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Article

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Posted Date: November 16th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11477391/v1

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Additional Declarations: No competing interests reported.

Drying the Cradle of Civilization: Water, Food, and Societal Security at a Crossroads in Iraq

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Abstract

Iraq is facing grave problems and threats regarding the future of its nation, which can be classified into water security, food security, and societal security. These challenges spring from a legacy of past conflicts, unwise administrative policies, and complex geopolitical and environmental factors. Water scarcity results from a severe reduction in the abundant flows of the Tigris and Euphrates rivers, unfair transboundary sharing, climate change impacts, and haphazard water management. Food insecurity is a natural consequence magnified by agricultural stagnation and population growth. This paper provides an overview of the present situation and outlines proposed solutions, though the future remains uncertain given the fragile economy and the political will required for reforms.

Keywords: Water Security, Food Security, Societal Security, Tigris and Euphrates Rivers, Riparian Countries, Climate Change Impacts, Population Explosion.

1. Introduction

Iraq relies heavily on the Tigris and Euphrates rivers for its water resources [1, 2].

Figure 1: Location of Iraq [1].

The country confronts an existential threat endangering its economic structure, social fabric, and internal security through deteriorating water security, fragile food security, and societal security interactions [3, 4, 5]. Shrinking water availability and declining agricultural productivity lead to tribal conflicts, rural-to-urban migration, rising unemployment, poverty, and crime [6, 7, 8]. Combined with high population growth, Iraq heads toward a human catastrophe unless drastic actions are taken [9, 10].

A distinction must be made between water security and water scarcity, though both are used interchangeably here [11]. Water security encompasses availability, quality, risk mitigation, and resource management [11], whereas water scarcity refers to supply-demand imbalances from physical shortages or misuse [3]. Water scarcity is the primary driver of insecurity, rooted in regional and national factors [12, 13]. Food security requires sustainable water management, modernized agricultural practices, institutional and legislative revisions, and intensive training for farmers who consume about 70% of Iraq's water [14, 15, 16]. Rapid population growth acts as a time bomb that could lead to famine, epidemics, and social upheavals without family planning and educational programs [10]. Societal insecurity is a natural consequence of water and food insecurity, requiring a comprehensive water-food-society-security framework [4, 17].

2. Methodology and Data

The methodology analyzes causes and effects of water and food sector problems on societal security based on four criteria [9]:

- Food security links strongly with water security [15].
- Causes of decline in each sector must be individually analyzed and overlaps investigated [9].
- Treatment is encompassed within a single water-food-society-security framework [4].
- Solutions must be practical and within reach [9].

Data is derived from international organization reports (World Bank, IMF, FAO, UN), official statistics, scientific research articles, and public media filtered for credibility [18, 19, 20, 21].

3. Concepts of Water, Food, and Societal Security and Their Interconnections

- **Water Security:** Defined as the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for livelihoods, human well-being, socio-economic development, ecosystem protection, and peace [11]. It ensures safe access, quality, and climate resilience for future generations [11]. Water acts as a key driver for growth and poverty alleviation, but also as a force for destruction through droughts, floods, and contamination [11]. It covers disasters, water-borne diseases, shared resource conflicts, governance, and groundwater quality [3, 11]. Global deficits stem from transboundary disputes, poor management, climate change, pollution, regional disparities, and population growth [12, 1, 5].
- **Food Security:** Defined as a situation where all people have physical and economic access to sufficient, safe, and nutritious food [22]. The WHO links it to availability, accessibility, and utilization, resting on four pillars: availability, access, utilization, and stability [15]. The HLPE recommended strengthening global food security governance through international cooperation [15]. Conflicts and wars disrupt agricultural production and food distribution, driving acute food insecurity and famine [23]. Conflicts have caused six of seven major African famines since 1980, with conflict remaining the primary driver of acute food insecurity in Africa [23]. Early warning reduces famine risks, but war zones prevent relief aid delivery [1, 23]. For example, the ISIS war (2014–2017) weaponized infrastructure and caused a 40% drop in agricultural production in affected areas [9, 24]. Shared waterways lack binding international laws, linking water and war with increasing frequency [25, 26]. Armed conflicts damage water networks, undermining security, while climate change shrinks water supplies and increases demand [27].
- **Societal Security:** Developed by the Copenhagen School, focusing on human security and social peace [4]. Shortages of water and food drive rural-to-urban migration, unemployment, crime, municipal strain, and tribal disputes in southern Iraq [6, 7, 8]. Post-2003 governance failures, corruption, and fragile economies have left successive administrations unable to meet basic needs [28, 29].

4. Historical and Current Context of Water and Agriculture in Iraq

Known historically as Mesopotamia, Iraq has practiced irrigated agriculture since 5000 BC [30]. Southern agriculture relied on irrigation; northern agriculture benefited from moderate rainfall [30]. Historical infrastructure projects include the Al-Hindiyah Barrage (1910–1915), Al-Kut Barrage (1937), Samarra Barrage (1956), Dokan (1959), Darbandikhan (1961), Hemren (1981), Mosul (1986), Haditha (1987), and Adhaim (1999) dams, alongside reservoirs and the Main Outfall Drain (MOD) project initiated in the 1980s [2, 30]. By 1990, irrigation potential exceeded 5.5 million hectares, but political instability, poor maintenance, and upstream diversions caused irrigated areas to decline sharply [3, 30, 31].

5. Upstream Developments in the Tigris and Euphrates Basins

The Euphrates is shared among Turkey, Syria, and Iraq; the Tigris among Turkey, Iraq, and Iran [32, 33]. Upstream developments have drastically reduced river flows [1, 2, 34]. These transboundary basin layouts are illustrated below:

Figure 2: Tigris and Euphrates Rivers Basins [1].

Furthermore, annual flow volume statistics for the Euphrates River from 1930 to 2011 are summarized below:

Table 1: Summary of annual flow volume statistics for the Euphrates River 1930–2011 [1, 2].

Decadal hydrographs of the Tigris River at Sarai Baghdad for the period 1930–2013 are presented below:

Figure 3: Decadal hydrographs of the Tigris River at Sarai Baghdad for period 1930–2013 [1].

Corresponding annual reductions in water inflow across main gauging stations are detailed below:

Table 2: Annual reductions in water inflow of main gauging stations [2].

Turkey and Syria have constructed extensive dams exceeding 100 BCM in storage capacity through projects like the Southeastern Anatolia Project (GAP) [35, 36]. Specific Turkish dams on the Tigris and Euphrates rivers and their tributaries up to 2017 are listed below:

Table 3: Turkish dams on the Tigris and Euphrates rivers and their tributaries up to 2017 [35, 36].

Syrian dams on the Euphrates River and its tributaries up to 1999 are outlined below:

Table 4: Syrian dams on the Euphrates River and its tributaries up to 1999 [37].

Similarly, Iran has constructed numerous dams on Tigris tributaries (such as the Diyala and Lesser Zab) and diverted border rivers (like the Alwand and Karkheh), causing severe drinking water shortages and environmental degradation in Iraqi Kurdistan and southern marshes in violation of international agreements like the Ramsar Convention [38]. A comprehensive inventory of Iranian dams constructed on the Karkheh and Karun rivers and tributaries of the Tigris River until 2019 is provided below:

Table 5: Iranian dams constructed on the Karkheh and Karun rivers and tributaries of the Tigris River until 2019 [21, 38].

6. Climate Change and Water Scarcity

Climate change is driven by global warming and greenhouse gases [39, 40]. The World Atlas of Desertification indicates that southern, central, and western Iraq, Jordan, Saudi Arabia, southern Turkey, and Syria are shifting from semi-arid to arid and hyper-arid states [41, 42], as mapped out across aridity indices below:

Figure 4: Map of the distribution of drought in the world according to the aridity indices (AI) [41].

Mediterranean precipitation is linked to the North Atlantic Oscillation (NAO), which global warming has disrupted, shifting moisture northward and drying the Middle East [43]. The atmospheric pressure oscillation effects on wind paths in the North Atlantic Ocean are depicted below:

Figure 5: The effect of the change in wind path due to the phenomenon of the regular atmospheric pressure oscillation in the North Atlantic Ocean (NAO) [43].

Studies confirm warming trends and declining precipitation across the Arab East, threatening 12 million people in Iraq and Syria [15, 16, 44, 45]. These shifts are demonstrated through time series of maximum and minimum temperature rates from 1966 to 2010 across the entire Middle East and North Africa region shown below:

Figure 6: Time series of change in maximum (TMAX mean) and minimum (TMIN mean) temperature rates from 1966 to 2010 in the entire Middle East and North Africa region [46].

Annual total precipitation decreases alongside rainy day reductions in the Arab East are shown below:

Figure 7: Time series of the rates of decrease in the annual total precipitation (PRCPTOT) and the decrease in the number of days in which precipitation exceeds 10 millimeters (R10mm) from 1966 to 2010 in the countries of the Arab East [15, 44].

Simulation results showing projected flow reductions in the Euphrates, Seyhoun, and Jordan rivers under future climate change scenarios (2081–2100) are presented below:

Table 6: Simulation results showing reduction of flow in the Euphrates, Syhoun and Jordan Rivers in (2081–2100) under the climate change assumed future scenarios [47, 48].

Projected temperature changes and discharge impacts under FM and FH scenarios are displayed below:

Figure 8: Output results of the FM and FH scenarios for the projected temperature change during the period (2081–2100) and impacts on the discharges of the Euphrates, Cyhoun, and Jordan rivers [47, 48].

Observed and projected monthly average discharge hydrographs are shown below:

Figure 9: Hydrographs of observed (1961–1990) and projected monthly averages of Euphrates River discharges at the observation stations (2071–2100) in Palu, Beşktaş, and the Hindiyah Barrage, and for the Tigris River in Saray Baghdad station according to the six climate models [47, 48].

Future monthly discharge comparisons are illustrated below:

Figure 10: The clear decrease in the monthly discharge of the Euphrates River in the future period (2071–2100) relative to the discharges in the period (1969–1990) using two different models for each of the stations of Palu, Beşktaş, and Hindiyah Barrage [47, 48].

7. Water Quality Degradation

Water quality has deteriorated due to transboundary pollution, agricultural return drainage, untreated sewage, and industrial wastes, violating Articles 5 and 7 of the 1997 UN Convention [25, 26]. Salinity levels in the Shatt Al-Arab and Euphrates have escalated sharply [6, 49], with salt level changes along the Euphrates River from 1996 to 2013 tracked below:

Figure 11: Change in salt levels along the Euphrates River from 1996 to 2013 [38, 49].

Salt level changes along the Tigris River from 1983 to 1995 are tracked below:

Figure 12: Change in salt levels along the Tigris River from 1983 to 1995 [25, 49].

Heavy metal contamination from industrial plants in Turkey and untreated sewage discharges across riparian states have severely impacted aquatic life and public health [50, 51, 52].

8. Poor Water Management Practices

In 2017, 87.8% of Iraq's water withdrawals were used for agriculture, 2.5% for industry, and 2.7% for municipal supply [53, 54], as illustrated by sector breakdowns below:

Figure 13: Water withdrawal in Iraq by sector [53, 54].

Outdated flood and furrow irrigation methods waste over 90% of agricultural water [46, 55]. Legislative frameworks lag behind sector needs, and World Bank reports highlight severe water deficits and weak infrastructure [5, 20]. Municipal wastewater treatment is severely strained, discharging millions of cubic meters of untreated sewage into rivers daily [56, 57].

9. Agricultural Sector Challenges

Agriculture employs nearly 10% of the workforce, but production is declining due to climate change, conflicts, and political neglect [58, 59]. LULC surveys show that abandoned farmland occupies 22.21% of Iraq's total land area due to water scarcity and soil degradation [60]. Staple crop production, such as wheat, has plummeted significantly, increasing dependency on food imports [19]. Climate-induced displacement has affected tens of thousands of citizens, compounded by fiscal risks and economic instability [21, 61, 62].

10. Escalating Population Growth Interplay with Water and Food Security

Iraq's population reached over 46 million with an annual growth rate of 2.15% [54, 10]. Rapid population growth combined with shrinking water resources threatens food security and social peace [15, 63]. Social indicators reveal poor health infrastructure, rising waterborne diseases, high dependency on food rations, and significant numbers of refugees and internally displaced persons [29, 62, 64].

11. What to do? Suggesting a Comprehensive Plan of Action

To address these challenges, a long-term strategy across regional and national levels is required [9, 65]:

- **Diplomatic and Political Actions:** Establish a Joint Inter-governmental Committee (JIC) to foster regional water cooperation and "Water for Security and Enhanced Economy Diplomacy" [38, 66].
- **Technical Actions:** Create the Supreme National Council for Water and Agriculture (SNC-WA), promulgate a Federal Water Law, implement progressive irrigation water pricing tariffs based on international practices, adopt Decision Support Systems (DSS) and SCADA automation, and expand non-traditional water resources like solar desalination and greywater recycling [67, 68, 69, 70, 71].
- **Agricultural and Economic Actions:** Modernize agricultural infrastructure and irrigation efficiency, implement crop water footprints and virtual water trade, promote family planning and education to curb population growth, develop private-sector market mechanisms and agrifood systems, and transition the rentier economy away from absolute oil dependency [3, 16, 17, 63, 72].

Data Availability Statement: Data is available by request from corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

Funding: This research did not receive any funding.

Ethical approval: This work has no effect on humans or animals and all work and images are properly used.

Consent to participate and publish: All authors agreed to publish this version of the paper.

Contribution of authors:

Nadhir Al-Ansari: Conceptualization, methodology, validation, investigation, data curation, visualization, writing original draft preparation, review and editing.

Nasrat Adamo: Conceptualization, methodology, validation, investigation, data curation, visualization, writing original draft preparation, review and editing.

Manal Sh. Alkubaisi: Conceptualization, validation, writing original draft preparation, review and editing.

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Table 1: Summary of annual flow volume statistics for the Euphrates River 1930- 2011

STATION (DRAINAGE AREA, km^2)	PERIOD	Mean (BCM)	Minimum (BCM)	Maximum (BCM)
Jarablus, Syria (120,000)	1938-2010	26.6	12.7	56.8
	1938-1973	30.0	15.05	6.8
	1974-1987	24.9	12.7	34.1
	1988-1998	25.5	14.4	50.1
	1974-1998	25.1	12.7	50.1
	1990-2010	22.8	14.4	32.6
Hussaybah, Iraq (221,000)	1981-2011	20.0	8.9	47.6
	1988-1998	22.8	8.9	47.6
	1990-2010	15.5	9.3	20.7
	1974-2010	16.8	8.9	30.7
Hit, Iraq (264,000)	1932-1998	27.1	9.0	63.0
	1938-1973	30.6	15.1	63.0
	1974-1987	23.1	9.3	31.2
	1988-1998	22.4	9.0	46.6
	1974-1998	22.8	9.0	46.6
Hindiyah, Iraq (274,100)	1930-1999	17.6	3.1	40.0
	1938-1973	19.8	6.6	40.0
	1974-1987	15.3	3.1	24.1
	1988-1998	13.8	7.7	27.9
	1974-1998	14.7	3.1	27.9

Table 2: Annual reductions in water inflow of main gauging stations (After [28]).

Station	Average annually inflow		Average annual water reduction		Annual percentage reduction %
	$m^3\ sec^{-1}$	km^3	$m^3\ sec^{-1}$	km^3	
Mosul ,TS_3,	569.75	17.96	1.35	0.0426	0.2372
Beiji ,TS_6,	1295.94	40.87	8.64	0.272	0.666
Baghdad ,TS_8,	979.26	30.882	9.73	0.307	0.994
Kut ,TS_{11},	815.50	25.72	14.73	0.464	1.804
Husaybah ,ES_1,	708.30	22.33	1.57	0.0495	0.222
Hit ,ES_2,	802	25.292	7.72	0.243	0.961
Hindiya ,ES_3,	551.62	17.40	4.02	0.127	0.730
Nasiriya ,ES_4,	430	13.5	1.452	0.0458	0.339

Table 3: Turkish dams on the Tigris and Euphrates rivers and their tributaries up to 2017, noting the symbols (I = irrigation), (P = power generation), (W = drinking water), (M* = military purposes)

	Dam	River/Tributary	Height (m)	Purpose	Completion Date
1	Çetin Dam (Alkumru)	Tigris/Botan	145	P	2016
	Aslandağ	Tigris/Greater Zab/Bembo	60	I/M/P (future)	2012
3	Beyyurdu	Tigris/Greater Zab/Bembo	48	I/M/P (future)	Under Construction
4	Atatürk (Karababa)	Euphrates	169	P	1992
5	Balli	Tigris/Khabour/Hezil/Ortasu	49	I/M/P	Under Construction
6	Batman	Tigris/Batman	74	I/P	1999
7		Euphrates/Murat	97	P	2015
8	Beyhan II	Euphrates/Murat	62	P	Planned
9	Birecik	Euphrates	62.5	I/P	2001
10	Burç Bendi	Euphrates/Göksu	47	P	2010
11	Cizre	Tigris/Botan	46	I/P	Planned

12	Çoukurca	Tigris/Greater Zab/Gűzedlere	45.5	W/M	Under Construction
13	Dumluka	Euphrates/Bugur	30	I	1991
14	Erkenek	Euphrates/Adiyaman	-	p	Operational
15	Göksu	Euphrates/Göksu	52	I	1991
16	Hecihider	Euphrates/Sehir	42	I	1989
17	Hancağiz	Euphrates/-	-	I	1988
18	Ilisu	Tigris	135	I/P/F	2017
19	Upperkalekõy	Euphrates/Murat	137,5	P	2017
20	Lowerkalekõy	Euphrates/Murat	115	P	Planned
21	Karakaya	Euphrates	158	P	1987
22	Karkamiș	Euphrates	21.1	P	2000
23	Kavsaktepe	Tigris/Khabour/Hezil/Ortasu	66	W/M	Under Construction
24	Kayacik	Euphrates/Sajur	45	I/P	2005
25	Keban	Euphrates	207	P	1974
26	Kirazlik	Euphrates/Botan	60	I/P	2011
27	Kralkizi	Tigris/Maden	113	I/P	1997
28	Musatatepe	Tigris/Khabour/Hezil/Ortasu	34.5	W/M	Under Construction
29	Silope	Tigris/Khabour/Hezil	79.5	W/M/P	2012
30	Silvan	Tigris/Batman	174,5	I/P	2017
31	Sirrntiș	Birimşe	92	I	2013
32	Șirnak	Tigris/Khabour/Hezil/Ortasu	56.8	W/M	2012

Table 4: Syrian Dams on the Euphrates River and its tributaries up to 1999, noting the symbols (I = irrigation), (P = power generation), (W = drinking water), (M* = military purposes)

	Dam	River/Tributary	Height (m)	Purpose	Completion Date
1	Baath (Manaoura)	Euphrates	14	P	1986
	Tabaqa	Euphrates	60	I/P	1975
3	Tishren	Euphrates	40	I/P/	1999
4	Upper Kabour	Kabour	169	P	1992

Tables 5: Iranian dams constructed on the Karkheh and Karun rivers and tributaries of the Tigris River until 2019

	Dam	River	Year of Operation	Height (m)	Capacity (Km^3)	Type
1	Karka 1	Karkha, Tigris	1952		7.8	I
2	Kohrank 1	Karon, Shat alarab	1954	10	0.32	Diversion
3	Dez	Dez,karon,shat alarab	1962	203	3.3	Hp,I
4	Karon 11	Karon, shat alarab	1976	200	3.13	Hp
5	Kofand down	Karon, shat alarab	1977	65	0.071	Hp
6	Khashlak	Serwan, Diyala, Tigris	1979	89	0.215	I
7	Shankasem	Barkon, Tigris	1966	49	0.215	I
8	Bazaft	Bazaft, karon, shat alarab	Planned	211	0.45	Hp

9	Karkha 2	Karkha,Huwaza, Shatt alarab	1998-2000	127	5.9	Hp,I
10	Karkha 3	Karkha, shat alarab	2002	177	0.061	I, Hp
11	Karon 2	Karon, shat alarab	2002	177	0.261	Hp
12	Ghafoshan	Ghafi,serwan, Tigris	2004	123	0.55	I, Hp
13	Kohrank 2	Karon, shat alarab	2005	15	0.01	Hp
14	Karon 3	Karon, shat alarab	2005	205	2.97	I, Hp
15	Suleiman shah	Ghafi, Serwan, Diyala	2006	50	0.05	I, Hp
16	Karon 4	Karon, shat alarab	2010	230	2.19	Hp
17	Upper Kofand	Karon, shat alarab	2012	180	4.5	I, Hp
18	Azadi	Zamankan, Diyala, Tigris	2012	64	0.07	D, Industry
19	Gheran	Gheran, Serwan, Diyala	2013	62	0.11	I
20	Semar	Karkha, shat alarab	2013	180	3.2	Hp
21	Gafa	Serwan, Diyala	2013	86	0.172	I, industry
22	Zafia	Shaheni, Serwan	2013	54	0.017	I, industry
23	Azad	Serwan, Diyala	2014	115	0.3	I, Hp
24	Asfahan	Harod, Karon, Shat alarab	2015	71	0.05	Drinking
25	Safelah	Lower Zab	2017	79	0,0163	Hp
26	Kharsan 1	Karon, Shat alarab	2015	195	1, 158	I, Hp
27	Karsan 2	Karon, Shat alarab	Planned	240	2.3	Hp
28	Karsan 3	Karon, shat alarab	2015	176	1.1	Hp
29	Zamkan	Zamkn, Diyala, Tigris	2017	65	0 023	I
30	Daryan	Serwan, Diyala, Tigris	2018	146	0,316	Hp
31	Herwa	Serwan, Diyala, Tigris	2018		0.012	Water diversion
32	Nawsood tunnel	Water diversion to Karmanshah	2018	48.3 km Long	1.0	Water diversion
33	Azkalah	Serwan, Diyala, Tigris	2018	65	0.03	Water diversion
34	Saradesht	Tigris, L.zab	2018	116	0,0545	Hp
35	Amer abad	Serwan, Diyala, Tigris	2019	30	0,018	I
36	Ramshad	Serwan, Diyala, Tigris	2018	35	0,006	Water diversion

Table 6: Simulation results showing reduction of flow in the Euphrates, Syhoun and Jordan Rivers in (2081–2100) under the climate change assumed future scenarios [53].

River	Scenario	
	Future Moderate (FM)	Future High (FH)
Euphrates	29%	73%
Syhoun	39%	88%
Jordan	82%	82%



Figure 1: Location of Iraq.

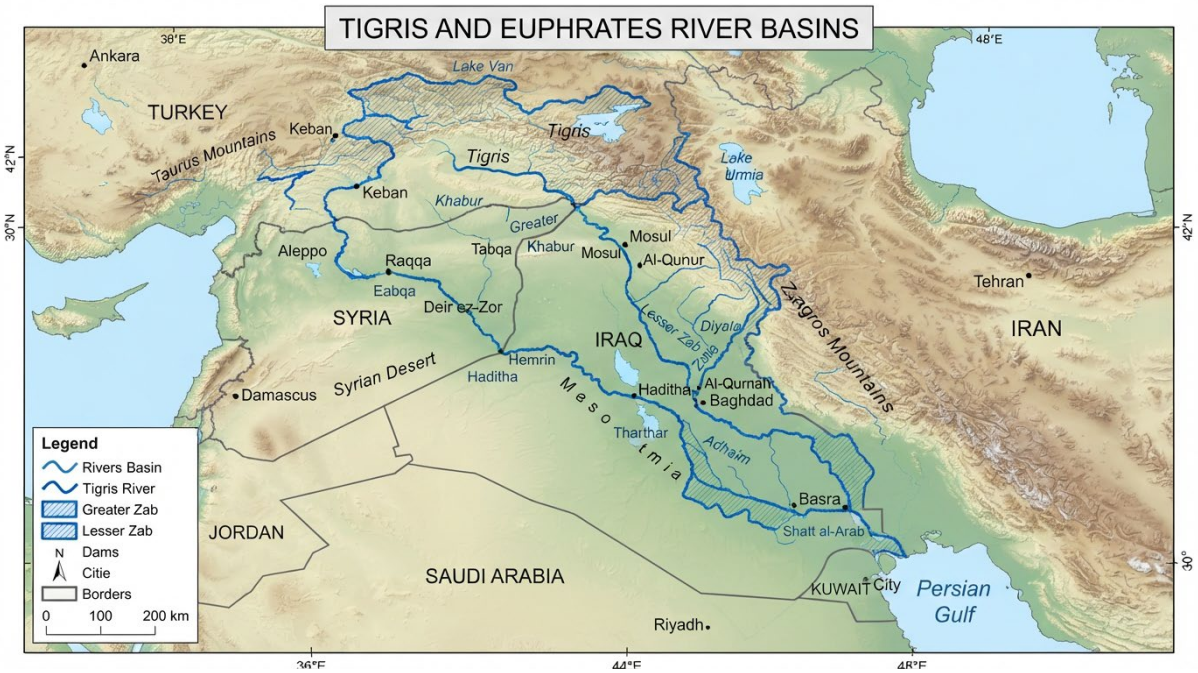


Figure 2: Tigris and Euphrates Rivers Basins

(modified from ESCWA, 2013).

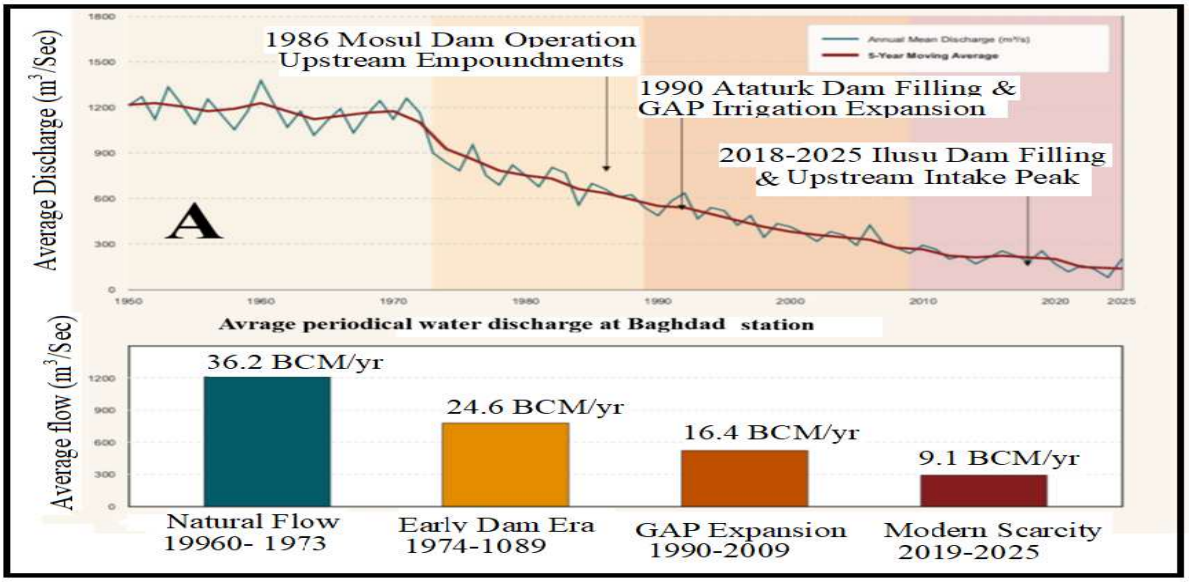


Figure 3: Decadal hydrographs of the Tigris River (modified from [27].

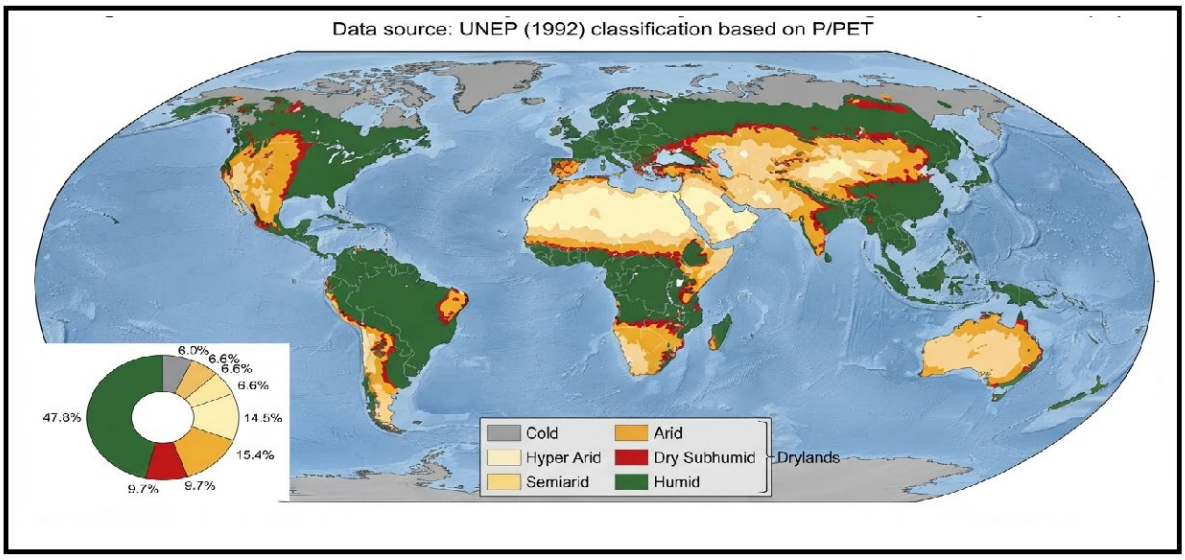


Figure 4: Map of the distribution of drought in the world according to the aridity indices (AI). [42].

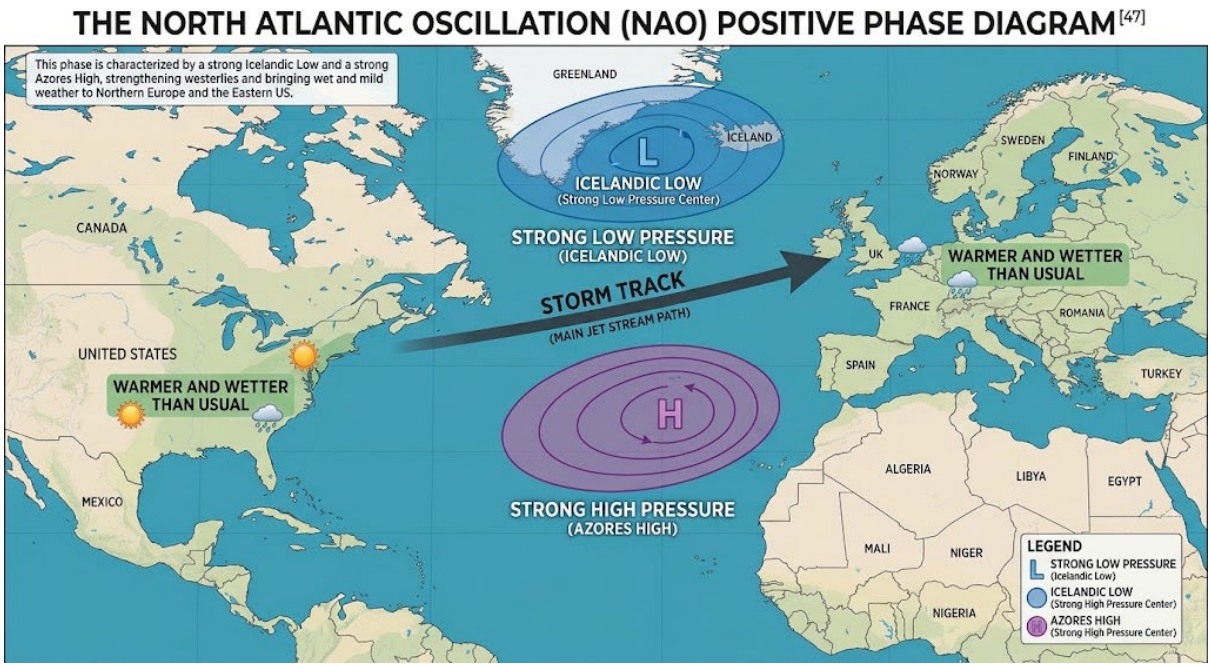


Figure 5: The effect of the change in wind path due to the phenomenon of the regular atmospheric pressure oscillation in the North Atlantic Ocean (NAO) [47].

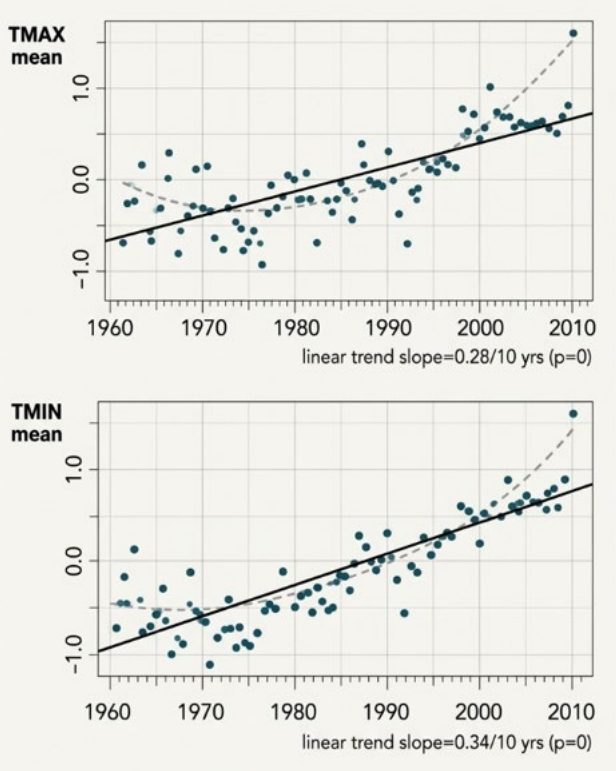


Figure 6: Time series of change in maximum (TMAX mean) and minimum (TMIN mean) temperature rates from 1966 to 2010 in the entire Middle East and North Africa region, [48].

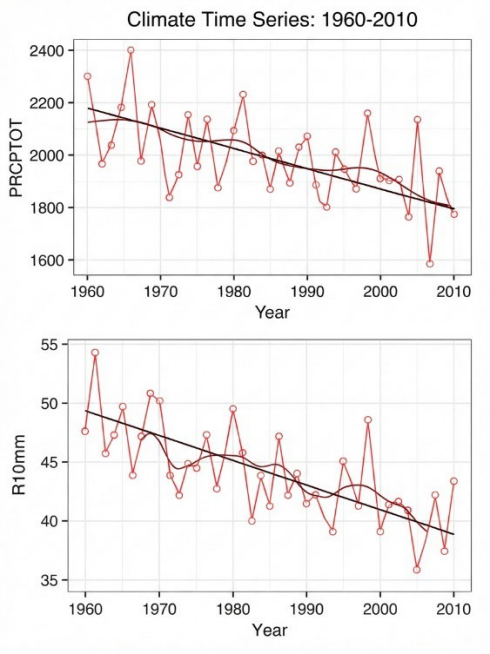


Figure 7: Time series of the rates of decrease in the annual total precipitation (PRCPTOT) and the decrease in the number of days in which precipitation exceeds (10) millimeters (R10mm) from 1966 to 2010 in the countries of the Arab East [48].

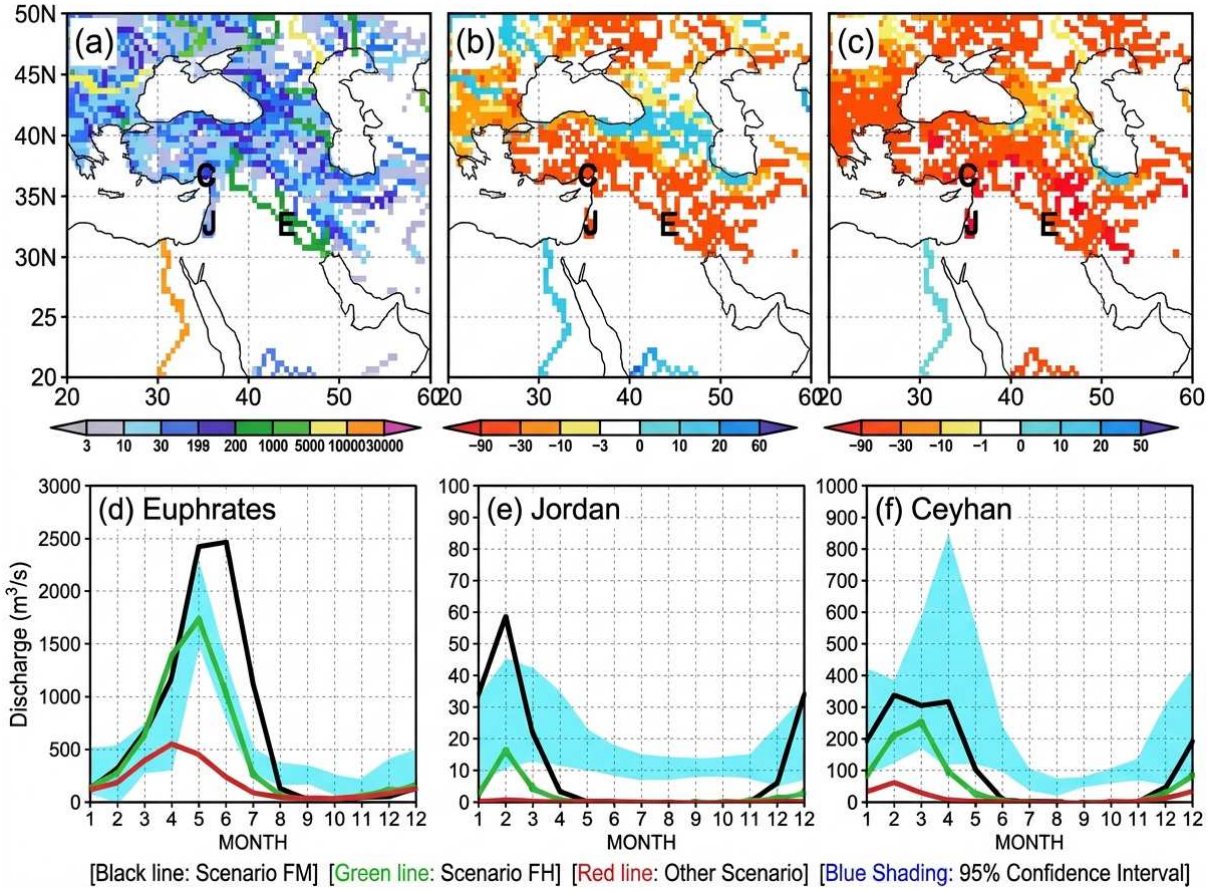


Figure 8: Output results of the FM and FH scenarios for the projected temperature change during the period (2081-2100) and impacts on the discharges of the Euphrates, Cyhoun, and Jordan rivers [53].

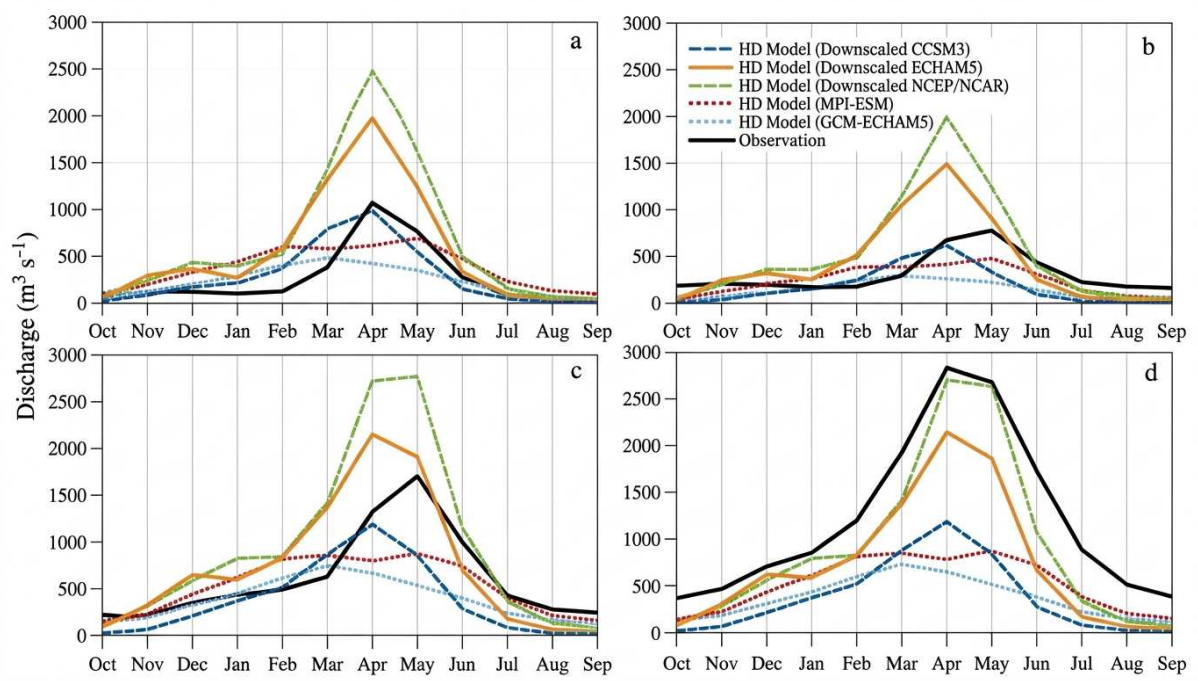


Figure 9: Hydrographs of observed (1961-1990) and projected monthly averages of Euphrates River discharges at the observation stations (2071-2100) in Palu, Beşktaş, and the Hindiyah Barrage, and for the Tigris River in Saray Baghdad station according to the six climate models [57].

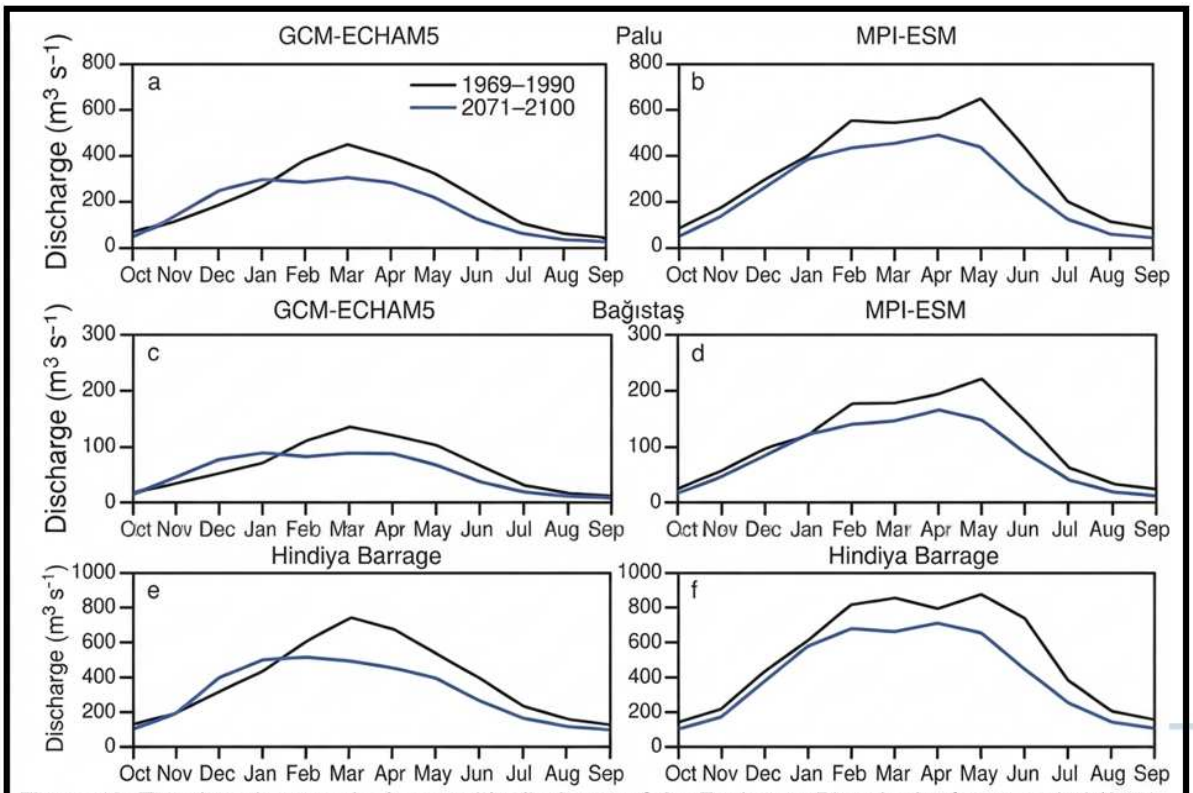


Figure 10: The clear decrease in the monthly discharge of the Euphrates River in the future period (2071-2100) relative to the discharges in the period (1969-1990) using two different models for each of the stations of Palu as in (a) and (b), Bağıstaş station as in (c) and (d), and Hindiyah Barrage station as in (e) and (f). Adapted from Bozkurt and Hagemann, 2015.

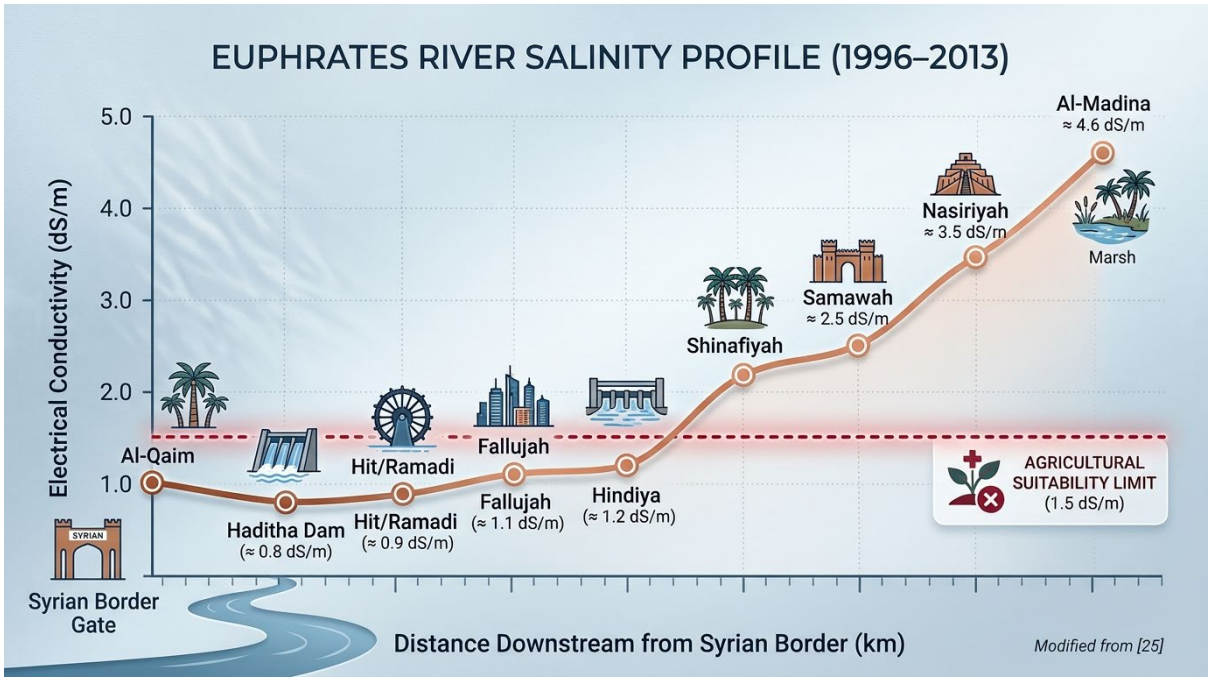
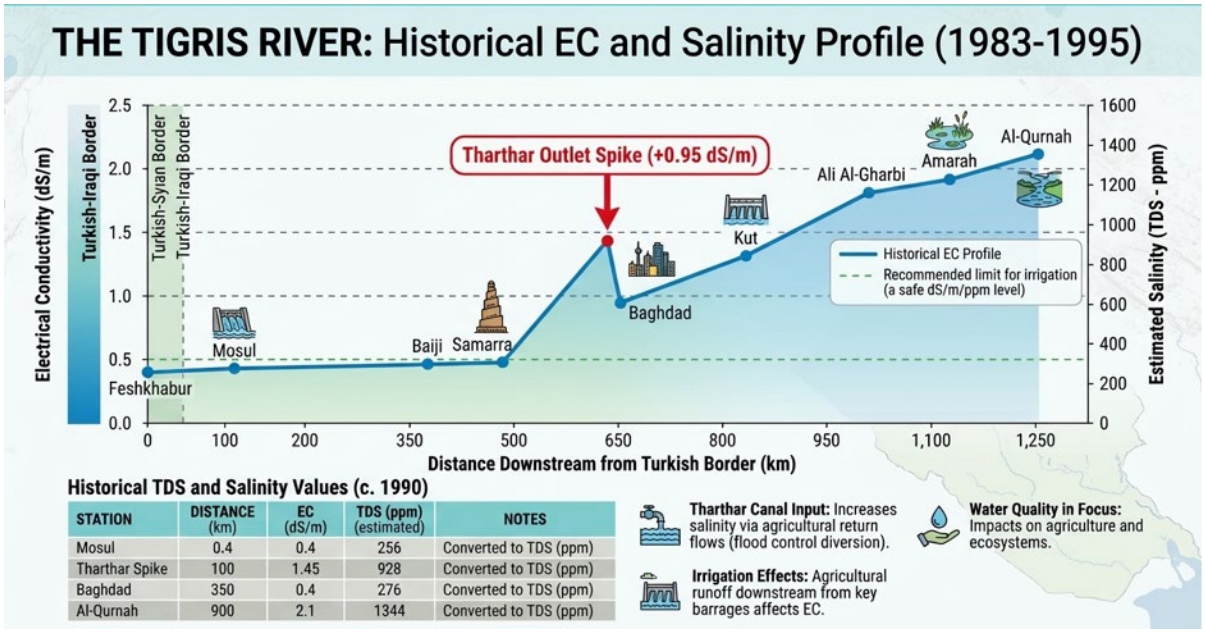


Figure 11: Change in salt levels along the Euphrates River from 1996 to 2013(modified from[25]).



STATION	DISTANCE (km)	EC (dS/m)	TDS (ppm) (estimated)	NOTES
Mosul	0.4	0.4	256	Converted to TDS (ppm)
Tharthar Spike	100	1.45	928	Converted to TDS (ppm)
Baghdad	350	0.4	276	Converted to TDS (ppm)
Al-Qurnah	900	2.1	1344	Converted to TDS (ppm)

Figure 12: Change in salt levels along the Tigris River from 1996 to 2013(modified from [25]).

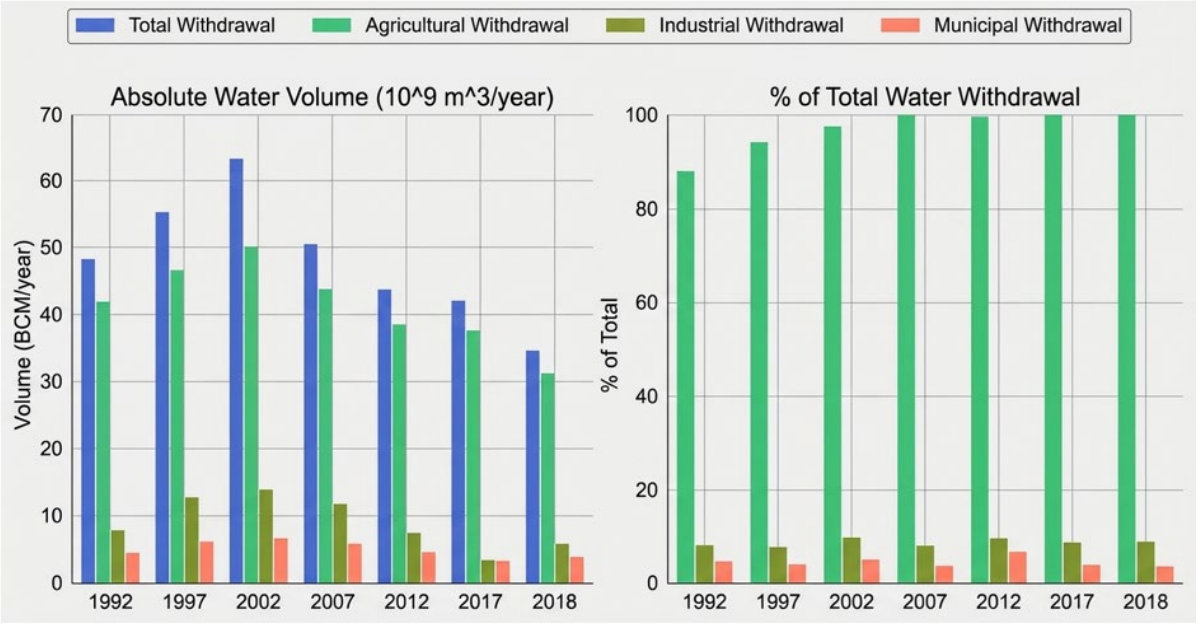


Figure13. Water withdrawal in Iraq by sector ([68])