iraq, Syria and Turkey. The basin extends over approximately 221,000 km², of which 24.5% is located in Turkey, 0.4% in Syria, 56.1% in Iraq and 19% in Iran (Figure 2).[1]

Figure 2. Distribution of the Tigris Basin area



Source: Compiled by ESCWA-BGR.

RIVER COURSE

The Tigris River is the second longest river in Western Asia, with a length of 1,800 km.[2] The river originates in the Taurus Mountains in Turkey, south of the Armenian Highlands and the city of Elazig, which lies at an altitude of 1,500 m asl. It is formed by the confluence of two headwater tributaries, the Batman, which drains from an altitude of approximately 4,000 m asl, and the Botan.

In general, the course of the Tigris is less meandering than that of the Euphrates. After covering a distance of almost 400 km in Turkey, it forms the Syrian-Turkish border[3] for about 47 km and then flows through Iraq for more than 1,350 km.

The Tigris Basin has a number of tributaries, most of which are shared by Iraq and Turkey or Iran and Iraq (Table 1).[4]

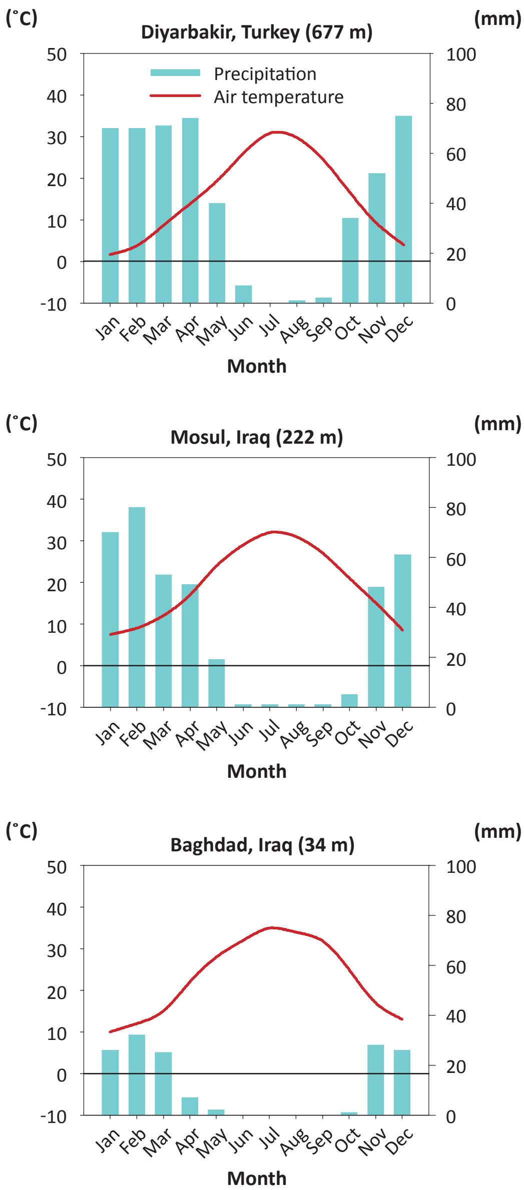
Table 1. Main tributaries of the Tigris River

HEADWATERS	
Batman	This river is a major tributary of the Tigris and originates in the Anti-Taurus Mountains in Turkey at an altitude of 2,500-4,500 m asl. The region is known for its oil fields.
Botan	This is a tributary of the Tigris in south-eastern Turkey. It comprises several small tributaries, some of which originate around Lake Van at an elevation of 1,000-1,500 m asl.
LOWER TRIBUTARIES	
Feesh Khabour	This tributary is shared between Iraq and Turkey. It rises in Sırnak, Turkey, and flows through Zakho, Iraq, before its confluence with the Tigris at the Iraqi-Turkish border. The Feesh Khabour delineates the international border between Iraq and Turkey. Its mean annual flow volume at the confluence with the Tigris is approximately 2 BCM.
Greater Zab	This river, which is shared by Iraq and Turkey, originates in Turkey and is the largest Tigris tributary. It supplies the Tigris River with an average annual flow volume of 12.7 BCM.
Lesser Zab	The Lesser Zab is shared by Iran and Iraq. It originates in Iran, not far from the Iraqi border. The average annual flow volume of the Lesser Zab is about 7.8 BCM, contributing an average of 249 m³/s to the Tigris.
Adhaim	While not a shared tributary in itself, the Adhaim is an intermittent stream that drains an area of about 13,000 km² in Iraq. The river generates about 0.79 BCM annually at its confluence with the Tigris and is subject to flash flooding.
Diyala	Shared by Iran and Iraq, this tributary also forms the border between the two countries for about 30 km. The Diyala has a mean annual flow volume of 4.6 BCM.
Tib	The Tib is shared by Iran and Iraq. Its average annual discharge is about 1 BCM.
Dwairej	The Dwairej originates in Iran and is shared with Iraq. Its average annual discharge is less than 1 BCM. The Dwairej meets the Tib in the city of Amarah.

Source: Compiled by ESCWA-BGR based on USGS, 2012; ACSAD and UNEP-ROWA, 2001; Shahin, 2007; FAO, 2009; UN-ESCWA, 1981; Ministry of Environment in Iraq et al., 2006a.

Six main tributaries and several smaller rivers join the Tigris in Iraq. The river receives water from its first upstream tributary, the Feesh Khabour,[5] in the border region before flowing through Iraqi Kurdistan for almost 190 km and crossing Mosul, the largest city in northern Iraq. Downstream from Mosul, two shared tributaries, the Greater and Lesser Zab (or Little Zab), contribute to the Tigris. Farther downstream, the smaller Adhaim River, which originates in Iraq, joins the Tigris. North of Baghdad, a barrage diverts water from the Tigris to the Euphrates via the Tharthar Canal. Downstream of Baghdad, the Tigris flows through a flat landscape for 343 km, where it receives water from the shared Iranian-Iraqi Diyala River and several wadis before forming the Shatt al Arab at the confluence with the Euphrates near the city of Qurnah.

Figure 3. **Climate diagrams for Diyarbakir in Turkey, Mosul in Iraq and Baghdad in Iraq**



Source: Compiled by ESCWA-BGR based on data provided by WorldClim, 2011; Climate Diagrams, 2009; Phytosociological Research Center, 2009.

CLIMATE

The climate in the Tigris Basin ranges from semi-humid in the headwaters to the north, to semi-arid close to the confluence with the Euphrates in southern Iraq. Mean annual basin precipitation is estimated between 400 and 600 mm (Figure 4). However, values of 800 and 150 mm have been registered in the upper and lower parts respectively. Figure 3 illustrates the shift from a more humid climate to an increasingly hot and dry climate (see Overview Map for locations). Mean precipitation in the Tigris Basin is significantly higher than in the Euphrates Basin (approx. 300 mm/yr). This difference can be attributed to the high precipitation rates in the Zagros Mountains in the east of the Tigris Basin, which contributes to Tigris stream-flow. Precipitation mostly occurs between November and April, with snowfall in the mountains from January to March.[6]

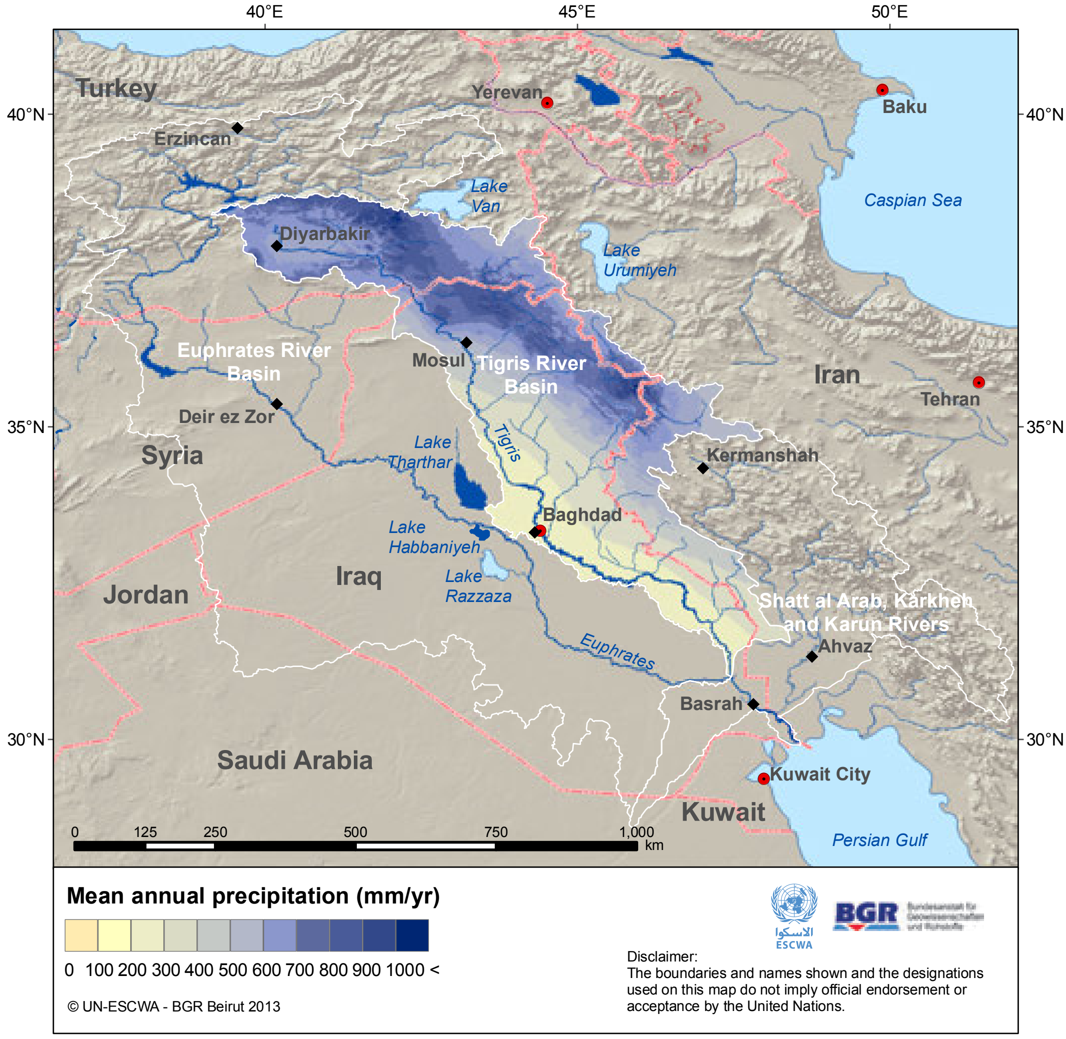
Given the semi-arid to arid climate in the lowlands of Iraq and Syria, evapotranspiration causes considerable water loss in the Mesopotamian region.[7] Air temperatures in the Tigris Basin range from -35°C in winter in the Armenian Highlands to 40°C in summer on the Jezira Plateau.[8]

POPULATION

The Tigris Basin comprises a total population of 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.

Hasankeyf, Turkey, 1992. Source: Ed Kashi/VII.

Figure 4. Mean annual precipitation in the Tigris Basin



Source: Compiled by ESCWA-BGR based on data provided by WorldClim, 2011.

Table 2. Estimated basin population

RIPARIAN COUNTRY	COUNTRY POPULATION (MILLIONS)	ESTIMATED POPULATION IN THE BASIN		SOURCE
		MILLIONS	AS PERCENTAGE OF TOTAL BASIN POPULATION	
Turkey	73.7	3.47	14.8	Turkstat, 2010.[a]
Syria	20.9	0.05	0.2	Central Bureau of Statistics in the Syrian Arab Republic, 2010.[b]
Iraq	32	18.4	78.7	Central Organization for Statistics in Iraq, 2010.[c]
Iran	..	1.48	6.3	Statistical Center of Iran, 2006.[d]
Total		23.4		

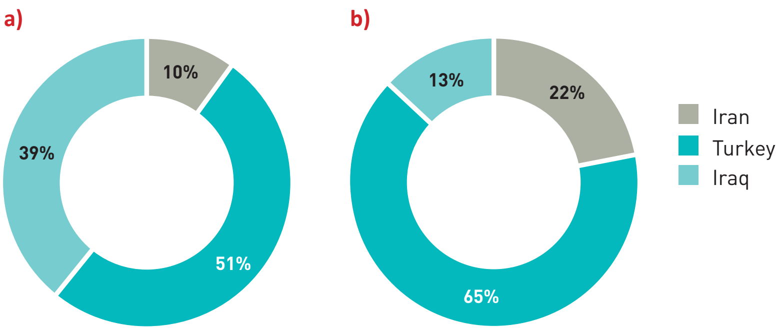
Source: Compiled by ESCWA-BGR.
(a) The population estimate for the area of the basin situated in Turkey is based on a 2010 census and includes populations living in the Turkish provinces of Batman, Diyarbakir, Hakkari, Siirt, as well as parts of the provinces of Bitlis, Mardin and Van.
(b) The population figures for the area of the basin situated in Syria is based on a 2010 estimate and only covers parts of Hasakah Governorate.
(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.
(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.

Hydrological Characteristics

The Tigris River waters mainly originate in Iran, Iraq and Turkey. Syria does not contribute any significant discharge to the river. In the absence of measured water balance data, riparian contributions are expressed as ranges: upstream Turkey contributes an estimated 40-65% of the river's annual discharge,[9] Iraq 10-40%,[10] while Iranian headwaters and tributaries are estimated to contribute between 5% and 25% to Tigris river flow. The most recent estimates are represented in Figure 5.[11]

The Tigris is mainly fed by precipitation that falls in the Armenian Highlands and Zagros Mountains in Turkey, near the country's south-eastern border with Iran.[12] While the Tigris headwaters lie in Turkey, most of its tributaries originate in Iran and join the Tigris in the Iraqi Lowlands.

Figure 5. Riparian contribution to annual discharge of the Tigris based on published data



Source: Compiled by ESCWA-BGR based on (a) MacQuarrie, 2004, p.7, (b) FAO, 2009; El-Fadel et al., 2002, p. 101.

ANNUAL DISCHARGE VARIABILITY

Available flow data for the Tigris River covers the period 1931-2011 and comes from the Mosul and Kut gauging stations (see Overview Map for location). In order to allow for comparison of the flow along the Tigris main stream, common periods have been selected (Table 3) for both stations. The period 1931-1973 was selected as it represents the near-natural flow of the river. The records for the station at Mosul represent the river's natural flow after crossing the border between Turkey and Iraq as no dams were built on the Turkish stretch of the Tigris until the 1990s. During the second period from 1974 until 2005 major water infrastructure projects were implemented in the basin, though the Tharthar Dam was already built in the 1950s.

The mean annual flow for the entire period of record is 20 BCM at Mosul and 25.7 BCM at Kut. Maximum flow levels were recorded in 1969 with 43.1 BCM at Mosul and 59.2 BCM at Kut in 1946. This contrasts with the lowest annual flow of 6.5 BCM at Mosul in 1999 and 4.2 BCM at Kut in 2001.

Table 3. Summary of annual flow volume statistics for the Tigris River in Iraq (1931-2011)

STATION (DRAINAGE AREA, km²)	PERIOD	MEAN (BCM)	MINIMUM (BCM)	MAXIMUM (BCM)	CV[a] (-)
Mosul (56,000)	1931-2011	20.0	6.5	43.1	0.36
	1931-1973	**21.3**	**11.7**	**43.1**	**0.34**
	1931-1952	19.4	12.2	27.6	0.25
	1953-1984	22.0	11.7	43.1	0.35
	1974-2005	**19.5**	**6.5**	**41.7**	**0.38**
	1985-2005	**19.1**	**6.5**	**41.7**	**0.45**
Kut (173,000)	1931-2005	25.7	4.2	59.2	0.51
	1931-1973	**32.0**	**15.2**	**59.2**	**0.36**
	1931-1952	36.8	15.2	59.2	0.29
	1953-1984	24.5	13.2	50.3	0.37
	1974-2005	**16.7**	**4.2**	**47.5**	**0.58**
	1985-2005	**13.9**	**4.2**	**47.5**	**0.76**

Source: Compiled by ESCWA-BGR based on USGS, 2012; Ministry of Water Resources in Iraq, 2012.
(a) Coefficient of Variation. For information on the definition and calculation of the CV see 'Overview & Methodology: Surface Water' chapter.

Tributary contribution

In contrast to the Euphrates River which has few tributaries, the numerous tributaries originating in the Zagros Mountains make significant contributions to runoff along the course of the Tigris River.[13] Flow contribution to the mean annual flow volume of the Tigris from tributaries located between Mosul and Kut amount to an estimated 25 BCM.[14] In the literature these contributions are often referred to as significant, accounting for 50% of the Tigris flow in Baghdad.[15]

The addition of 25 BCM to the near-natural mean annual flow volume of the Tigris at Mosul (approx. 21 BCM for the period 1931-1973,

Table 3) would be expected to produce a 46 BCM flow volume at Kut. However, the actual mean annual Tigris flow volume at Kut for the same period was around 32 BCM. There are various explanations for this surprisingly large difference, including hydrological measurement errors, and large-scale abstraction between Mosul and Kut for flood control or other purposes.

Negative trend

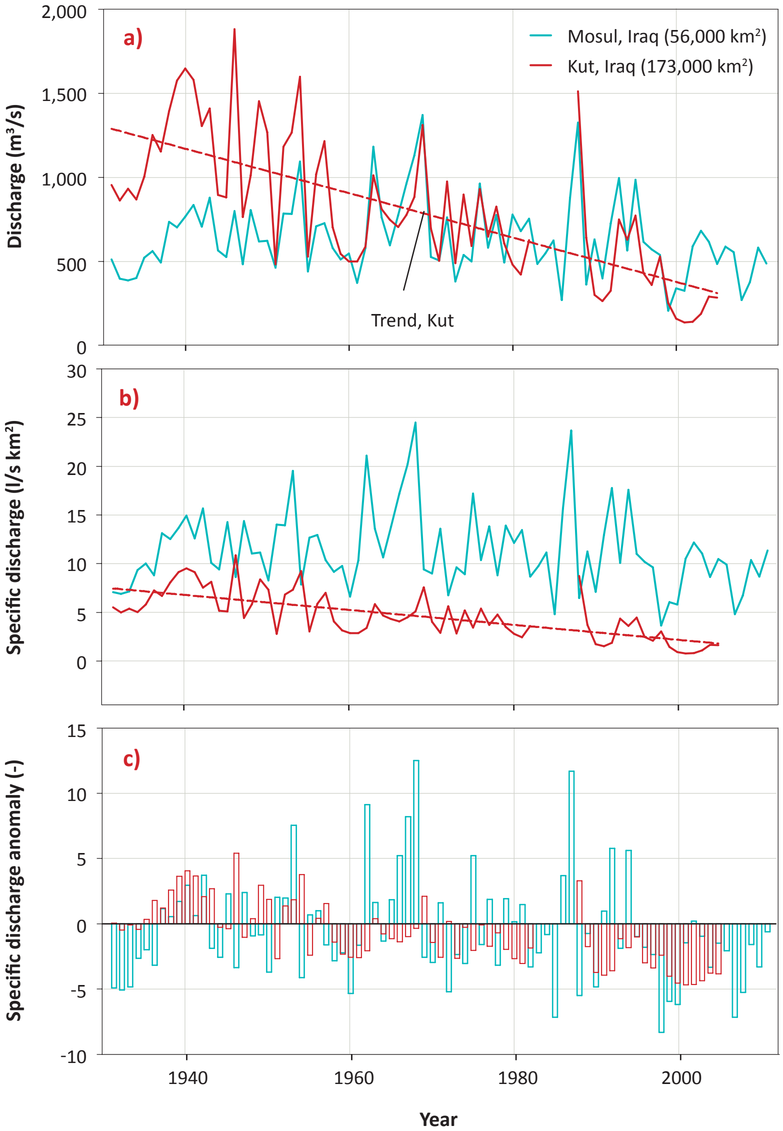
Figure 6 shows the mean annual discharge time series for gauging stations near the city of Mosul and farther downstream near Kut in Iraq over the period 1931 to 2011. Based on the available discharge data, mean water yield of the Tigris River appears to exceed Euphrates water yield. No trend can be observed at Mosul, while at Kut the records show a significant negative trend. It should be noted, however, that the data record at Kut exhibits more data gaps and missing values than the discharge record at Mosul, which may bias the trend analysis.[16] In terms of discharge anomalies (Figure 6c), a major wet period in the 1960s is more pronounced compared to the overall mean. Below average values since the 1990s can also be observed.

Comparison

Table 3 provides no clear evidence that the mean annual flow volume has decreased significantly upstream of Mosul since 1974. However, river runoff is currently controlled by several dams in Iraq (Table 4), with more dams under construction and in planning stages (Table 5). This may have led to a significant reduction in flow volumes farther downstream, especially between Mosul and the confluence with the Euphrates in Qurnah. This is evident from the increased flow variability that may be caused by reservoir operations at Kut since 1973[17] and the reduction in mean annual flow volume (from 32 BCM before 1973 to 16.7 BCM after 1973).

According to the New Eden Master Plan for the Sustainable Development of the Iraqi Marshlands (a joint project between three Iraqi ministries),[18] there is also a significant difference between pre- and post-1990 measurements in terms of annual flow volumes. The natural Tigris water regime has been affected by the construction of large water control structures in Iraq and Turkey. A report published by the New Eden Master Plan claims that flow peaks in southern Iraq have disappeared since the construction of new dams in the 1990s (Table 4). This has in turn impacted the ecosystem of the Mesopotamian Marshlands in Iraq, which depend on regular high flows and floods. Before 1990, annual water availability in the Mesopotamian Marshlands was estimated

Figure 6. a) Mean annual discharge, b) specific mean annual discharge and c) discharge anomaly time series of the Tigris (1931-2011)



Source: Compiled by ESCWA-BGR based on data provided by Hydrological Survey of Iraq, 1958; Ministry of Irrigation in Iraq in ACSAD and UNEP-ROWA, 2001; USGS, 2012; Ministry of Water Resources in Iraq, 2012.

at 47.5 BCM. After 1990, this figure dropped to a maximum of 24 BCM, with minimum flows of 4.2 BCM recorded in 2001.

The comparison of available data records for the station in Kut supports the claim by the New Eden Master Plan. Table 3 shows a decrease in annual flow volume of around 10 BCM between the 1953-1984 period and the 1985-2005 period.

FLOW REGIME

The Tigris river flow regime can be considered natural before the 1970s, with limited water regulation in the runoff generation area in Turkey, Iran and Iraq upstream of Mosul. This natural flow regime is represented in Figure 7a and shows a high-flow season from February to June and a low-flow season from July to January. The increased discharge during the high-flow period is typically generated by snow-melt and increased precipitation in the Turkish and Iraqi-Iranian mountains. Such a rainfall/snow-melt regime was typical for the 1931-1973 period of record at Mosul and farther downstream at Kut. However, if the stream-flow regime is split into a pre-1973 and post-1973 period, a significant modification with largely reduced high flows and increased low flows becomes apparent at Kut. No significant changes in the stream-flow regime are discernible at Mosul for the same period.

Compared to the Euphrates flow regime, the Tigris high-flow season is much longer and more pronounced due to higher winter precipitation over a much greater basin area.[19] The gradual melting of snow cover in the headwater region of the Tigris River and its tributaries helps to maintain water levels. Peak discharge in the Tigris Basin generally occurs in April, a month before the peak of the Euphrates River. One study based on measurements from Iraq claims that the March-May high-flow season accounts for more than half of the mean annual flow volume of the Tigris.[20]

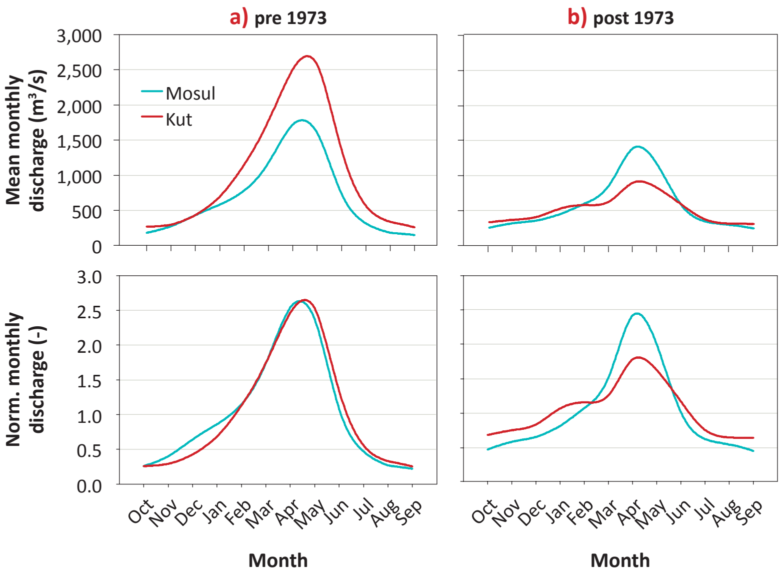
Minimum flow generally occurs in September. In Mosul, a lowest monthly discharge of 87.7 m^3/s was recorded in September 1935, while measurements at the station near Kut indicated a minimum monthly discharge of 219 m^3/s for the same period.[21]

GROUNDWATER

Little is known about hydrogeological connectivity between Iraq and Turkey in the Tigris Basin.[22] However, piezometric water levels in the Jezira Aquifer, which is located north-east of the Tigris Basin, suggest a hydraulic connection, with water flowing towards Turkey and possibly entering the country via outcropping aquifers.

A minor inflow of groundwater may occur in the area where the river runs along Syria's north-eastern border, with water flowing in from the unconsolidated Pliocene aquifer. The water of small springs issuing from aquiferous basalts or from underlying Pliocene conglomerates in that area is generally consumed before it reaches the Tigris River.[23] As such, there are virtually no exploitable groundwater resources in the small Syrian section of the Tigris Basin.

Figure 7. Mean monthly flow regime of the Tigris River at different gauging stations for different time periods (1931-2011)



Source: Compiled by ESCWA-BGR based on data provided by Hydrological Survey of Iraq, 1958 and Ministry of Irrigation in Iraq, 1999 in ACSAD and UNEP-ROWA, 2001, p. 59; USGS, 2012; Ministry of Water Resources in Iraq, 2012.

There is limited evidence that groundwater flows south-west from the southern part of the Taurus-Zagros Aquifer System towards Iraq. Additionally, it is assumed that some groundwater moves between Iraq and Iran in the south-western Mesopotamian Plain. It has also been suggested that the lower part of the Mandali-Badra-Tib Aquifer lies within Iraq, whereas the higher parts of this aquifer system are mostly located in Iran.[24]

In north-western Iraq, groundwater from Neogene Aquifers discharges mainly into the Tharthar Depression (Wadi Tharthar and Lake Tharthar), extending west of the Tigris River. Natural conditions have changed due to the diversion of water from the Tigris into the Tharthar Depression, with Lake Tharthar presently recharging the Quaternary Mesopotamian aquifer south of the lake.[25]

Between Fatha and Tikrit in north-western Iraq, the Tigris River drains groundwater from the Neogene and Quaternary aquifers on both banks. Between Tikrit and Samarra, the effluent conditions along the river seem to be retained on its western bank only, while the eastern bank becomes influent.[26] Groundwater moves in the Quaternary aquifer from the Tigris River to local depressions in the east.

Water Resources Management

Several major dams and diversion structures have been built on the Tigris and its main tributaries since the 1930s. They serve multiple purposes, but the most important is to regulate river flow. These structures have paved the way for large irrigation projects, including integrated irrigation-drainage systems. Maximum capacity of the main dams in the Tigris Basin is estimated at 116.5 BCM (Table 4 and 6).

DEVELOPMENT & USE: TURKEY

The Tigris River was the last major river system in Turkey to be developed, as geographic conditions in the basin made large-scale developments more difficult than in the Euphrates Basin. Nevertheless, due to its upstream riparian potential, Turkey has started to make more use of the Tigris in recent years.

Initial projects launched in the 1940s focused on hydroelectric power production and support for irrigated agriculture in the lower parts of the basin.[27] In the early 1970s, Turkey developed a series of ambitious schemes on the Euphrates and Tigris Rivers as part of the Southeastern Anatolia Project (GAP).[28] Plans for dams, power plants and irrigation areas in the Turkish part of the Tigris Basin were first touted as the "Western Tigris Development Plan".[29] At a later stage, GAP also included infrastructural development in the lower section of the Turkish Tigris Basin. Turkey has to date built eight large dams and eight hydroelectric power plants on the Tigris River and its tributaries as part of GAP.

The project also aims to establish a reservoir system on the upper Tigris River for flow regulation. The Ilisu Dam Project lies at the heart of this system, with a hydroelectric power generation capacity in the range of 1,200 MW.

The Ilisu Dam is assumed to substantially attenuate floods and increase seasonal low flows.[30] However, the project, which includes

Table 4. Main dams on the Tigris River in chronological order of construction

COUNTRY	NAME	COMPLETION YEAR	CAPACITY (MCM)	PURPOSE[a]	BACKGROUND INFORMATION
Iraq	Kut	1939	-	I	This barrage was constructed in the city of Kut to provide irrigation water for the surrounding area.
	Tharthar (Samarra Barrage)	1954	85,000	FC, I, HP	Diverts floodwater through a 64 km canal to Lake Tharthar. Water is then conveyed to the Euphrates through a 37 km canal with a 550 m^3/s capacity. Lake Tharthar (the reservoir) covers an area of 2,420 km^2, with estimated evaporation losses of 2.86 km^3/yr.
	Mosul (Chambarakat, formerly Saddam Dam)	1985	11,100	HP, FC, I	Located upstream of the city of Mosul, this is the largest dam in Iraq. It is mainly a hydroelectric dam with a capacity of 350 MW that provides electricity to the estimated 1.7 million inhabitants of Mosul.
Turkey	Goksu	1991	600	I	The dam supports the Cinar-Goksu Irrigation Project that irrigates an area of 3,582 ha.
	Kralkizi	1997	1,900	HP	Hydropower capacity: 90 MW
	Tigris (Dicle)	1997	6,000	HP, I, WS	Hydropower capacity: 110 MW Projected irrigated area: 128,080 ha
	Batman	1999	1,200	I, HP, FC	Hydropower capacity: 198 MW Projected irrigated area: 37,744 ha
	Garzan	..	..	HP, I	Hydropower capacity: 89 MW Projected irrigated area: 60,000 ha

Source: ESCWA-BGR based on ACSAD and UNEP-ROWA, 2001, p. 78-80; Ministry of Water Resources in Iraq, 2009; General Directorate of State Hydraulic Works in Turkey, 2009; Isaev and Mikhailova, 2009, p. 384; Ministry of Environment in Iraq et al., 2006a.
(a) Irrigation (I), Flood Control (FC), Hydropower (HP) and Water Supply (WS).

the planned downstream Cizre Dam, has sparked public controversy resulting in building freezes and protests. In 2010, construction work restarted despite ongoing protests (Box 1).

In the long term, GAP irrigation schemes in the Tigris Basin aim to cover an area of 600,000 ha with a potential water consumption of 5.6 BCM.[31] Most of this capacity remains in the planning stages. According to the Turkish State Hydraulic Works (DSI), approximately 42,000 ha of the GAP irrigation network sourced from the Tigris are operational, while 53,400 ha are currently under construction (Figure 8).[32]

Due to its geographic position, Turkey controls about a third of the total Tigris flow[33] and its influence on the river's water regime is constantly growing. Theoretically, Turkey could also use the Greater Zab headwaters, as this tributary originates in Turkey before it flows into Iraq. The region's topography, however, would make this a challenging endeavour.

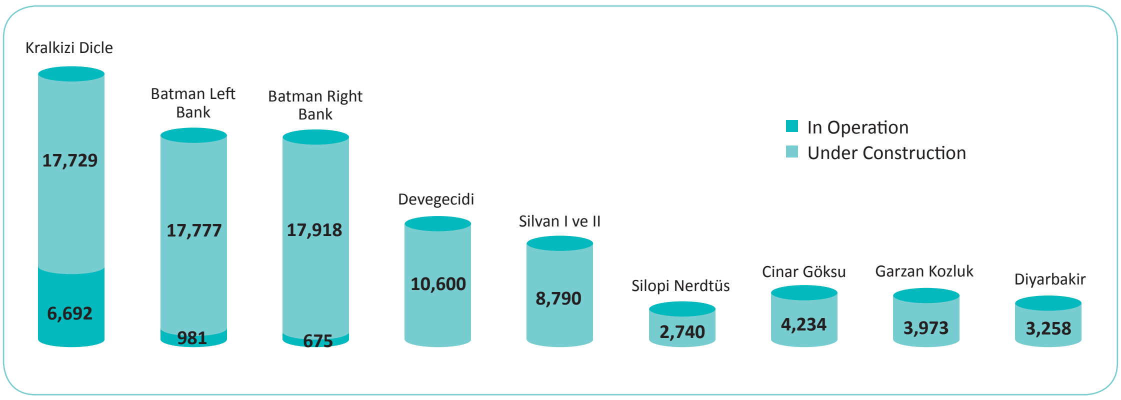
The Tigris River at Baghdad, Iraq, 2006. Source: James Gordan.

Table 5. **Planned dams in the Tigris Basin in Turkey**

NAME	STATUS	CAPACITY (BCM)	PURPOSE[a]	BACKGROUND INFORMATION
Ilisu	Construction started in 2006, but was suspended in 2008. Work resumed in March 2010.	10.41	HP	Planned hydropower capacity: 1,200 MW Projected irrigated area: 313,000 ha
Cizre	Construction was to begin in June 2008. Completion scheduled: 2017.	0.36	HP	The downstream Cizre Dam will work in parallel with the Ilisu Dam. Planned hydropower capacity: 240 MW Projected irrigated area: 121,000 ha
Silvan	Construction started in 2012.	..	HP	Planned hydropower capacity: 150 MW
Kayseri	Master plan completed.	..	HP	Planned hydropower capacity: 90 MW

Source: Compiled by ESCWA-BGR based on ACSAD and UNEP-ROWA, 2001, p. 78-80; Ilisu Environment Group, 2005, p. 17; Spiegel Online, 2010 (on Ilisu); Angell, 2009; Environmental Consultancy Co., 2005, p. 4; General Directorate of State Hydraulic Works in Turkey, 2009; Ministry of Environment in Iraq et al., 2006a.
(a) Hydropower (HP).

Figure 8. **Irrigated area as part of GAP in the Tigris Basin in Turkey (ha)**



Source: Compiled by ESCWA-BGR based on data provided by General Directorate of State Hydraulic Works in Turkey, 2009.

BOX 1

The Ilisu Dam Project

The controversial Ilisu Dam Project has raised concerns among a wide range of stakeholders including the main Tigris riparians, local residents who will be displaced, export credit agencies and international non-governmental organizations. While the dam's design was finalized in 1982, social, historical, environmental and financial concerns have stalled its implementation for decades.

As one of a total of 22 dam projects in the Southeastern Anatolia Project (GAP), the Ilisu Dam will be located near the Kurdish village of Ilisu, about 65 km from the Syrian-Turkish border. It will be the largest hydroelectric power plant in GAP with a hydropower capacity of 1,200 MW, producing an expected 3,800 GWh/yr. With a planned height of 135 m, the dam will have a 10.4 BCM reservoir. The Ilisu Project includes plans to build the smaller Cizre Dam for irrigation purposes and additional hydropower production.

The entire project cost was estimated at USD 1.7 billion and was initially supported by an international consortium of export credit agencies from Austria, Germany, Italy, Japan, Portugal, Sweden, Switzerland, the United Kingdom and the United States of America. The project itself and the policies of the consortium were heavily criticized by several environmental and human rights groups.

Critics of the project claim that the region's cultural heritage will suffer irreparable damage with the flooding of the ancient city of Hasankeyf and neighbouring areas and the involuntary resettlement of about 50,000 people, while at the same time causing further environmental damage to the Mesopotamian Marshlands.

Construction began in August 2006, but was interrupted two years later following a successful campaign launched by environmental groups and international organizations. This led to the cancellation of international funding support from European governments and several private firms.

Determined to see the project through, Turkey sought other lenders, both domestically and abroad. Construction work resumed in 2010. The project aims to meet the country's rising energy demand, create jobs and stimulate economic growth in Turkey's impoverished south-east.

DEVELOPMENT & USE: SYRIA

Syria is a minor Tigris riparian as the river defines only a short stretch of the Syrian-Turkish border. The country only exploits the basin's water resources for small-scale agricultural activity and domestic use.

However, in mid-2010, Syria launched the first phase of an irrigation project on the Tigris River.[34] The project is based on a 2002 agreement between Syria and Iraq, which authorizes Syria to pump an annual 1,250 MCM from the Tigris River.[35] 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 (see Chap. 2)[36] through an inter-basin water transfer.[37] The project also aims to generate hydroelectricity and strengthen the local economy by improving agricultural yield.[38]

DEVELOPMENT & USE: IRAQ

Iraq has a long history of water use in the Tigris Basin and was also the first riparian to develop irrigation projects, and construct dams, barrages and cross regulators on the river and its tributaries. Early engineering projects

Table 6. Main constructed dams on the Tigris tributaries in Iraq

NAME (RIVER)	COMPLETION YEAR	CAPACITY (MCM)	PURPOSE[a]	BACKGROUND INFORMATION
Dukan (Lesser Zab)	1961	6,800	I, HP	The purpose of the dam is to store and regulate flows for the Kirkuk Irrigation Project. Hydropower capacity: 400 MW
Dibis (Lesser Zab)	1965	3,000	I	The Dibbis Regulator project has four primary components: the main dam, the spillway and fish pass, the fuse plug (emergency spillway) and the head regulator for the Kirkuk Irrigation Project.
Derbendikhan (Diyala)	1962	3,000	I, HP, FC	Hydropower capacity: 240 MW
Hemrin (Diyala)	1981	2,400	I, HP	Hydropower capacity: 50 MW
Diyala (Diyala)	1969	..	I, FC,HP	-
Adhaim (Adhaim)	1999	1,500	FC, I, HP	The Adhaim Dam project is located about 70 km upstream from the Adhaim's confluence with the Tigris. It diverts water at the confluence of the Adhaim and the Aq Su Rivers. Hydropower capacity: 28 MW

Source: Compiled by ESCWA-BGR based on ACSAD and UNEP-ROWA, 2001, p. 78-80; General Directorate of State Hydraulic Works in Turkey, 2009; Ministry of Environment in Iraq et al., 2006a; The Iraq Foundation, 2003.
(a) Irrigation (I), Hydropower (HP) and Flood Control (FC).

included the 1939 Kut Barrage and the 1956 Tharthar System Barrage, two water regulation projects with limited irrigation capabilities. The Tharthar Dam and Canal were constructed north-west of Baghdad in the 1950s to protect it from flooding. The scheme diverts floodwater from the Tigris through the 64 km Tharthar Canal to the Euphrates River. Completed in 1977, the project is regarded as the cornerstone of Iraq's surface water management system.[39]

A number of important reservoirs and regulating structures were built on the eastern tributaries of the Tigris between the 1960s and 1980s, including the Dukan and Dibis Dams on the Lesser Zab, and the Derbendikhan Dam on the Diyala. Other dam projects followed, including the Mosul Dam, which has one of the largest reservoirs in Iraq.[40] It is mainly used for hydropower production, but also serves irrigation and flood control purposes (Table 4).

The Tharthar Canal, which connects the Tigris to the Euphrates, is the cornerstone of Iraq's water development system. The Tharthar Dam has allowed Iraq to overcome water shortages in the Euphrates Basin by diverting water from the Tigris to the Euphrates via Lake Tharthar. The capacity of Lake Tharthar is twice that of the Atatürk Dam reservoir in Turkey and equal to the operating capacity of the Aswan Dam in Egypt.[41] The Main Outfall Drain, formerly known as the Saddam River, was constructed to collect drainage water from more than 1.5 million ha of agricultural land between the Euphrates and Tigris Rivers (see Chap. 1, Box 4).[42] Iraq constructed several other canals in the Tigris Basin, including the East al Gharraf Drain and the Tigris East Drain, for the purpose of land reclamation and drainage. The main irrigation canal in the Tigris Basin is the 170 km Shatt al Gharraf which irrigates an area of 700,000 ha.[43]

Table 7. **Planned dams in the Tigris Basin in Iraq**

NAME (RIVER)	STATUS	CAPACITY (MCM)	PURPOSE[a]	BACKGROUND INFORMATION
Badush (Tigris)	Partially constructed. Completion scheduled: 2015	10,000	HP	Planned hydropower capacity: 170 MW
Bekhme Dam (Greater Zab)	Partially constructed	17,000	HP	Planned hydropower capacity: 150 MW
Mandawa (Greater Zab)	Completion scheduled: 2015	..	HP, I	-
Taq Taq (Lesser Zab)	Completion scheduled: 2015	..	HP, I	-

Source: Compiled by ESCWA-BGR based on UNESCO, 2009.
(a) Hydropower (HP) and Irrigation (I).

Agriculture in the region of Arbil, Iraq, 2007. Source: Ben Barber, USAID.

Agriculture

In the mid-1970s, Iraq irrigated approximately 5.6 million ha of land, of which almost 70% (3,825,000 ha) were located in the Tigris Basin.[44] The river currently irrigates around 4 million ha of land in Iraq.[45]

The largest irrigation projects in the Tigris Basin in Iraq include the Kirkuk Irrigation Project in the Adhaim Basin, the North Jezira Irrigation Project and the East Jezira Irrigation Project. Launched in 1983, the Kirkuk Irrigation Project initially irrigated 87,500 ha, with plans to expand to a total of 300,000 ha. The North Jezira Irrigation Project was initiated in the early 1990s to supply approximately 60,000 ha with water from the Mosul Dam. The East Jezira Irrigation Project created irrigation networks on about 70,000 ha of rain-fed land near Mosul. The latter two projects were part of a scheme to irrigate 250,000 ha of land in the Jezira Plain.[46] Iraq launched several other irrigation projects before the 1991 Gulf War, most of them focused on draining the Iraqi marshlands (Box 2).

In recent decades, Iraq's agricultural and water resources policies have focused on land reclamation with the expansion of irrigation networks and drainage systems to improve soil productivity. As a result, an area of approximately 1 million ha was reclaimed, in addition to 1.5 million ha of semi-reclaimed land.[47] Land reclamation projects in the Tigris Basin are situated in Kirkuk and Diyala Governorates and in the area south of Baghdad.

In an attempt to rehabilitate agricultural infrastructure, the ministries responsible for water resources, irrigation and agriculture are planning to implement several integrated irrigation projects using both surface and groundwater resources. Planned projects include the reclamation of 920,000 ha by 2015 and the irrigation of 134,000 ha of new land in Kirkuk Governorate and in the eastern and southern Jezira. Irrigation rehabilitation projects have also been implemented on almost 800,000 ha.[48]

WATER QUALITY & ENVIRONMENTAL ISSUES

Rising salinity in the basin is causing soil degradation and impacting surface and groundwater quality. Salinization is mainly caused by intensive irrigated agriculture and high evaporation rates.[49] However, water resources in the Tigris Basin are also threatened by other sources of pollution, such as untreated sewage and contamination by heavy metals.

In Turkey, salinity poses no threat to agricultural activities in the basin. Here the Tigris exhibits acceptable Electrical Conductivity (EC) values, with a mean value of 330 μS/cm for the period between 1971 and 2002[50] and 433 μS/cm for the period between 1995 and 2002.[51] However, other forms of pollution occur in this upstream part of the river, with a number of large urban settlements directly discharging untreated domestic and industrial wastewater into the river.[52] Pollution sources also include effluents from a copper plant, agricultural runoff and irrigation return flows.[53] The high levels of heavy metals in the river sediments can accumulate in aquatic organisms, which may in turn enter the human food chain and cause toxicity.[54] Moreover, samples taken in 2008 have shown that mean concentrations of Total Phosphorus (TP) were above 0.075 mg/L in most places, indicating the onset of eutrophication.[55] The increase in phosphorus concentrations coupled with the constant discharge of untreated wastewater has led to the depletion of Dissolved Oxygen (DO) in the river, particularly in the town of Diyarbakir, where wastewater from domestic and industrial sources drain directly into the Tigris.[56]

Downstream in Iraq, untreated wastewater from urban areas is released into the river, carrying discharges from domestic and industrial users, as well as hotels and hospitals.[57] Return flows from irrigated agriculture further affect water quality.[58] Pollution rates are highest near major cities such as Baghdad and Mosul.[59]

Salinity poses a greater problem in Iraq than in Turkey. Based on salinity data compiled from different sources, the general trend displays a gradual increase in salinity along the course of the Tigris, as shown in Figure 9. The effect of salinization is amplified in the central and southern parts of the Mesopotamian Plain as a result of higher evaporation rates and intensive irrigation in the area.[60] Moreover, salinity values increase sharply downstream of Baghdad, making the water unsuitable for agricultural use.[61] In addition to pollution from human sources in this area, the river also receives saline groundwater from the floodplains that extend to the south-west until Basrah.[62] The problem is exacerbated during summer months when the river's discharge is reduced. Water quality is further threatened by irrigation return flows from the Tigris tributaries originating in Iran.[63] With regard to temporal variations in salinity, no clear trend can be deduced based on the available data (Figure 9 and Table 8), even though some sources suggest an increase over the years.[64]

The water quality of the Tigris in Iraq has also been affected by bacterial contamination, with levels of coliform bacteria exceeding maximum recommended limits[65] (faecal coliform counts reached levels as high as 170,000 cfu/100 ml)[66] as a result of contamination from untreated sewage discharges. Poor infrastructure, including damage to wastewater treatment plants during the 1991 Gulf War, also plays a role in the deterioration of water quality.[67] An estimated 400,000 m^3 of untreated wastewater is discharged daily at Mosul.[68] The situation is similar in Baghdad, with coliform levels far above the permissible limits.[69] The presence of chlorophenols has also been reported in the river at Baghdad.[70] This compound is an industrial by-product that becomes toxic and carcinogenic when coupled with chlorine (Cl).[71] Moreover, high levels of heavy metals were detected in Tigris water samples between Mosul and Kut.[72]

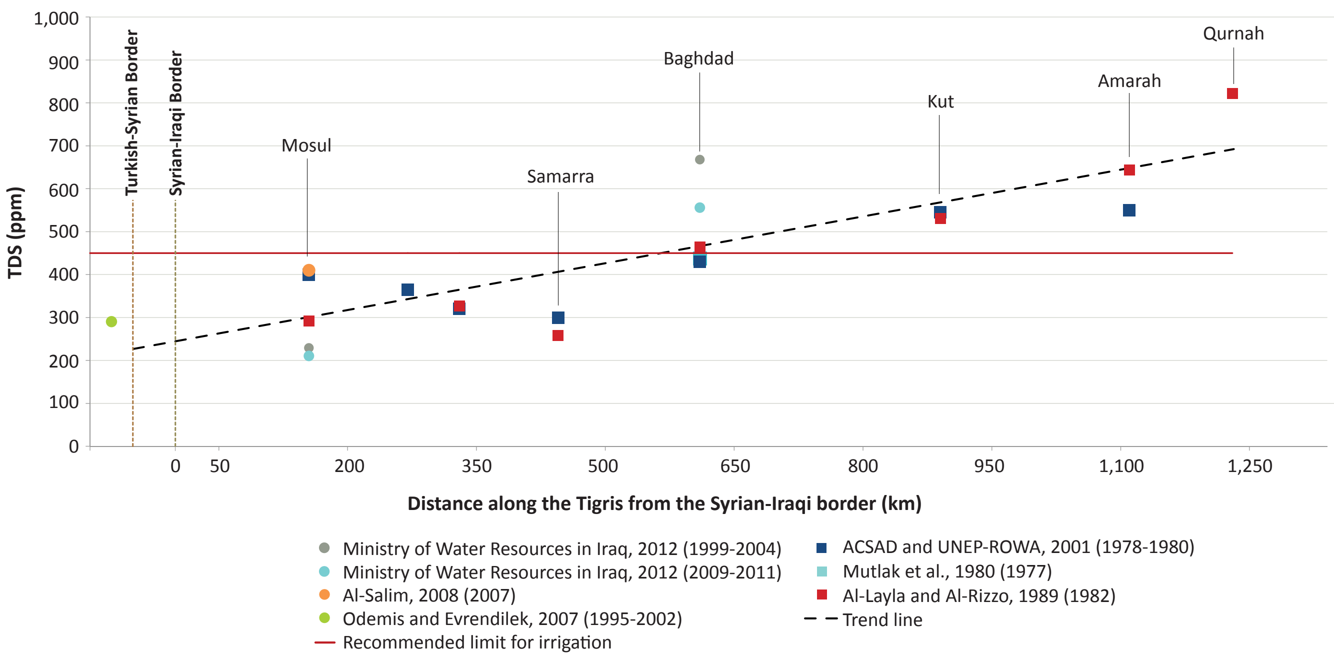
The Tigris at Diyarbakir, Turkey, 2007. Source: Raki Man.

Table 8. **Mean Total Dissolved Solids (TDS) values of the Tigris River at different stations (1999-2011)**

STATION	TDS (ppm)								
	1999	2000	2001	2002	2003	2004	2009	2010	2011
Mosul Dam	224	209	226	..	256	..	237	197	199
Baghdad	851	739	637	597	..	514	560	475	632

Source: Compiled by ESCWA-BGR based on Ministry of Water Resources in Iraq, 2012.

Figure 9. **Salinity variations along the Tigris River before 1983 and after 1995**



Source: Compiled by ESCWA-BGR based on the sources mentioned above.
Notes:
- This graph aims only to provide a general overview of salinity variations along the Tigris River and should not be considered fully accurate: data was extracted from a number of literature sources and official data provided by riparian countries; for some stations only individual measurements were available. The margin of error may be significant as readings could differ depending on the methodology used, location and date of measurement, rounding off of means, etc. Interpretation of the salinity data is further hampered by the fact that values cannot be compared with river flow data due to information gaps.
- The years in brackets refer to the sampling years. Square and round markers refer to the pre-1983 and post-1995 periods respectively. The TDS value for Turkey was converted from an initial Electrical Conductivity value. The location of cities/stations and distances between them along the river were estimated using Google Earth.

BOX 2

The Mesopotamian Marshes

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% of the Mesopotamian Marshes had been destroyed[a] as a result of heavy damming and massive drainage projects in the second half of the 20th century.

Historically, the marshes constituted a sequence of interconnected marshlands and lake systems. The heart of the marshes comprised three main areas: the Hammar Marshes south of the Euphrates, the Haweizeh Marshes east of the Tigris River and the Qurnah (or Central) Marshes situated between the two rivers. The Qurnah Marshes were the largest of the marshland formations. Before the marshes were drained, they acted as a natural wastewater treatment system for the Euphrates and Tigris Rivers, filtering out fertilizers before the water drained into the Persian Gulf.

The regular annual flooding of the Euphrates and Tigris inundated the marsh lowlands over an area of more than 10,000 km^2. During low-flow periods, the area would shrink to a few thousand square kilometres. The damming of the Euphrates and Tigris during the 1970s diminished water flow to the downstream ecosystems. In the early 1990s, the Iraqi Government embarked upon a large-scale water diversion scheme designed to drain the southern marshes. The project was driven by the prevailing belief at the time that the Mesopotamian Marshes were a source of diseases such as malaria and an obstacle to human development in the area.

Originally the Mesopotamian Marshes were home to 250,000 Marsh Arabs. By draining the marshes, the Iraqi Government displaced the Marsh Arabs, who were regarded as opponents to Iraq's former regime. Today only 40,000 indigenous people still live in the region, adding a human dimension to the environmental disaster.

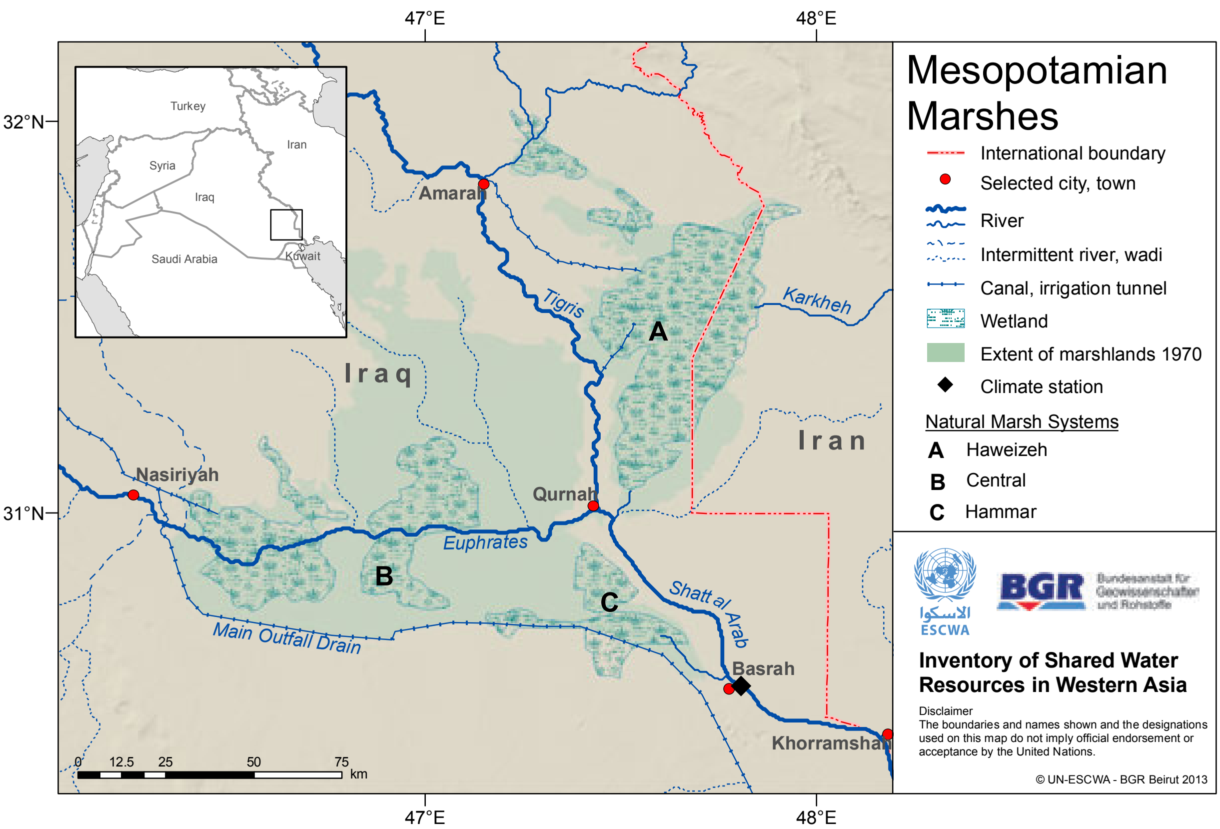
The draining of the Mesopotamian Marshes also destroyed a unique freshwater ecosystem that once formed a habitat for wildlife and migratory birds, and supported coastal fisheries along the Persian Gulf coast. Today most of the territory has become barren land and salt crusts.

In 2002, the marshes had shrunk to 14% of their original size. Only 35% 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.

(a) Satellite-based assessment studies carried out by the United Nations Environment Program (UNEP) provide striking evidence of the decline of the marshlands. See UNEP-DEWA, 2001.

Figure 10. The Mesopotamian Marshes in 2012



Agreements, Cooperation & Outlook

AGREEMENTS

The Tigris has received much less attention at the negotiation table than the Euphrates. While the few agreements forged among riparian countries have generally addressed both the Euphrates and the Tigris, the focus has always been on the Euphrates.[73] There is no basin-wide agreement in place that includes the four Tigris riparians or that allocates Tigris water resources among the four riparians. Besides a 2002 agreement between Syria and Iraq, there are no bilateral agreements that deal exclusively with the river (Table 9).

The 2002 agreement is also the only one to address water quantity issues in the Tigris Basin. The agreement allowed Syria to establish a pumping station on the Syrian side of the river. After Turkish approval in 2009,[74] Syria launched the project, which aims to withdraw 1,250 MCM annually from the Syrian part of the Tigris River (provided that the river's flow is average) and irrigate an area of 150,000 ha.[75]

Although Turkey refers to the Euphrates and Tigris as part of a single water basin, it has only guaranteed flow levels of the Euphrates, and provided no statement or commitment regarding

Table 9. Water agreements on the Tigris River

YEAR	NAME	SIGNIFICANCE	SIGNATORIES
1920	Franco-British Convention	Mandatory powers agreed to establish a committee to examine and coordinate the use of the Euphrates and Tigris Rivers.	France (Syria), Great Britain (Iraq)
1923	Lausanne Treaty	Article 109 confirms that issues related to transboundary water should be dealt with separately and with mutual respect. It also includes a provision that Turkey must consult Iraq before undertaking any hydraulic works.	Allied powers, Turkey
1930	Turko-French Protocol (on Commission of Delimitation)	The Final Delimitation Protocol states that the border between the two countries is to follow the thalweg principle, establishing the border in the middle of the Tigris, regardless of shifts in the river's course.[a]	France (Syria), Turkey
1946	Treaty of Friendship and Good Neighbourly Relations	This was the first legal instrument of cooperation. Both parties agreed that Turkey shall install and operate permanent flow measurement facilities and inform Iraq periodically about the recorded data (article 3) and water infrastructure projects.[b]	Iraq, Turkey
1980	Protocol for Technical and Economic Cooperation	The protocol mandates establishment of a joint technical committee to study the issue of regional waters – particularly the Euphrates and Tigris Rivers.	Iraq, Turkey (Syria signed in 1983)
1987	Protocol on Economic Cooperation	Article 7 of the protocol states that Syria and Turkey shall work together with Iraq to allocate Euphrates and Tigris water within the shortest possible timeframe. Article 9 asserts the intention of the two states to construct and jointly operate irrigation and hydropower projects on the two rivers.[c]	Syria, Turkey
2002	Agreement on the Creation of a Pumping Station in Syria on the Tigris	The agreement governs the establishment of a Syrian pumping station on the Tigris River. It also specifies project area and volume of water extracted.	Iraq, Syria
2009	Turkish-Syrian Strategic Cooperation Council Agreement	The agreement states that water is a focus point for cooperation between the two countries with specific emphasis on improvements to water quality, the construction of water pumping stations (on the Syrian stretch of the Tigris) and joint dams, as well as the development of joint water policies.	Syria, Turkey

Source: Compiled by ESCWA-BGR based on Oregon State University, 2010; ORSAM, 2009a; ORSAM, 2009b.
(a) The protocol states: "Since the sharing of both sides of the Tigris River mandates special responsibilities on the owners of both sides, and mandates the establishment of regulations with regard to the rights of each of the two countries which have sovereignty over their mutual relationships. Therefore, the resolving of all issues such as navigation, fishing, the utilization of water for industrial and agricultural purposes, and river policing have to be on the basis of complete equality" (ACSAD and UNEP-ROWA, 2001).
(b) Scheumann, 1998, p. 120. Hager states that while the treaty has demonstrated the two countries' best intentions, it has not been applied by either Turkey or Iraq (Hager in Elhance, 1999, p. 141).
(c) Syrian Arab Republic and Turkey, 1993.

flow levels of the Tigris. In the late 2000s, prior to the uprising in Syria, Syrian-Turkish relations had improved considerably with the establishment of the Turkish-Syrian Strategic Cooperation Council Agreement in 2009 (Table 9). Under this umbrella, the parties signed several protocols, projects and memorandums, mainly on security issues. They also agreed to cooperate in the domain of water, with specific reference to the construction of a pumping station on the Syrian stretch of the Tigris River, the improvement of water quality and the pursuit of joint efforts to combat drought.[76]

COOPERATION

At the Joint Economic Committee meeting in 1980 (Table 9), Iraq and Turkey set up a Joint Technical Committee (JTC) for Regional Waters to determine how they would allocate a reasonable amount of water to each country and exchange data.[77] In 1983, Syria joined JTC, creating a trilateral forum.

The work of the JTC experts focused mainly on the Euphrates River rather than the Tigris. After 16 meetings, JTC came to a deadlock in 1992 over the question of whether the Euphrates and Tigris Rivers constitute a single system or not (Box 3).

Since 2004, a number of meetings have been convened at ministerial and technical levels, indicating a thaw in basin relations. For instance, relations between Syria and Turkey played a crucial role in advancing the current Syrian project on the Tigris, with construction only starting after Turkish approval was secured. Iraq and Syria then experienced a remarkable rapprochement in recent years, with reciprocal visits leading to a number of agreements, mainly on economic cooperation and security issues.

Little is known about cooperation between Iran and Iraq on the issue of shared water (i.e. tributaries of the Tigris). However, both countries met regularly to discuss pressing water issues of mutual concern. Following Iran's exploitation and diversion of shared rivers without prior notification (e.g. on the Karkheh River), the two states decided to form a joint technical committee in order to address issues of mutual concern. Iraq's Ministry of Water Resources reports that this committee holds regular meetings and organizes technical exchange visits.[78]

OUTLOOK

Relations between Syria and Turkey have seriously deteriorated since 2011 on the backdrop of the Syrian crisis. It can be assumed that the periodic trilateral meetings on water issues and other matters have been put on hold. A crucial issue for Iraqi-Turkish relations on the Tigris River will be the completion of the Ilisu Dam and reservoir as it is likely to impact overall discharge and flow regime of the river significantly especially in downstream Iraq.

Shared water resources are a recurring point of discussion in Iran-Iraq relations. For instance, in 2011 Iraq accused Iran of diverting the water of the Wand River (a tributary of the Diyala) for agricultural purposes.[79] In addition, Iraq recently disregarded the bilateral Agreement Concerning the Use of Frontier Watercourses between Iran and Iraq, which specifically addresses the division of seven shared rivers.[80] The development of water resources in Iran has the potential to impact relations between riparians. In periods of drought, rising tension and local protests cannot be ruled out, as witnessed in 2011 and 2012 in the border region.[81]

BOX 3

Differing Positions on the Euphrates and Tigris

IRAQ & SYRIA

- Syria and Iraq favour the term "shared waters" and consider the Euphrates to be an international river that all riparians should treat as a shared entity.
- Syria and Iraq consider the Euphrates and Tigris as separate basins. Syria opposes the inclusion of the Orontes River in negotiations regarding shared water resources, while Iraq does not want waters flowing into the Tigris Basin from Iran to be included in the overall equation.

TURKEY

- Turkey speaks of transboundary waters when referring to the Euphrates or Tigris Rivers, emphasising that both rivers fall under Turkish sovereignty while they flow through Turkish territory.
- Turkey argues that the Euphrates and Tigris form a single river basin system and that the basin's total water discharge should therefore be included as the basis for any allocation calculations.

Bridge spanning Tigris River in Baghdad, Iraq, 2010. Source: Larisa Epatko.

Notes

1. The Tigris Basin area (221,000 km^2) was estimated based on a digital elevation model (HydroSHEDS) similar to Lehner et al., 2008 and does not include the Lake Van and Karkheh River sub-basins. This explains the difference in basin size compared to other estimates which calculate a basin area of 375,000 km^2 (FAO, 2009, p. 65; Isaev and Mikhailova, 2009, p. 384), 387,600 km^2 (Kibaroglu, 2002a, p. 162) or even 471,606 km^2 (Al-Ansari et al., 1979; UN-ESCWA, 1981, p. 77). However, it should be noted that there is a limited connection between the Karkheh and the Tigris during high-flow periods when Karkheh overflow is channelled through the Haweizeh Marshlands and canals into the Tigris.
2. The length of the Tigris was calculated by tracing the Butan from its source to the confluence of the Tigris with the Euphrates. Different literature sources establish the length of the river at 1,850 km (Kibaroglu, 2002a; Kliot, 1994b; FAO, 2009) and 1,718 km (Shahin, 2007; Al-Ansari and Knutsson, 2011).
3. According to the Syrian Ministry of Irrigation, the Tigris defines the Syrian-Turkish border for 39 km and the Iraqi-Syrian border for 5 km (Daoudy, 2005, p. 65).
4. See Chap. 4.
5. ACSAD and UNEP-ROWA, 2001; Shahin, 2007, p. 248.
6. This snow does not melt until air temperatures increase in the late spring.
7. For more information on climate, including comprehensive climatological data for the Iraqi part of the Tigris Basin, see Ministry of Environment in Iraq et al., 2006a.
8. Isaev and Mikhailova, 2009.
9. Kibaroglu, 2002b, p. 168 states a figure of 40%, while Kolars, 1992, p. 108 and Beaumont, 1998, p. 170 refer to 43% and 44% (including the Greater Zab) respectively. Others estimate the Turkish contribution at 51% (FAO, 2009, p. 65; Daoudy, 2005, p. 66), 53% (Altinbilek, 2004, p. 18) and 65% (MacQuarrie, 2004, p. 7, also quoted in Isaev and Mikhailova, 2009).
10. FAO, 2009, p. 65; El-Fadel et al., 2002, p. 101 refer to 39%. Kibaroglu, 2002a, p. 168 states a 51% contribution to total annual flow, while MacQuarrie, 2004 claims that Iraq contributes only 13.2% to the Tigris discharge.
11. Kibaroglu, 2002a, p. 168 speaks of 9%, El-Fadel et al., 2002, p. 101 and FAO, 2009, p. 65 both refer to 10%. By contrast, MacQuarrie, 2004, p. 7 states that the Iranian contribution to Tigris Basin discharge is 21.7%, a figure which probably includes the Karkheh River's discharge.
12. Shahin, 2007, p. 247.
13. UN-ESCWA, 1981.
14. Including mean annual flow volume of the Greater Zab (12.7 BCM), Lesser Zab (7.8 BCM) and the Diyala River (4.6 BCM) according to data provided by USGS, 2012; Ministry of Water Resources in Iraq, 2012. See Chap. 4.
15. Kliot, 1994a; Shahin, 2007; ACSAD and UNEP-ROWA, 2001.
16. A Student T-test was performed to assess whether the mean values of the two sampling periods are significantly different (at significance level $p<0.01$).
17. CV = 0.58 compared to CV = 0.36 before 1973.
18. Ministry of Environment in Iraq et al., 2006b.
19. The flow regime figures in Chap. 1 and 3 are directly comparable.
20. Beaumont, 1998, p. 169; Isaev and Mikhailova, 2009, p. 386 state that from March until August-September, the flood season accounts for 56%-75% of annual Tigris runoff.
21. Hydrological Survey of Iraq, 1958 and Ministry of Irrigation in Iraq 1999 in ACSAD and UNEP-ROWA, 2001, p. 59.
22. FAO, 2009.
23. FAO and UNDP, 1966, p. 26.
24. Wagner, 2011.
25. Jassim and Goff, 2006, p. 268.
26. Ibid.
27. Ozis, 1983, p. 343.
28. In Turkish: Güneydoğu Anadolu Projesi.
29. For more information on the first projects on the Tigris see Ozis, 1983.
30. Ilisu Environment Group, 2005.
31. ACSAD and UNEP-ROWA, 2001 states a figure of 5,595 MCM, similar Beaumont, 1998 with 5,580 MCM.
32. Ministry of Environment and Forestry in Turkey, 2009.
33. Beaumont, 1998, p. 176.
34. Also referred to as the Khabour River Basin Irrigation Development Project.
35. Ministry of Irrigation in the Syrian Arab Republic and Ministry of Irrigation in Iraq, 2002.
36. The Khabour is a sub-basin of the Euphrates Basin. See Chap. 2.
37. IFAD, 2009.
38. Ministry of Irrigation in the Syrian Arab Republic, 2010.
39. ACSAD and UNEP-ROWA, 2001, p. 78.
40. Recent data suggest that the hydropower capacity of the Mosul Dam is 320 MW, and not 1,050 MW as originally planned. Furthermore, the dam was declared unsafe due to its location. A 2006 United States Army Corps of Engineers report declared that the dam is the most dangerous in the world (The Washington Post, 2007).
41. Kibaroglu, 2002a, p. 210.
42. FAO, 2003.
43. Al-Sakhaf in Isaev and Mikhailova, 2009.
44. Ibid.
45. ACSAD and UNEP-ROWA, 2001, p. 99.
46. FAO Aquastat, 2008.
47. Ministry of Planning in Iraq, 2010.
48. FAO, 2008.
49. FAO, 1988.
50. Odemis et al., 2010.
51. Odemis and Evrendilek, 2007. Based on FAO, 1994, the EC guideline for irrigation water was set at <700 μS/cm.
52. Varol, 2011. The main Turkish cities which pollute the Tigris are Bismil, Cizre, Diyarbakir and Hasankeyf.
53. Ibid.; Gumgum et al., 1994.
54. Varol, 2011; Unlu and Gumgum, 1993.
55. Varol et al., 2011.
56. DO levels at Diyarbakir have reached 1.9 mg/L (Varol et al., 2011).
57. These are the major contributing factors to the pollution of the Tigris in Iraq (Al-Rawi, 2005).

58. FAO Aquastat, 2008; Al-Rawi, 2005.
59. These are major sites where untreated wastewater is discharged. Alobaidy et al., 2010; Thana et al., 2009; World Bank, 2006; Al-Salim, 2008; Al-Layla and Al-Rizzo, 1989.
60. UN-ESCWA et al., 1996, p. 157.
61. Mutlak et al., 1980. Based on FAO, 1994, the TDS recommended guideline for irrigation water is set at <450 ppm.
62. ACSAD and UNEP-ROWA, 2001, p. 130, 136.
63. UNDG, 2005. ACSAD and UNEP-ROWA, 2001, p. 134 cite sources that ascribe increased salinity south of the Samarra Barrage and up to Baghdad to the high salinity of the Adhaim River. The construction of the Adhaim Dam has improved water quality.
64. For instance, ACSAD and UNEP-ROWA, 2001, p. 134 suggest a considerable increase in salinity at Amarah when comparing pre-1978 values with salinity in later years.
65. The guideline for irrigation water is 1,000 cfu/100 ml, and 10,000 cfu/100 ml for bathing. Based on European Union guidelines in World Bank, 2006; Chapman, 1996.
66. Woerden and Berkel, 2004 in World Bank, 2006. The sampling location and period are not mentioned.
67. World Bank, 2006.
68. Al-Rawi, 2005.
69. Thana et al., 2009.
70. Al-Janabi et al., 2011.
71. Goodman, 2001 in Al-Janabi et al., 2011. Chlorine is commonly used to disinfect water for drinking purposes, and when in contact with phenols (not effectively removed by water treatment plants) it reacts to form chlorinated phenols that are dangerous to human health.
72. Al-Lami and Al-Jaberi, 2002.
73. This may also be linked to Turkey's desire to treat the Euphrates-Tigris as a joint basin. While Syria and Iraq have never officially agreed to this approach for various reasons, the international scientific community studying conflict and cooperation on the two rivers follows the joint basin approach.
74. Droubi, 2010.
75. Ministry of Irrigation in the Syrian Arab Republic and Ministry of Irrigation in Iraq, 2002.
76. ORSAM, 2009b.
77. The idea of JTC dates back to 1946 when experts from Iraq and Turkey met to discuss flow guarantees on the Euphrates (see Chap. 1). The committee was subsequently established based on a Turkish-Iraqi Joint Economic Committee meeting protocol.
78. Ministry of Water Resources in Iraq, 2012.
79. ORSAM, 2011.
80. Ministry of Water Resources in Iraq, 2012.
81. AINA, 2011; Iraq Business News, 2012; ORSAM, 2012.

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