Euphrates-Tigris Basin
2040-2060


40°0'0"E
50°0'0"E
40°0'0"N
30°0'0"N
BLACKSEA
GEORGIA
TS'Khinvali
Tbilisi
Caspian Sea
Samsun
Trabzon
ARMENIA
Yerevan
AZERBAIJAN
Baku
Xankandi
Araz
Erzurum
Sivas
TURKEY
Kayseri
Kizilirmak
KEBAN DAM
Elazig
Murat Nehri
Malatya
Lake Van
Van
Diyarbakir
Batman
Tigris
Tabriz
Ardabil
Talkheh Rud
ATATÜRK DAM
Gaziantep
Adana
Mersin
Ceyhan Nehri
Orumiyeh
Rasht
Zanjan
Mosul
Irbil
AL-TABQA DAM
Aleppo
Euphrates
As Sulaymaniyah
Kirkuk
Sanandaj
Karaj
SYRIA
Homs
Hamadan
Qum
Mediterranean Sea
LEBANON
Beirut
QADISIYA DAM
Kermanshah
Arak
Damascus
Abu Ghurayb
Baghdad
Khorramabad
Haifa
IRAQ
Amman
SYRIAN DESERT
Jerusalem
Gaza City
Nahr al Gharraf
Ahvaz
ISRAEL
Alraudah
Euphrates
Shatt al Arab
JORDAN
Basra
0 75 150 300 Kilometers
Sakakah
Persian Gulf
Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

RIVERS OF COMPETITION

Competitive and uncoordinated water development projects

Table No.1: Euphrates River Basin

Country	Name of Dam	Use	River	Date of Completion	Gross Storage (BCM)	Surface Area (km^2)	HP (MW)	Height (m)
Turkey	Adiyaman	HP	Goksu	Planned	1.887	60	75	90
Turkey	Ataturk	HP, Irrigation	Euphrates	1992	48.70	817	2400	166
Turkey	Birecik	HP, Irrigation	Euphrates	2000	1.22	56.25	672	53
Turkey	Camgazi	Irrigation	Euphrates	1998	0.056	5.55	-	39
Turkey	Derik-Dumulca	Irrigation	Euphrates	1991	0.022	2.23	-	24
Turkey	Hacihidir	Irrigation	Euphrates	1989	0.062	4.4	-	32
Turkey	Hancagiz	Irrigation	Euphrates	1988	0.100	7.50	-	45
Turkey	Kahta	HP	Kahta	Planned	1.887	100	-	125
Turkey	Karakaya	HP	Euphrates	1987	9.58	268	1800	158
Turkey	Karkamis	HP, Flood Control	Euphrates	1999	0.157	28.4	189	21.2
Turkey	Kayacik	Irrigation	Euphrates	UC	0.116	2.91	-	45
Turkey	Keban	HP	Euphrates	1975	31	675	1330	163
Syria	Baath	HP, Irrigation, Flow Regulation	Euphrates	1988	0.09	27.15	75	
Syria	Tabaqa	HP, Irrigation	Euphrates	1975	11.7	610	800	60
Syria	Tishrine	HP	Euphrates	1999	1.9	166	630	40
Syria	Upper Khabur[1]	Irrigation	Khabur	1992	0.988	1.37	-	-
Iraq	Al Hindiyah Barrage	Flow Diversion	Euphrates	1918, rebuilt 1989	-	-	-	
Iraq	Al Qadisiyah[2]	HP, Irrigation	Euphrates	1984	8.2	500	660	57
Iraq	Fallujah Barrage	Irrigation	Euphrates	1985	-	-	-	
Iraq	Baghdadi	Flow Regulation	Euphrates	Planned	-	-	-	
Iraq	Ramadi-Habbaniyah[3]	Flood Protection	Euphrates	1948	3.3	426	-	-
Iraq	Ramadi-Razaza[4]	Flood Protection	Euphrates	1951	26	1850	-	-

HP: Hydropower
UC: Under Construction

[1] Also called the Great Khabur, the project is made up of three dams: Al-Khabur (Basil Al-Assad), West Al-Hasakah (8 March Dam), and East Al-Hasakah (7 April Dam). [2] Formerly called Haditha dam. [3] Barrage diverting flows into natural depression via Warrar canal.
[4] Barrage diverting flows into natural depression via Mujarah canal.

Table No.2: Tigris River Basin

Country	Name of Dam	Use	River	Date of Completion	Gross Storage (BCM)	Surface Area (km²)	HP (MW)	Height (m)
Turkey	Batman	HP, Irrigation	Tigris	1998	1.175	49.25	198	71.5
Turkey	Cag-Cag	HP	Tigris		-	-	-	-
Turkey	Cizre	HP, Irrigation	Tigris	Planned	0.36	21	240	51.4
Turkey	Devegecidi	Irrigation	Tigris	1972	0.202	32.14	-	32.8
Turkey	Dicle	HP, Irrigation	Tigris	1997	0.595	24	110	75
Turkey	Dipni		Tigris		1.02	46		90
Turkey	Dilimi	Irrigation	Great Zab	UC	0.0591	2.41	-	70
Turkey	Garzan	HP, Irrigation	Tigris	Planned	.983	46	80	113
Turkey	Ilisu	HP	Tigris	Planned	10.41	299.5	1200	138
Turkey	Goksu	Irrigation	Tigris	1991	0.062	3.9	-	46
Turkey	Kralkizi	HP	Tigris	1997	1.919	57.5	90	113
Turkey	Silvan	HP, Irrigation	Tigris	Planned	0.82	164	150	165
Iraq	Al-Adheem	HP, Irrigation	Al-Adheem	1999	1.5	120		
Iraq	Al-Amarah Barrage	Flow Regulation	Tigris	UC	-	-	-	-
Iraq	Al-Faris[1]	HP, Irrigation	Great Zab	Not Completed	3.30	56	1600	200+
Iraq	Al-Kut Barrage	Flow diversion	Tigris	1939	-	-	-	-
Iraq	Derbendikhan	Irrigation	Diyala	1962	3.0	121	-	128
Iraq	Dibbis	Irrigation	Little Zab	1965	3.0	32	-	15
Iraq	Diyala Barrage	Irrigation	Diyala	1969	-	-	-	12
Iraq	Dokan	Irrigation	Little Zab	1961	6.8	270	-	116
Iraq	Hamrin	Irrigation	Diyala	1980	3.95	440	-	40
Iraq	Saddam[2]	HP, Irrigation	Tigris	1985	11.1	371	320	126
Iraq	Samarra-Tharthar[3]	Flow diversion	Tigris	1954	72.8	2170	-	-
Iraq	Sennacherib[4]	Flow Regulation	Tigris		0.5	-	-	
Iran	Bazoft		Bazoft	Under Design				
Iran	Dez [5]	HP, Irrigation	Dez	1962	3.460	-	520	203
Iran	Garm-ab		Karkheh	Under Design				
Iran	Karkheh	HP, Irrigation, Flood Control	Karkheh	2001	7.795		400	128
Iran	Karun-1[6]	HP, Irrigation	Karun	1977	3.139	54.8	1000	200
Iran	Karun-2	HP	Karun	UC-2005			1000	
Iran	Karun-3	HP, Flood control	Karun	UC – 2001	2.750		2000 (3000)	205
Iran	Karun-4	HP, Flood control	Karun	UC-2006	2.190		1000	222
Iran	Khersan I	HP	Khersan	Under Design	0.520		750	180
Iran	Khersan II	HP	Khersan	Under Design	0.500		500	180
Iran	Khersan III	HP	Khersan	Under Design	0.730		750	165
Iran	Marun	Irrigation, HP	Marun	1998	1.2	25	145	165
Iran	Masdjied-e-Soleiman[7]	HP, Irrigation	Karun	UC-2001	0.228		1000(2000)	177
Iran	Saz-e-bon		Karkheh	2004			500	
Iran	Shushtar[8]	HP	Karun	UC – 2005	4.53		2000	180
Iran	Simareh	HP	Karkheh	UC-2004			500	
Iran	Tang-e-mashoreh		Karkheh	Under Design				
Iran	Upper Gotvand	HP	Karun				1000 (2000)	

[1] Formerly called Bekme dam, it is reportedly destroyed. [2] Formerly called Aski Mosul dam. [3] Barrage diverting flows into natural depression via canal. [4] Formerly called Badush dam. [5] Formerly known as the Mohammed Reza Shah Pahlavi Dam. [6] Formerly called Shahid Abbaspur. [7] Formerly called Karun-4 (Godar-e-Landar). [8] Also known as Gatvand.

Reservoir Sedimentation

- Based on study of upstream geology, experts estimate an annual storage volume loss for Keban dam on the Euphrates of 0.147%.
- The 1975-2060 loss will amount to 13%.
- Diverting, dredging or dewatering of sediment are possible but these are extremely expensive response strategies.

Figure 3:

Euphrates-Tigris river basin

Legend

- International boundary
- Administrative boundary
- Capital, town
- River basin
- Lake
- Intermittent lake
- Wetland
- Salt pan
- River, intermittent river
- Canal
- Dam (capacity > 1 km^3)
- Zone of irrigation development
- Southeastern Anatolia Project (GAP), ongoing
- Irrigation scheme

0 40 80 160 240 km

Albers Equal Area Projection, WGS 1984

FAO - AQUASTAT, 2009

Disclaimer

The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Irrigable lands and irrigated areas

- Data on the extent of irrigated lands, irrigable lands and water requirements are varied and contradictory.
- The values given in the table below represent the best estimates of the extent of irrigable lands in Turkey, Syria and Iraq.
- At present it is estimated that the irrigated areas cover:
  - 474 528 ha (30% of realization in the GAP project) in Turkey,
  - 350 000 ha in Syria
  - 2.8 million ha in Iraq

Irrigable lands in Turkey, Syria and Iraq

	Euphrates (ha)	Tigris (ha)	Total (ha)
Turkey	1 777 000	650 000	2 427 000
Syria	800 000	150 000	950 000
Iraq	2 500 000	1 500 000	4 000 000
Total	5 070 000	2 300 000	7 370 000

Irrigation sector (2040-2060)

- institutional problems
  - irrigation associations-farmers-state
  - cost recovery-water pricing
- inefficiencies:
  - infrastructure
  - irrigation methods
- salinization

Water Supply and Demand

- While many innovations may affect the water supply and the use within the next 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 km3/y in the Euphrates at full development.

Water budget at full development scenario (km^3/y)

	Altinbilek (1997)	Kolars (1994)	Kliot (1994)	US Army Corps of Engineers (1991)	Belul (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 bySyria	− 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	9.1
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.

Water Balance Study for the Tigris-Euphrates River Basin

N. Ohara, A.M.ASCE[1]; M. L. Kavvas, F.ASCE[2]; M. L. Anderson, M.ASCE[3];
Z. Q. Richard Chen, M.ASCE[4]; and J. Yoon[5]

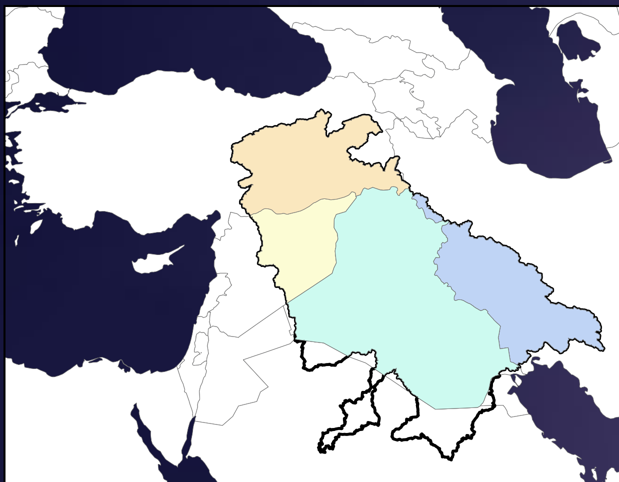
Abstract: Several case studies of the Tigris-Euphrates (TE) river basin were performed to investigate the effects of various water resource utilizations on dynamic water balances of the watershed. A daily dynamic water balance model was developed to simulate water resource conditions corresponding to four utilization scenarios in the TE watershed: (1) pre-1970 natural conditions; (2) current levels of water resource development/utilization in Syria and Iraq while maintaining pre-1970 conditions in Turkey (i.e., natural, unobstructed flows from Turkey); (3) scenarios involving constant-discharge water release from the Turkish sector downstream on the basis of estimations of future water utilization in the Turkish sector of the TE watershed; and (4) minimum time-varying water releases from Turkey to meet current irrigation water demands in the downstream region. All water balance simulations reconstructed atmospheric and hydrologic conditions during historical critical drought and flood periods. Irrigation demands were estimated by using the Food and Agricultural Organization of the United Nations (FAO) method, with reconstructed atmospheric and crop distribution data derived from satellite observations. Operations of 15 major dams in the Syrian and Iraqi sectors of the TE watershed were dynamically simulated under several different flow regimes regulated and unregulated by the upstream country, Turkey. This study illustrates that irrigation water demands in Iraq and Syria can be effectively met by various constant-discharge water releases from the Turkish sector. Also, if the seasonality of irrigation water demands in the lower TE region is considered when scheduling water releases from Turkey, these releases can be decreased while still meeting the current irrigation water demands of downstream countries. Water diversion from the Tigris to the Euphrates through the Samarra-Thartar complex may provide significant freedom to optimize water allocation in this region. Additionally, because of the arid climate in the lower TE river basin, a considerable amount of water evaporates from the reservoirs. The analyses indicate that storing water in the upstream region seems to be more effective in reducing reservoir water evaporation compared to storing water in the downstream region because the small surface area-to-storage volume of the upstream TE reservoirs and the cooler climate in the upstream sector of the watershed. **DOI: 10.1061/(ASCE)HE.1943-5584.0000209.**

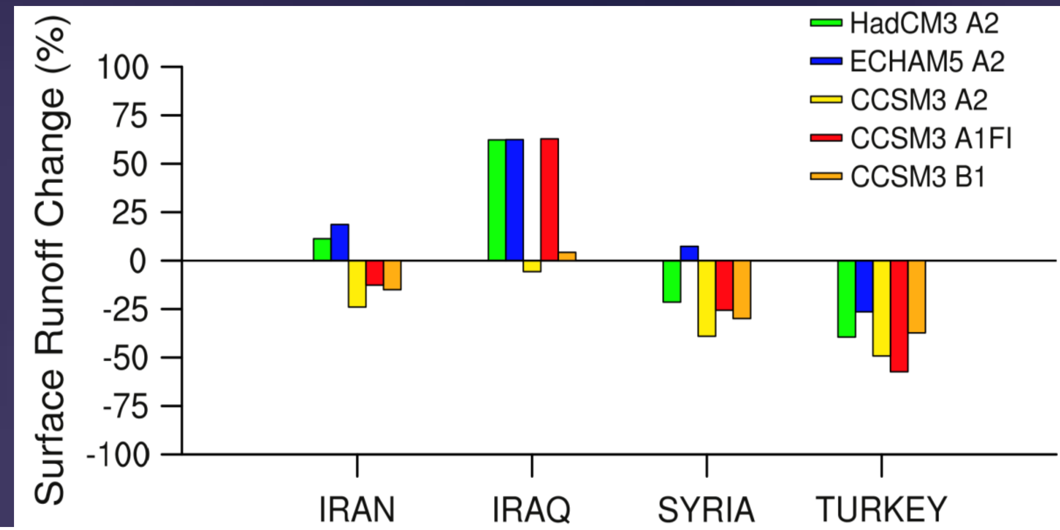
Knowledge on impacts of climate change

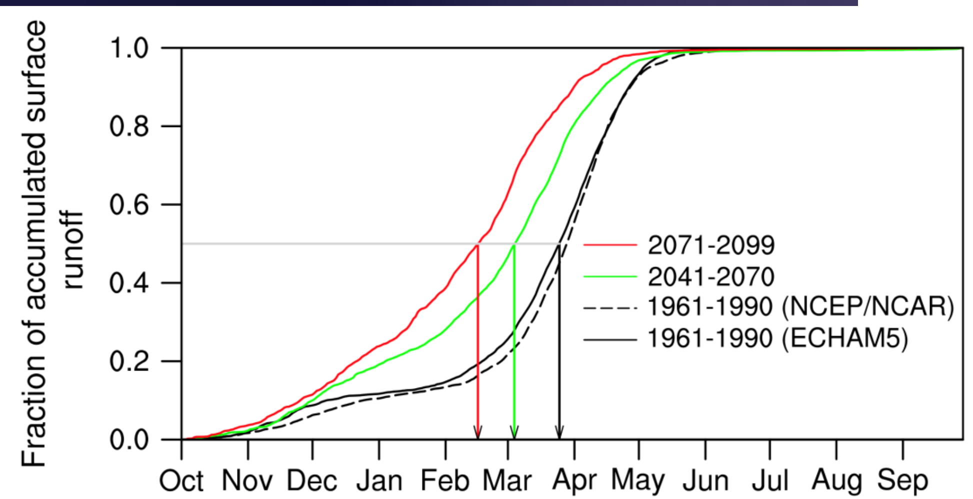
- The IPCC has predicted gradually drier and warmer conditions in the Euphrates and Tigris basin during the 21st century, with earlier snowmelt in the Taurus and Zagros mountains, the basic water resource of the watershed.
- This emerging hydro-climate regime translates into decreasing snowfall and substantially increasing evaporation and transpiration losses in the watershed in the 21st century.

IPCC. (2007). "Contribution of working group I to the fourth assessment report of the intergovernmental panel on climate change." S. Solomon,et al., eds., Cambridge University, Cambridge, UK and New York.

Changes in surface runoff







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 the Euphrates and Tigris basins respectively by the end of the present century (these figures are calculated for the Turkish portions of these basins).

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

- Runoff reduction 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 conveys 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.

Population projections

	2017	2025	2050
Turkey	80 773 696	83 713 000	94 606 000
Syria	18 361 926	27 865 000	36 706 000
Iraq	38 274 618	45 892 000	71 336 000
Iran	81 162 788	88 064 000	100 598 000

World Population Prospects: The 2012 Revision, Key Findings and Advance Tables, United Nations Department of Economic and Social Affairs/Population Division

Population growth rates

	1985-2000	2000-2015	2015-2030	2030-2050
Turkey	1,70 %	1,30 %	0,80 %	0,40 %
Syria	2,75 %	2,18 %	1,52 %	0,85 %
Iraq	2,75 %	2,92 %	2,67 %	2, 06 %
Iran	2,55 %	1,26 %	0,90 %	0,55 %

http://esa.un.org/unpd/wpp/Demographic-Profiles/index.shtm
United Nations Department of Economic and Social Affairs/Population Division

ET basin is home to around 54 million people in Iran, Iraq, Syria and Turkey (UN ESCWA-BGR, 2013).

FUTURE OF TRANSBOUNDARY WATER GOVERNANCE

RIVERS OF CONFRONTATION

- *1975 Crisis* → **Impounding of the Keban and the Tabqa Dams**
- *1990 Crisis* → **Impounding of the Atatürk Dam**
- *1996 Crisis* → **Construction of the Birecik Dam**

JOINT TECHNICAL COMMITTEE (JTC)

- *1983-1992*→ JTC held 16 meetings
- *1993*→ JTC meetings suspended
- 2007 → JTC meetings revitalized

WATER USE RULES IN THE REGION

- The Interim Protocol of 1987 Between Turkey and Syria
- The Protocol of 1990 Between Syria and Iraq

RIVERS OF COOPERATION

- HIGH LEVEL STRATEGIC COOPERATION COUNCILS
- NEW PROTOCOLS ON WATER

New Water Protocols

- Turkey and Iraq MOU on Water (2009)

-calibration of existing hydrological measuring stations;

-modernisation of existing irrigation systems;

-prevention of water losses from domestic water supply construction of water supply and water treatment facilities in Iraq wtp of Turkish companies;

-development of mechanisms to solve problems arising during drought period;

-joint investigation, planning for flood protection.

Turkey and Syria signed fifty MOUs including four related to water (2009)

- The Joint Friendship Dam on the Asi/Orontes river
- Syrian water withdrawals from the Tigris
- Coping with the drought
- Remediation of the water quality

CHALLENGES

- The biggest obstacle to cooperation and coordinated management of transboundary water resources in the basin is political instabilities and shifting power balances.
- Overarching political problems, namely the Syrian 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 basin.

Control of water resources by non-state violent actors

- The spread of ISIS across region ended up with “non-state actors” to seize control of water resources in Syria and Iraq.
- IS subsequently lost control of all of the dams, but not before using them to flood or starve downstream populations, to pressure them to surrender.
- The emergence of IS in the region urges riparian states to be thoroughly prepared and utterly responsive to possible attacks to water supply and development infrastructure in the region.
- This phenomenon should instruct the riparian states of the need to establish regional security arrangements to preserve and protect their resources.

Protection of water during conflict

- Syrian civil war is pushing the riparian states to develop new water governance principles and practices during conflict and post-conflict situations.
- The riparian states should improve their understanding of the strategic role that water and water supply infrastructures play in armed conflicts and to reflect on possible ways to improve the protection of water under international law during and after armed conflicts.
- The riparian states should also envisage joint ways of dealing with transboundary water resources during reconstruction and rehabilitation efforts in the post-conflict phase.

- **How would transboundary water cooperation look like in future?**
  - Building on and strengthening existing transboundary institutions.
  - Transboundary water institutions, namely the JTC, could act as a multilateral platform in framing and implementing water cooperation frameworks.
  - Compared to bilateral water sharing treaties, the existing MOUs, with their broader outlook, can provide useful guidelines for establishing comprehensive transboundary water cooperation.

- These bilateral MoUs should be synthesized in a multilateral framework agreement which involves all of the riparian states as well as all of the concerned stakeholders, including civil society organizations and private companies from the sectors of energy, agriculture, environment, and health.

- Transboundary water cooperation should resume, whenever there is a chance to do so, from a variety of perspectives and issues that may provide opportunities for regional cooperation anew.
- Collaborative projects could be conducted in water-related development fields such as energy, agriculture, the environment, and health.
- International actors could facilitate such regional cooperation through technical and financial assistance.

- Multilateral cooperation could provide a number of important building blocks that can support cooperative efforts in the region:
- It could contribute to improved water security for small and large water users; efficiency and productivity of water use, and generation of additional socio-economic benefits per unit of water; management of ecosystem goods and services at the regional scale and restoration options of deteriorated ecosystems; participation of stakeholders; accountability and communication.

On-going cooperation: Turkey-Iraq track

– It demonstrates that even during volatile times when multilateral negotiations became impossible, riparians could continue talks regarding the transboundary waters at a bilateral level.
– It involves technical cooperation on issues related to building joint dams; promoting exchange and calibration of data pertaining to Tigris river flows; irrigation technologies and dam safety (Mosul Dam).