Challenge C: Ecosystem

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Tigris-Euphrates River Ecosystem:

A Status Report

Paper for the Mesopotamia Water Forum 2019, Sulaymaniyah, Kurdistan Region of Iraq

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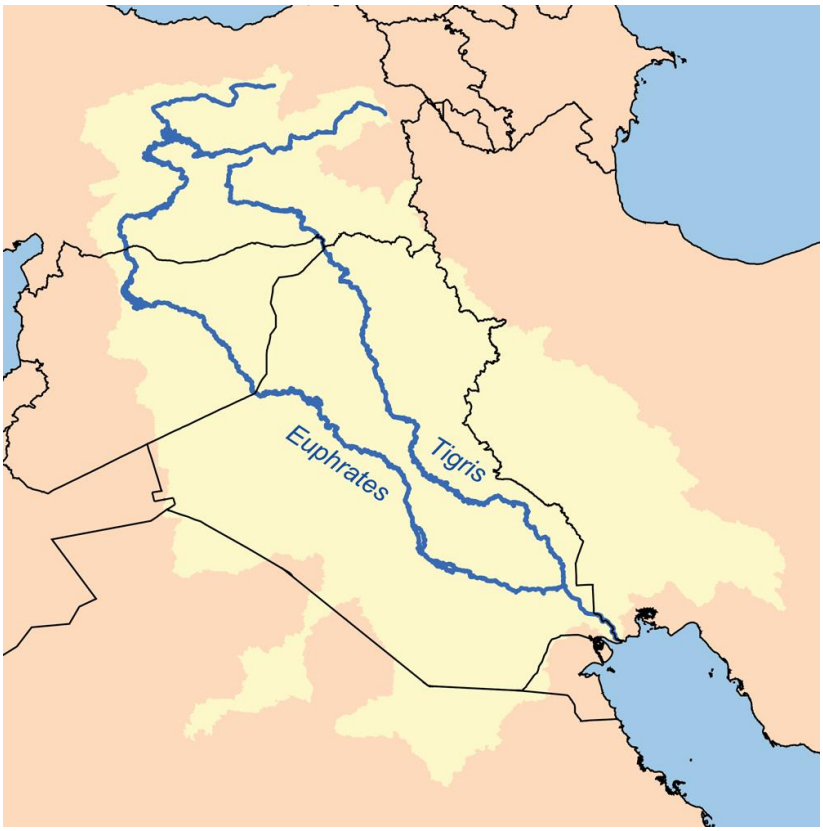
This paper provides a brief overview of the status and some of the key issues impacting the Tigris-Euphrates ecosystem today from the perspectives of each of the riparian states, the shared cross-border issues that impact this ecosystem, as well as how its overall health influences conditions in the Gulf. Actions necessary to protect the integrity and healthy functions of this ecosystem are discussed with an emphasis on solutions that can be taken at the local, community level.



Abstract

The ecosystem that makes up the Tigris-Euphrates River Basin provides the foundation upon which the biological diversity, economic productivity, human health, and cultural resources of the states of Turkey, Iran, Syria, and Iraq are based. But the health and vitality of the Tigris-Euphrates ecosystem is greatly impacted by water pollution, unsustainable management of the basin's hydrological systems, and climate change. This paper provides an overview of the current status of the basin as well as key issues from both the state and transboundary level. The first section covers the water resources, discussing the status of groundwater, water quality, infrastructure development, water resource management, and regional cooperation. The second section covers biodiversity, providing an overview of the status of a number of key species and issues impacting the biological diversity of the basin. The third section reviews two out of the many important Ecosystem Services of the Basin: agriculture and fisheries/aquaculture. The final section covers climate change impacts to the Basin. Taken together, these issues provide the framework in which regional water rights advocates must engage to develop an active civil society response to the challenges facing the Tigris-Euphrates Basin Ecosystem.

Introduction

In the summer of 2018, residents in Baghdad awoke to something they had never seen before: they could walk across the Tigris River, from bank to bank, and barely get their trousers wet. This alarming situation caused confusion and a search for answers -- as well as a desire to place blame. Many Iraqis pointed at Turkey, arguing that the massive reservoir of Ilisu Dam was stealing the water, and activists on social media called for a boycott of Turkish goods. But the Ilisu had not yet begun to be filled, an inconvenient fact for those looking for simple answers to Iraq's water crisis[1].

[1]The Turkish Government is intending to fill the reservoir in the spring of 2019.

In order to address the region's water woes, one must first understand them. With an eye to that endeavor, this paper provides a short overview of where the Tigris-Euphrates Basin stands today in terms of water resources, biological diversity, basic ecosystem services and the impacts of climate change. While not meant to be a comprehensive review, its goal is to focus on some of the key issues that regional water rights advocates should be aware of so that they can contribute to efforts to solve the basin's water resource issues.

The Tigris-Euphrates Basin Ecosystem - Water Resources

The Tigris and Euphrates Rivers cross four states from their headwaters to their terminus in the Gulf. Turkey, Syria, Iran and Iraq collectively contain 23 major and many more minor tributaries that are part of this massive system. The drainage basin covers 825,000 square kilometers of terrain that includes mountains over 4,500 meters in height, arid and semi-arid plains, and low-lying coastal wetlands.

Both the Tigris and Euphrates originate in Eastern Turkey, flowing thousands of kilometers before joining to form the Shatt Al-Arab River in southern Iraq, which finally enters the Gulf at Al-Faw. Table 1 provides an overview of basic information on the surface waters of the Tigris and Euphrates Basin along with some demographics and features about the basin.

Table 1: Tigris-Euphrates Basin Facts (adapted from UN-ESCWA, 2013)

Basin Facts	Tigris River	Euphrates River
Riparian Countries	Iran, Iraq Syria, Turkey	Iraq, Syria, Turkey
Basin Area Shares	Iran 19%, Iraq 56.1%, Syria 0.4%, Turkey 24.5%	Iraq 47%, Jordan 0.03%, Saudi Arabia 2.97%, Syria 22%, Turkey 28%
Basin Area	221000 km2	440,000 km2
River Length	1,800 km	2,786 km
Mean Annual Flow Volume	20 BCM (Mosul, Iraq Station), 25.7 BCM (Kut, Iraq Station)	26.6 BCM (Jarablus, Syria Station) 27.1 BCM (Hit, Iraq Station); ~30 BCM (Before damming: 1930-73);
Riparian contribution to annual discharge	Turkey: 40-65% Iraq: 10-40% Iran 5-25%	Turkey: 89% Syria 11%
Projected Irrigated Areas (in Basin)	~4.6 million ha	~2.3 million ha
Basin Population	23.4 million	23 million
Main tributaries	9 (Batman, Botan, Feesh Khabour, Greater Zab, Lesser Zab, Adhaim, Diyala, Tib, Dwairej)	5 (Karasu, Murat, Sajur, Balikh/Jallab, Khabour)

Many reports have been released providing detailed information on the Tigris-Euphrates Basin, much of it based on data from older studies[2]. Yet it remains difficult to obtain up-to-date information on the status of the Basin's water resources. This is mainly due to a lack of studies carried out or published in international journals. The data that is collected by the government is frequently hard to access because water data is frequently viewed as a bargaining chip in regional negotiations and therefore protected. Also estimates of the amount of water in the Basin that are available vary due to the natural high variability of flows throughout the year.

Groundwater

Surface waters and ground water are intimately connected. Changes to surface water (impounding it behind dams or withdrawing it from rivers) impacts groundwater and withdrawing water from wells impacts discharge and flows along rivers. Throughout the Basin, over extracting groundwater has impacted traditional methods of water supply and agricultural practices.

[2]Examples include the Inventory of Shared Water Resources in Western Asia (UN-ESCWA & BGR, 2013) and FAO's AQUASTAT (FAO, 2008).

For example, qanats, or kariz as they are known in Iran and Iraqi Kurdistan, are an ancient technique for tapping into groundwater through an elaborate series of interconnected wells and tunnels that were common throughout the region for thousands of years. But, in the 20th Century, with access to cheap fuel and motorized pumps, the use of qanats fell into sharp decline. A price has been paid for the new technology: for whereas qanats did not utilize groundwater beyond the limits of natural replenishment - and therefore didn't destabilize the hydrological equilibrium of the aquifer – mechanical pumping can quickly go beyond that limit and deplete the system (de Châtel, 2007). Current figures aren't precise but qanat use in Iran dropped from more than 70% in the 1950s to below 10% by 2007. Similarly, one survey in Syria of 91 qanats in the early 2000s found that only 30 were still flowing (Ibid., p184).

Over-pumping has lowered the groundwater table in Iraqi Kurdistan as well. Erbil has many Kariz, but most were built to a depth of 20-25 meters below ground. Since the 1980s, due to over-pumping, the water level has dropped to 80 meters deep (Westra, 2011), leaving the Kariz high and dry.

Groundwater recharge is the hydrologic process through which water moves downward from surface water to groundwater to "recharge" or fill the underground aquifer. The rate that this will occur varies based on precipitation and geology and is still poorly understood in many areas of the basin. In Iraq, the Iraqi government, in cooperation with UNESCO, conducted the ASHRI II Project (Advanced Survey of Hydrogeological Resources in Iraq, Phase II) to study the country's aquifers in order to begin to understand the potential of these systems and start developing tools and a roadmap for better governance. Throughout the riparian states of the basin, understanding groundwater and finding a pathway towards integrated and efficient management of these resources will be an important prerequisite to protecting the basin as a whole.

Water Quality

In 2011, the Strategic Foresight Group (SFG), an international think-tank that focuses on water diplomacy, peace, and global foresight, noted that across the Middle East, river flows have been dropping and pollution increasing. In the Tigris and Euphrates Basin, these trends have become acute.

There are a variety of pollutants impacting the basin. For the purposes of this paper, we will single out two of the most prevalent water quality issues in the region: salinity and nutrient pollution from agricultural runoff and sewage. Irrigated agricultural fields return drainage water back to the river and this drainage water carries with it fertilizers, pesticides and salts that have washed out of the soils. As a result, the rivers become saltier and more toxic as they travel south. For example, historically, the freshwaters of the Shatt Al-Arab in the lower basin only became brackish[3] near the towns of Seeba (Iraq)/Abadan (Iran) but over the last 40 years, average salinity levels in Basra, approximately 50 km upstream, are 2545 ppm, and levels over 18,000 ppm have also been recorded there (Rahi, 2018).

A number of studies on the Euphrates River done since 1996 have found that the river's waters reach alarmingly high levels of salinity as the river progresses southward from Turkey and becomes unsuitable for irrigation just before the river reaches the Syrian-Iraqi border (ESCWA & BGR, 2013). Kangarani (2005) points out that over pumping of wells has made the problem worse and many irrigation development projects have caused greater pollution and higher salinity from returning agricultural drainage water. In the case of the Tigris River, by the time the river reaches Baghdad, its waters have also become too salty for use in agriculture and its salinity continues to increase as the river flows southward (Al-Ansari et al., 2018). As irrigated agriculture expands in the upper basin of the Tigris, salinity levels will continue to climb.

[3]Freshwater is <1,000 ppm TDS (Total Dissolved Solids, a measurement of the total ionic concentration of dissolved minerals in water), where as Brackish water is between 1,000-5,000 ppm TDS.

Dumping of untreated sewage into the rivers and their tributaries is also a major source of bacteria and nutrient pollution. Wastewater treatment facilities, when they do exist, are often not able to fully treat municipal wastewater. In Iraq, only 14 cities have wastewater treatment plants (Al-Ansari et al., 2018). Kaisi et al. (2005) stated that Syria had six plants with four under construction and plans to build 15 more but their current status is unknown since the start of the Syrian Civil War. Iran has over 120 municipal wastewater treatment facilities, largely built after the Islamic Revolution of the 1980s but wastewater treatment and collection rates are still only at 45% and 35%, respectively (Tajrishy, 2011). In Turkey, only 41% of wastewater discharged from sewage systems was being treated (Ministry of Environment and Forestry, 2007 & FAO, 2008) and within the upper Tigris-Euphrates Basin there are only wastewater treatment facilities in larger cities such as Diyarbikir, Batman, Siirt, and Ufra.

Disease outbreaks such as cholera have troubled areas where drinking water sources have become cross-contaminated with wastewater[4]. Those that can afford it drink bottled water but for the vast majority of people, drinking from the tap is their only option.

Polluted water not only transmits disease, it is also toxic for the flora and fauna in the basin. In the fall of 2018, for example, a massive fish kill resulted in the death of hundreds of tons of carp packed in floating fish farms that densely line the Euphrates River in the Babylon Province of Iraq. After conducting water quality tests, the World Health Organization determined the river had high levels of bacteria, heavy metals and ammonia (AP, 2018a), all signs of pollution from municipal and industrial sources[5].

Fish kill on the Euphrates River near the town of Sadat Al-Hindiya, north of Hilla, Iraq, 2 November 2018. Source: AFP.

Infrastructure Development

Large dam projects in the Tigris and Euphrates Basin began in the 1950s in Iraq, and were predominantly focused on flood control and irrigation. Large irrigation projects, such as the North Al-Jazeera and East Al-Jazeera projects, involved the installation of networks of canals to bring the waters of the basin into areas that would serve thousands of hectares of newly-irrigated farmland (FAO-AQUASTAT, 2009). Syria and Turkey began large projects on the Euphrates in the 1960s. Turkey's Ataturk Dam on the Euphrates was completed in 1992. As the centerpiece of Turkey's Southeastern Anatolia Project (GAP) it is but one of many power and irrigation projects that Turkey plans to complete in the basin. The most recent, the Ilisu Dam on the Tigris, is almost completed.

Iran has only in the last few decades started large dam projects on tributaries to the Tigris (e.g. Chomani & Bijnens, 2016). The effect of this has already been felt, as small rivers and private wells in the Kurdistan region in northern Iraq have begun to dry up. When the Kurdistan Regional Government objected to Iran's development and accused Iran of withholding water, Iran disputed the characterization, saying drought is to blame (not its actions on the Tigris) and emphasized that water scarcity is a regional issue as it is dealing with its own water crisis (Aljazeera,

[4]According to the World Health Organization, outbreaks occurred in Iran in 2005; in Iraq in 2007-08, 2012, & 2015; Turkey has reported no cases since the 1970s, and Syria has no recent reports (see www.who.int) but there are various accounts of cholera outbreaks there since the start of the Syrian civil war.

[5]In the absence of information released to the public from reputable government studies, conspiracy stories have been circulated that fish kills have more exotic causes such as strange new diseases or foreign actors intentionally poisoning the waters, when the real culprit is far simpler – the on-going disposal of untreated wastewater into local rivers as well as the uncontrolled development of aquaculture beyond the carrying capacity of the river.

2018). This dispute highlights the complexity of the issue and the need for regional, basin-wide communication and coordination. For more details on dams within the basin, see Ayboga (2019).

Water Resource Management

Part of managing water in the basin requires understanding, influencing, and balancing of supply and demand. In many areas of the Middle East, demand is already outstripping supply. To better understand this dynamic, from 2011 to 2014, Iraq initiated an important project that culminated in a "Strategy for Water and Land Resources in Iraq" (SWLRI), which detailed a strategy for efficient and sustainable water and land usage for twenty years (2015 to 2035). One of the starkest graphs from the report analyzed Iraq's future water supply against its water demands (See Figure 1).

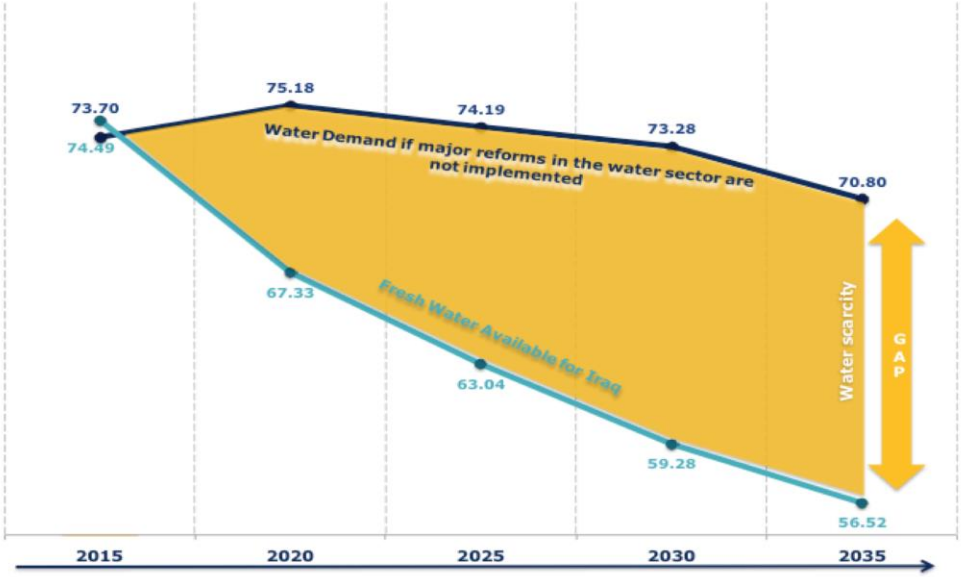


Figure 1: Iraq Water Supply-Demand (in Million Cubic Meters) without major water sector reforms (SWLRI, 2014)

This graph should be a wake-up call to Iraqi decision-makers: unless Iraq makes radical changes to the way it manages water or finds a way to secure more water from its neighbors, its supply of good quality water (represented by the blue line in the graph) will not be enough to meet the country's needs for food, energy, environment, drinking supply, etc. (represented by the black line in the graph). And the gap only widens with time. After 2015, Iraq's water needs (its demand) had already surpassed its supply.

But the SWLRI (2014) also provides a way forward for the country to sustainably manage its water resources, accomplish its development goals without sacrificing the environment. Indeed, the SWLRI Master Plan was the first time that the Government of Iraq officially allocated a minimum amount of water to the Mesopotamian Marshes. Also, with the envisioned reforms outlined in the strategy, a minimum environmental flow rate could be accomplished in the Tigris, Euphrates and Shatt Al-Arab, which is important to protect southern Iraq from saltwater intrusion. All of this, the Strategy argues, could be accomplished while achieving the country's development and agricultural goals.

Another important finding of SWLRI was that no new large dams would be required for Iraq to achieve its development objectives, such as those proposed at Bekhme, Mandawa or Fatha. Hydropower no longer needs to play a primary role for energy generation in Iraq, and rehabilitating Mosul Dam and expanding the Samara Barrage and

Tharthar Escape Canal can achieve Iraq's basic flood control needs. The SWLRI project assumed, however, that revolutionary changes would take place in Iraq's reservoir operation and there would be improved efficiency in all water sectors (by following the graduated steps outlined in the Strategy). But to do this, it requires Iraq to invest the financial and logistical resources that as yet its government has been unable to allocate.

In the case of Syria, even before the civil war started, water demand had already surpassed supply. Five of Syria's seven basins were seeing water shortages (Mourad & Berndtsson, 2012). In an interview in the early 2000s, Dr. Jamal Jamaleddin of the Syrian Ministry of Water Resources stated,

> "Every year, the water situation worsens and every year the population increases by half a million. Given the internationally recognized minimum water supply per person per year is 1,000 cubic meters, it means we need to provide half a billion cubic meters of extra water every year. This is impossible. There is no way we can provide this. We can't even satisfy current demand" (de Châtel, 2007, p21).

Water resource management, however, is not as simple as managing per capita demand alone. There is a range of factors that drive both water supply and demand decisions. These include the relative imbalances in geo-political and economic power structures between the various stakeholders; bureaucratic infighting and competition for resources; corruption; conflicts between growth-at-any-cost vs community-oriented development models, and overall stakeholder education and awareness.

As Syria continues to engage in its civil war, planning for water management that grapples with these issues is likely years away. For Iran, serious challenges in its water sector include rising water demand, water shortage, declining groundwater levels, deteriorating water quality, and increasing ecosystem losses (Madani, 2014). Though not, like Syria and Iraq, impacted by recent wars, poor water management (particularly wasteful agricultural practices) is a hallmark of Iran's water crisis as well.

Regional Cooperation

An ecosystem as vast and complex as the Tigris and Euphrates requires full cooperation and effective management between all of its riparian neighbors. Unfortunately, the basin has seen precious little of this. Instead, dams and agricultural development have been pursued by each nation unilaterally without much coordination (the appendix provides a review of this history). In the past, this lack of coordination almost caused armed conflict: Iraq amassed troops on Syria's border in the 1970's due to the building of the Keban (Turkey) and Tabqa (Syria) dams and Saddam threatened to bomb the dams if necessary to get the water levels back up. Despite the problems a lack of coordination has caused and the clear need for integrated management, to this day, there is still no comprehensive four-party agreement to manage the basin in an equitable and collaborative fashion.

In 2015 and 2017, the Strategic Foresight Group (SFG) released reports on the "Water Cooperation Quotient". The Water Cooperation Quotient or WCQ was the result of an analysis of different transboundary watercourses around the globe. The WCQ attempts to quantify the extent and success of water cooperation between riparian nations, such as the presence of binding agreements or the strength of communication mechanisms between riparian states[6]. A perfect score of 100 represents full and active water cooperation between riparian states. The scores for the riparian nations of the Tigris and Euphrates were assessed in 2015 and 2017 (see Table 2 below).

[6]The WCQ is computed based on 10 parameters that also include: Technical projects, Exchange of data, Alternative dispute resolution, Floods, droughts & ecosystem protection, Water infrastructure, Inclusion, Political commitment, and Institutional functioning.

Table 2: Water Cooperation Quotient Scores for Tigris-Euphrates Riparian States (SFG, 2015 & 2017)

	Iraq-Iran	Iraq-Turkey	Iraq-Syria*	Syria*-Turkey
River Basin	(Tigris)	(Tigris & Euphrates)	(Tigris & Euphrates)	(Tigris & Euphrates)
WCQ 2015	1.81	1.81	1.81	1.81
WCQ 2017	13.33	53.33	3.33	3.33
**Since 2011, due to the protracted armed conflict Syria has been unable to attend to its transboundary water relations.*				

Even though the assessment for 2017 represents an improvement (particularly between Iraq and Turkey), there is clearly a need for more cooperation if we are to solve the water problems in the basin.

Box 1: Bird diversity of Hawizeh/Hor Al-Azim Marshlands (Laith Al-Obeidi, Nature Iraq)

Hor Al-Azim, 24 Jan 2018, L. Al-Obeidi	**Birkat Al-Udheim, northern Hawizeh Marsh, 5 Feb 2018, L. Al-Obeidi**

Between January and February 2018, typically the wettest part of the year in the Iraqi marshes, Iraqi and Iranian bird researchers came together to visit Al-Azim Marshes in Iran and Hawizeh Marshlands in Iraq, which has been designated by Iraq as a Ramsar Wetland of International Importance. Together these represent a single, transboundary wetland ecosystem that is a key component of the Mesopotamian Marshlands.

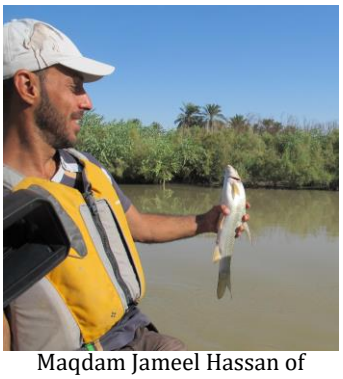
This was one of the first cooperative efforts between Iraqi and Iranian researchers to study a transboundary ecosystem. While Hor Al-Azim remained flooded, though at lower levels than was usual for winter, many areas of Hawizeh, such as Birkat Al-Udheim, in northern Hawizeh, were almost completely dry. Drought conditions caused by declining winter rain and snowfall led to historic low river levels in the Tigris and Euphrates Basin and extensive drying in the marshlands areas. Overall bird counts where higher in Hor Al-Azim (37,331) than in Hawizeh (10,318). Counts for waterbirds in Hor Al-Azim were 36,528 with nine conservation-concern bird species present but were only 9,043 in Hawizeh with just four conservation-concern bird species found.

In contrast, in annual winter surveys conducted of Hawizeh Marshes during the Key Biodiversity Areas (KBA) Program*, it was common to observe 35,000 waterbirds wintering or passing through Hawizeh Marshes. The 2018 winter survey represented a 74% decline in waterbird counts for Hawizeh. Also, many important species seen in previous surveys such as the Endangered White-headed Duck, Goliath Heron and African Darter were absent from the Iraqi-side of the marshes and others have decreased in number such as the Vulnerable Marbled duck.

*Nature Iraq and the Iraqi Ministry of Environment conducted these surveys between 2005 and 2010.

Tigris-Euphrates Ecosystem – Biodiversity

On a river expedition to highlight the plight of the Tigris River in the fall of 2013[7], a fish was caught by hand along the southern reaches of the river. Here, the river suffers from the bulk of pollution discharged by the four upstream states. This particular fish, a Yellowfin barbel, locally known as Gatan and to science as *Luciobarbus xanthopterus,* looked outwardly normal but was clearly near death, so easily was it caught.



Maqdam Jameel Hassan of Iraq Ministry of Water Resources with Gatan, Photo by A. Bachmann

Listed as "Vulnerable" (i.e. vulnerable to possible extinction)[8], Gatan are in decline due to a number of problems that they and many other aquatic species face: pollution from sewage and industries; unsustainable fishing practices; dam construction; drainage and drying of the marshlands in southern Iraq and Iran[9]; climate change-induced drought; and overall, by poor management. Releasing this dying specimen back to its fate in the river, it was clear to see that the Tigris River, as well as its partner, the Euphrates, has become unfriendly, perhaps even deadly places for the species that still call these rivers their home.

According to the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species, the number of aquatic animals within Iraq, Iran, Syria and Turkey as a whole include: 117 insects species (15 of which are listed as threatened species), 12 amphibians (7 of which are known to be threatened), 100 freshwater and marine fish (27 are threatened), 251 birds (32 threatened), and 6 mammal species (of which 3 are threatened). But the number of threatened species could be larger: very little is known about their status in the basin and many species on the IUCN Red List are listed in the category "Data Deficient" due to a lack of studies. Some key species are worth mentioning, not only because they represent the biological wealth of the basin but also because they are important indicators of the basin's health.

Dark-winged Groundling, Photo by

The Dark-winged Groundling, a jet-black species of dragonfly with translucent wingtips, has the scientific name *Brachythemis fuscopalliata*. It is a good example of the many threatened aquatic insects found in these river systems and has declined in population throughout its range. Dragonflies, much like other aquatic insects that include Ephemeroptera (Mayflies), Plecoptera (Stoneflies), and Trichoptera (Caddisflies) spend most of their life cycle as aquatic larvae, which are very delicate and highly vulnerable to water pollution. They decrease in number and diversity (and may totally disappear) from streams and rivers impacted by sewage, agricultural run-off or industrial effluents. Damage to the river from dredging and gravel mining can also kill these organisms outright by destroying them and their habitat. Also the practice of dam hydropeaking - raising river volumes up and down every day by dams to meet our hourly electricity needs - can disrupt the reproductive cycle of some species. Naturally, river levels generally only change gradually. But with so many dams, the rivers don't behave normally and the large fluctuations in river flows can wipe out populations of insects (OSU, 2016); with no insects, the foundation of the river's food chain disappears.

[7]Organized by Nature Iraq, the Fertile Crescent Foundation and Waterkeepers Iraq.

[8]The IUCN Red List of Threatened Species, (www.iucnredlist.org) is the world's most comprehensive inventory on the global conservation status of biological species. It uses a set of criteria to evaluate the extinction risk of thousands of species and subspecies. It classifies species into nine groups: Data Deficient, Not Evaluated, Least Concern, Near Threatened, Vulnerable Endangered, Critically Endangered, Extinct in the Wild, and Extinct.

[9]Marshlands have been drained to divert water for agriculture, to clear land for oil development, and most notoriously during the Saddam Regime's campaign to drain vast areas of the Mesopotamian marshlands in Iraq after the 1991 Gulf War. Iran has also drained marshlands and built a 40 km long embankment along its border with Iraq through the transboundary Hawizeh/Hor Al-Azim Marsh in 2009.

The health and survival of the Dark-winged Groundling is a litmus test for the health of our rivers. When present, they indicate that the water quality is good and the river functions are adequate to support aquatic life. If they live, so too can the near-threatened Arouss Al Ayn Salamander (*Salamandra salamandra infraimmaculata*). Breeding in pools and slow-flowing streams, this black salamander with brilliant yellow splotches is active at night but, according to the IUCN, is threatened by damming of its breeding streams, aquatic pollution, and the increase in groundwater extraction due to the rapid expansion of irrigation schemes for agriculture.

Marbled Teal, Photo by L. Al-Obeidi

A key endemic reptile species that is only found in the waters of the Tigris-Euphrates Basin is the Euphrates Softshell Turtle *(Rafetus euphraticus)*. While still found in good populations on the Tigris River, this large, Endangered turtle (it can reaching up to 20 kg with a shell over 2 feet long) has declined in the Euphrates River primarily due to dams.

Important waterbirds are already starting to by-pass large portions of the basin as wetland areas are dried due to dam construction, drainage and drought (See Box 1). The Marbled Teal (*Marmaronetta angustirostris*), an elegantly shaped, brown duck with a dark streak around its eye, was once native in all four countries of the Tigris-Euphrates Basin but is now listed as Vulnerable. The IUCN states that over 50% of the suitable marshland habitats that this small duck relies upon has been destroyed during the 20th century. Drainage of wetlands for agriculture and particularly the drainage of the Mesopotamian Marshlands have led to the decline of this species. In Iraq (but likely in all the countries where it is found), it is also a favored target for hunters and is, like a number of aquatic bird species, threatened by overhunting (Salim, 2010).

There are also mammals that are aquatic specialists such as the Eurasian Otter (*Lutra lutra)* and the Smooth-coated otter (*Lutra perspicillata*). The former is found throughout the Tigris-Euphrates Basin and is considered Near Threatened. The latter is considered Vulnerable and is endemic to the Mesopotamian marshlands of Iraq and Iran. Like many of the predator species that depend on rivers and wetlands and sit at the top of the food chain, the presence of these keystone species is a sign of a healthy, functioning ecosystem and their absence indicates that pollution, habitat destruction, decline in prey species, and over-hunting is prevalent.[10]

Eurasian Otter,
Photo by J. Al-Asadi

Despite the importance of aquatic insects and amphibians and the beauty of the birds and mammals that grace these rivers, it is often fish that we think of most when working for the protection of the basin. The Tigris and Euphrates Rivers once teemed with monster-sized fish and supported economically important fisheries that stretched down into the Gulf. Famous dishes like the Iraqi Masgoof come to mind and fish like Bizz (Farkh in Syria, Caner or Fırat Turnası in Turkey) (*Luciobarbus esocinus),* is a favored fish for the table across the region. *L. esocinus* was once common and could grow up to 2 meters in length and weigh over 100 kg.

[10]Much has been said about the conflict between keystone predators and humans. By the time that fisherman begin to view otters as competitors for dwindling fish stocks, the fisheries has likely already been compromised by other stressors.

For the rivers to support such leviathans and for the health of the humans who consume them, these species need not only clean water but, according to the IUCN, flowing rivers. While *L. esocinus* is found in reservoirs, it will still migrate to inflowing rivers to find habitat in which to spawn. Dams have reduced their ability to migrate between foraging and spawning sites. Declining water levels due to water extraction and drought, which appear to only be worsening due to climate change, shrinks their habitat. Also uncontrolled fishing has led to the over-harvest of *L. esocinus* and many other food-fish species. According to the IUCN assessments, *L. esocinus* have decreased in population by 30% in the last 42 years.

Luciobarbus esocinus caught in Turkey. Source: www.fishing-worldrecords.com

Often it is simply poor management that is to blame for the decline in fish species. In 2013, a fisherman on the lower Tigris River complained that after a particularly wet winter, Suwaibaat, a wetland that spans part of Thi Qar and Muthanna Governorate in Southern Iraq and is considered a Key Biodiversity Area, swelled with water that spring and was teeming with fish. Unfortunately, before any fisherman could harvest this bounty, the Iraqi Ministry of Water Resources, following directives from Baghdad that were out of touch with local interests, drained the marshlands, leaving thousands of fish to suffocate under the hot sun (Pers. Comm., October 2013).

There have been few, if any, biological studies in large sections of the Tigris-Euphrates Basin. In many areas, scientific field research came to a stop due to conflict and social upheaval. As a result, many of the rivers and tributaries in the basin are unstudied and species are likely going extinct without our ever having known they existed in the first place.

Some work has been done in the basin to identify and bring attention to areas of important biological diversity that meet international criteria for their rare and threatened species and unique habitats (for Iraq, see Nature Iraq & Iraq Ministry of Health and Environment, 2017; For Turkey see Magnin and Yarar, 1997 and Kilkic and Eken, 2004; and for Iran & Syria, see Evans, 1994). Over 150 Key Biodiversity Areas or KBAs have been identified throughout the Tigris-Euphrates Basin (80 in Iraq, 14 in Syria, over 35 in Turkey, and over 30 in Iran) (Birdlife International, 2018). These sites are worthy of protection, but according to the World Database of Protected areas (UNEP-WCMC, 2018), Syria has not officially designated any of its sites as "protected areas"; Iraq and Iran have 23 and 21 designated protected areas, respectively. Turkey has designated only one site as a protected area (Nemrut Caldera, near Lake Van), despite having several sites within the upper basin that meet global criteria as Key Biodiversity Areas (Birdlife International, 2018). For example, four internationally recognized “Important Bird and Biodiversity Areas”, along with significant populations of rare and threatened species, would be negatively impacted by the Ilisu Dam on the Tigris River (Doğa Derneği, 2006).

Yet while achieving official designation as a "protected area" is a positive step, most of the current protected sites have yet to see any real, on-the-ground conservation. Governmental initiatives to protect important sites will see more success if they plan jointly with local communities. Even local conservation initiatives alone can play an important part in conserving the biodiversity of the basin. Two areas within the Greater Zab River Basin in Iraqi Kurdistan have been designated as protected areas through locally-driven action: the Barzan Protected Area has been protected for many years by the Barzan Tribe (primarily from over-hunting and deforestation) and Halgurd-Sakran Park, has been the focus of a number of conservation actions by local government and community members (local action has raised awareness about conservation and recently helped shut down an in-stream gravel mine in the park (Nabil Musa, Waterkeepers Iraq, pers. comm., June 2018).

Box 2. Ecosystem impacts expected due to the Ilisu Dam on the Tigris River in Turkey (Dicle Tuba Kılıç, Doğa Derneği)

The Tigris Basin is characterized by extensive biological diversity. Many local species are endemic, meaning that they cannot be found anywhere else in the world. Large areas of the Tigris Valley have never been evaluated by biological surveys and most likely harbor many, yet-to-be-discovered ecological treasures. The roots of civilization lie in Mesopotamia. Agriculture originated here, and many of the cultivated plants that are taken for granted today came from this region: barley, spinach, rapeseed, flax, poppy, and so on.

Approximately 400 kilometers of the Tigris and its tributaries will be impacted upstream of the Ilisu Dam. Flooding will drown a dynamic river system, transforming the river into a static reservoir. The downstream ecosystem will be severely impacted by water surges downstream of the dam (hydropeaking) caused by the daily operation of the power plant. Specialists from the renowned Swiss Federal Institute of Technology Zürich (ETH) have determined that water released by the dam, which will come from the deeper levels of the reservoir, will be approx. 10 degrees colder than normal river temperature in the spring and summer; will be polluted with agricultural pesticides and fertilizers, and will be oxygen-deficient. The combination of these factors will result in extensive ecological damage to the downstream river ecology. Very few species can adapt to daily floods of polluted, oxygen-poor water.

The Tigris Valley is at present an extensive, intact river ecosystem, with islands, bays and sandbanks and many rare animal and plant species. When the dam is put into full operation, species such as the Euphrates Soft-shelled Turtle, the Pied Kingfisher, the Red-wattled Lapwing, and the Euphrates Poplar are not likely to survive, as well as approximately half of the 40 fish species currently identified in the upper basin. It is only the common species that will benefit, species that are already prevalent in many lakes. Negative ecological repercussions can be expected to reach as far as southern Iraq. Once the Tigris Valley is flooded, little arable land will remain; the soil in the surrounding area is dry, rocky and of limited fertility.

The upper Tigris Basin lies within the Irano-Anatolian Biodiversity Hotspot, a biogeographic region that is both a significant reservoir of biodiversity and is threatened with destruction. This is amplified by the fact that the region lies on the border between Europe and Asia; no one knows how great the biological diversity really is, as large areas of the Tigris remain unsurveyed. The Ilisu Dam has been built without an assessment of its impact on the environment, which is true for most dams constructed in the region. Turkey's extensive damming of the Euphrates has resulted in a drastic reduction in the amount of water entering Syria and then Iraq, with an accompanying decrease in water quality. Now the same thing threatens to take place on the Tigris.

Tigris-Euphrates Ecosystem Services

Tigris-Euphrates Ecosystem services, to name only a few, range from regulating the regional climate; supporting recreation and tourism; delivering an important freshwater input for the Gulf, and providing water for municipal and industrial uses. The cultural and environmental dimensions of the Tigris-Euphrates Ecosystem have also been recognized by global institutions (i.e. the listing of the Hawizeh Marshlands by Iraq as a wetland of International Importance under the Ramsar Convention and listing of the Mesopotamian marshlands (the "Ahwar") of southern Iraq as a World Heritage Site under the UNESCO convention (UNESCO, 2018). It is beyond the scope of this paper to address all of these services in the basin but the status of two, Agriculture and Fisheries & Aquaculture, are discussed here as examples of key basin ecosystem services that are vital to human health and prosperity.

Agriculture

Though the information is somewhat dated, Table 3 below shows two important statistics about the basin that are likely still generally true to this day: the percentage of the economically active population in each country involved in agriculture and the contribution of agriculture to the Gross Domestic Product (GDP) of each country.

	Iraq	Syria	Iran	Turkey
Portion of economically-active population involved in agriculture (2007)	8%	26%	24%	43%
Value added by agriculture to the Gross Domestic Product (2007, 2000 for Iraq)	5%	20%	9%	9%
Percentage of agricultural land under irrigation	53%	14%	18%	15%

Table 3: Agricultural Status of Populations and Agricultural GDP (adapted from FAO-Aquastat, 2009)

Despite the fact that agriculture is a relatively minor part of the GDP for these countries (with only Syria, at least prior to its civil war, reaching 20%), close to one quarter to under half of the economically-active populations in Syria, Iran and Turkey are involved in agriculture. In Iraq, according to the FAO-Aquastat (2009), despite only 8% of the economically-active population being involved in agriculture, it is still a key employer, with many people living in poverty and involved in subsistence agriculture. These numbers attest to the relative importance of the agricultural sector in each of these countries, despite the generally small contribution agriculture makes to their economies.

According to a 2009 FAO report (Aquastat), there is an estimated 6.5-7 million hectares of agricultural land in the Tigris-Euphrates basin that is being irrigated, with Iraq having the majority of its farmland under irrigation (See Table 3). Iraq's farmlands, which cover about one-fifth of the country, are almost entirely dependent on irrigation from the Tigris and Euphrates Rivers. Only in the northeastern plains and mountain valleys is there rain-fed farming (Kangarani, 2005).

In Syria, the main area for agricultural cultivation, which is also dependent on irrigation, is along the Euphrates River and its tributaries. In Iran, rain-fed agriculture only occurs in about 10% of the country, mostly in western Iran. Iran has always faced water shortage, which led to the development, centuries ago, of man-made qanats, as discussed previously, and more recently to a focus on the construction of large dams such as the Daryan Dam on the Sirwan River (a tributary to the Diyala and Tigris). Part of the Daryan Dam includes the Nawsud Water Conveyance Tunnel, which will remove water from the river to irrigate farmlands in Southwestern Iran and has been predicted to negatively impact more than 3,200 hectares of agricultural land in Iraqi Kurdistan (Chomani & Bijnens, 2016).

In the region served by the GAP Project in Turkey, according to the FAO (2014), access to irrigation water has turned areas previously based on rain-fed agriculture into "high yield acreage" but this has also changed the water cycle for the entire region. A tenfold increase in water usage is expected when the GAP project is fully completed (FAO, 2014)

but problems have already been seen in the project. These include: increased salinization of valuable agricultural areas due to improper use of irrigation water; loss of valuable agricultural areas due to flooded behind dams, and declining yields in fruit production due to the change to the micro-climate in the Euphrates Basin (changes in the occurrence of snow, heavy rain, frost etc.) (Dicle Tuba Kılıç of Doğa Derneği, Personal Comm., 23 January 2019). Figure 2 below shows the entire basin with its zones of irrigation development as well as the area covered by the GAP project in Turkey.

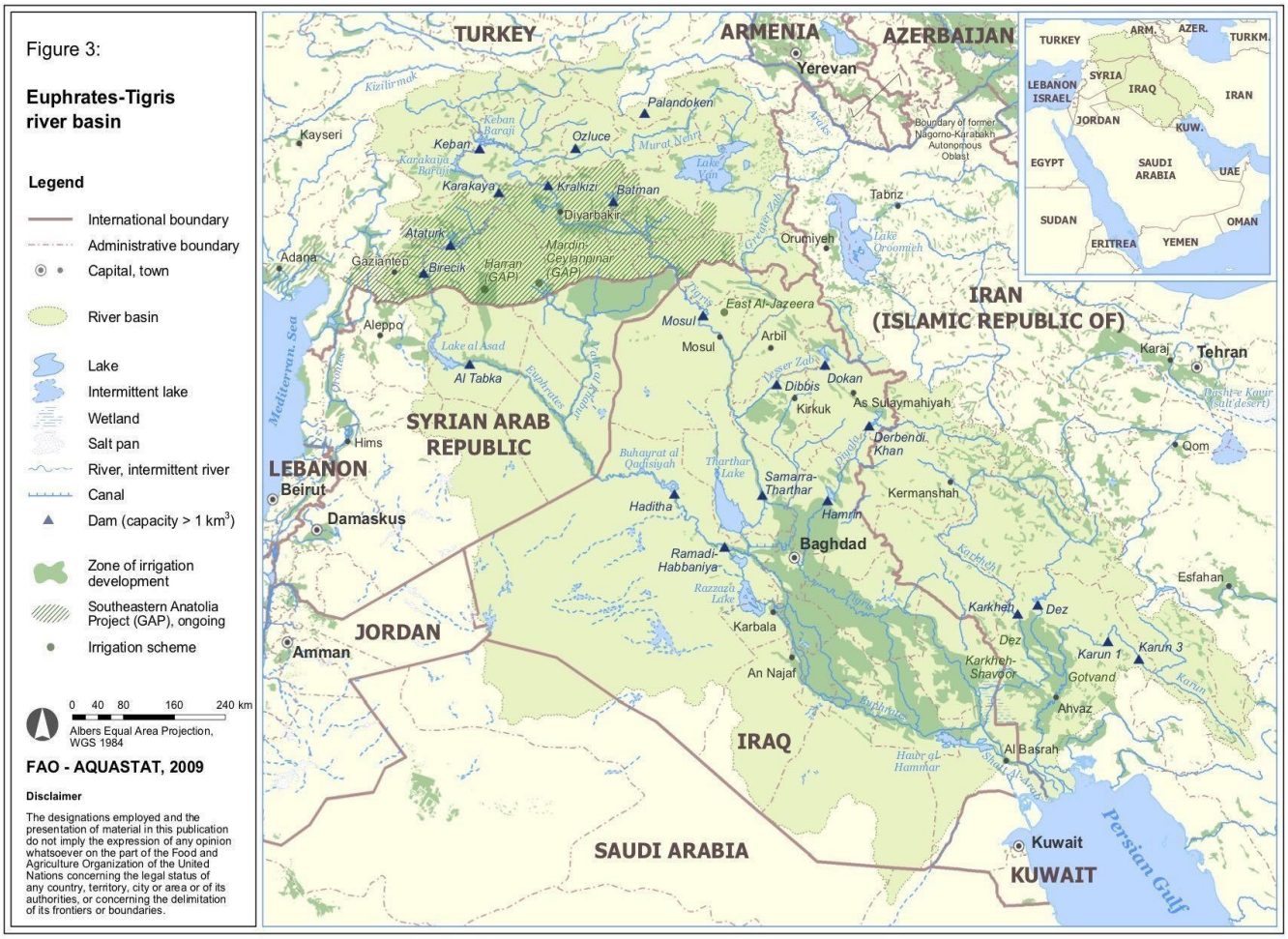


Figure 2: Euphrates-Tigris Bain showing zone of irrigation development and GAP project (FAO - AQUASTAT, 2009*)*

Over the last century, the region has seen increasing pressure on water resources and agricultural practices. Droughts that swept the region in 1998-1999 and 2007-2008 have also caused declines in agricultural production. The 2018 drought in Iraq was so "severe that the area under cultivation ... is estimated by the Ministry of Agriculture at half what it was in 2017" (AFP in Amnesty International, 2018). In addition, the conflicts in the region, including the war with Daesh (Islamic State), have caused extensive damage to and even abandonment of agricultural lands (Ibid).

Fisheries & Aquaculture

In the fall of 2012, fisheries experts from the Food and Agriculture Organization (FAO), Turkey, Syria and Iraq gathered in Iraqi Kurdistan to review the status of the fisheries and aquaculture in the Tigris-Euphrates Basin. Given the importance of inland capture fisheries and aquaculture as a source of employment and income for rural communities, the regional experts warned that this natural resource was deteriorating throughout the basin. They

pointed to illegal, unregulated and unreported fishing; a lack of fishers and fish farm associations or cooperatives that can provide services and advocate for their members; the lack of participatory management; the need for integrated policy and planning that recognizes the social and economic relevance of this sector; and the importance of adapting to climate change impacts (FAO, 2014). These experts stressed the need for a regional cooperation framework that would work for sustainability, improving management (both with government ministries and fishers and fish farmers), and promote regional technical cooperation and dialogue.

Although the findings of the report were submitted to regional authorities, there has been no further actions or efforts to create a mechanism for regional cooperation (Vartan A. Sarkissian, personal communication, 20 November 2018) and the fisheries and aquaculture sectors continue to suffer. For example, in-river, cage-based aquaculture has greatly increased in the lower basin of the Tigris-Euphrates due to the lack of government control and ease of construction. But due to poor water quality and, in some areas where overly dense aquaculture has developed, fish kills this past year have grown in size and extent as previously mentioned.

With the deterioration of the lower Tigris-Euphrates Basin, the marine environment of the Gulf and its fisheries have also declined. Many marine species including coastal fish and shrimp utilize the Mesopotamian Marshlands for spawning and as a nursery for juveniles. The marshlands have also always served to filter out waste and other pollutants before they could enter the Gulf (Richardson & Hussain, 2006). With the drying of the marshlands and lower flows in the river, less freshwater is reaching the Gulf and what waters do reach it are loaded with pollutants. As the freshwater recedes, saltwater is intruding much further inland, invading local aquifers, and leading to the continued deterioration of the northern gulf coastal environment.

As river flows have decreased and water quality has been reduced in the basin, agriculture, fisheries and aquaculture have seen significant declines. If the basin continues to be mismanaged and comprehensive agreements on resources sharing are not reached, these ecosystem services will break down further and this will lead to enormous losses to the region's economies as well as to the day-to-day livelihoods of every citizen living within the basin.

Climate Change Impacts

On July 1, 2018, the Associated Press reported that violent protests had erupted in Khorramshahr, Iran, along the border with Iraq. Large protests had been happening in Iran in previous months due to the poor economic situation in the country but these protests were different. Residents were turning on their taps and only salty, muddy water was coming out (AP, 2018b). Later that month protests arose over the same issue in Basra, southern Iraq (RFE/RL, 2018). In Basra, salt infiltration into the public water supply was reported to have sent over 90,000 people to the hospital for treatment (Independent, 2018).

Thermometer reading more than 50°C on July 30, 2015 in Baghdad. Photo by Ahmed Al-Rubaye/AFP/Getty Image

Teasing apart the many contributing factors that led to the water problems in Iran and Iraq that summer is difficult but it is likely that drought, which was experienced in many parts of the world in 2018, was worsened by global climate change. Water shortages became so severe that the Iraqi government initially told farmers not to grow certain summer crops[11] and extensive fires erupted in the Hawizeh/Al-Azim Marshes that impacted people on both sides of the Iran-Iraq border (Al-Monitor, 2018).

It is impossible to determine with precision what climate change will mean for the Tigris-Euphrates Basin, but the region can expect higher temperatures, more frequent heat wave events and droughts, lower rainfall, more intense storm events, as well as saltwater intrusion along Iraq and Iran's coast as sea levels rise and freshwater river flows decline (FAO & IBRD/WB, 2018). While climate change will decrease overall available water supplies, it is also likely to exacerbate socially-generated scarcity caused by an inequitable distribution of water. More recent projections for the upper basin in Turkey are that surface waters will be reduced by 20% by 2030, 35% by 2050, and 50% by 2100 (Climate Change Post, 2018). Among these impacts, Al-Ansari et al. (2018) also mention more intensive rainfall events, leading to increased erosion and less groundwater recharge. The region may already be seeing this in the heavy rains and flash flooding that was experienced in Iran, Iraq, Syria, Kuwait, Jordan, Saudi Arabia and Qatar in the fall of 2018 (Flood List, 2018). The World Meteorological Organization observed, for example, that Bushehr in southern Iran recorded 67mm of rain in a single 24-hour period in early November 2018, when the mean total precipitation for the entire month is usually only 27.3mm (Ibid).

Climate experts expect the Middle East to be disproportionately impacted by global climate change. Recent studies have looked at two climate change scenarios in the region. Scenario RCP4.5[12] is close to the target set at the recent UN Climate Summit: global warming would be limited to less than an increase of two degree Celsius. RCP8.5, also known as the "business-as-usual scenario", assumes that the mean surface temperature will increase by more than four degrees Celsius. But, in either scenario, the Middle East and North Africa (MENA) Region will experience the highest temperature increases in the summer with longer heat waves and more frequent desert dust storms. Between 1986 and 2005, the average period for very hot days in the MENA Region was approximately 16 days. Under these scenarios, the region is likely to experience 80 days of unusually hot weather by 2050 and up to 118 days by 2100 (MPG, 2016). The number of unusually hot days has already doubled since 1970 and since the beginning of this century desert dust in the atmosphere over Saudi Arabia, Iraq and Syria has increased by up to 70% mainly due to prolonged periods of drought (Ibid.).

[11] A decision that was later partially reversed (Reuters, 2018).

[12] RCP stands for a "Representative Concentration Pathway", a greenhouse gas concentration trajectory

In June of 2018, the Iran Meteorological Organization hosted a regional meeting of the Intergovernmental Panel on Climate Change in Tehran (IPCC, 2018). One presentation by M.M. Iqbal of the Global Change Impact Studies Centre in Pakistan focused on the expected impacts for Iran and the overall MENA region. Some of the projections that he noted, should no efforts be made to reduce carbon emissions, included the following:

- Summer temperatures rising twice as fast as the global average.
- Extreme temperature of 46C will be 5-times more likely by 2050 than at the beginning of the century. By 2100, temperature and humidity could rise to the extent to make the Gulf region uninhabitable, if emissions are not abated.
- Negative impacts on food crop production due to increasing temperatures, reduced/little rainfall and high evaporation rates
- And related negative impacts to livestock, fisheries and aquaculture, marine systems, etc.

Temperatures exceeding 53C – severe heat conditions that usually occur every 20 years in the Gulf will become the norm (Amer, 2015) and irrespective of which climate change scenario comes to pass, living conditions particularly in the southern part of the Tigris and Euphrates Basin may become unlivable, forcing people to migrate (MPG, 2016).

Given the importance of this issue, many countries are already planning to mitigate and adapt to a new climate regime and civil society organizations around the globe are deeply engaged in this issue. Since the Tigris and Euphrates Basin is likely to see disproportionally more significant changes than other parts of the globe, the countries of this region need to take this problem seriously. But of the four countries within the basin, only Turkey has a Climate Change Adaptation Management Plan (T.R. Ministry of Environment and Urbanization, 2011). The UNDP Climate Change Adaptation Portal (2018a) states that no such plan exists for Syria, Iran, or Iraq, though the latter established a National Disaster Risk Reduction (DRR) Committee in 2007. This is led by the Ministry of Science and Technology (MoST) with ten other ministries and departments participating, and is designed to develop into an Emergency Operational Centre under the control of a future National Disaster Risk Management Center but as yet the committee remains unfunded (UNDP, 2018b).

Take Aways

For decades, water management has been treated as merely a technical problem: how best to engineer the right infrastructure to hold, redirect and distribute water, mostly for agriculture. But the importance of water and its management is more complex than that; there are environmental, cultural, social, economic and political aspects that must be considered and integrated into management. Water Advocates in the basin can play an important role in helping illuminate and integrate these other dynamics. In order to do that, they need a clear-eyed and realistic understanding of the situation in the basin, the challenges to effective management, and what role they can play in helping bridge what gaps exist.

Historically many civil society organizations within the region have been marginalized and lacking in capacity. Water resource management decisions have usually been left entirely to the government to resolve. But given the difficult problems for water resources in the Tigris and Euphrates Basin reviewed in this paper, there is a role for regional Water Advocates to play. They must decide where and how best to dedicate their efforts. Whether they focus on cleaning up an individual stream or contributing to the transboundary water discussion, a wide variety of coordinated actions and cooperative initiatives will be necessary to develop a full civil society response to the needs of the basin.

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Appendix: Chronology of major events in the Tigris-Euphrates Basin (FAO-AQUASTAT, 2009 with additions)

Year	Plans/projects/treaties/conflicts	Countries involved	Main aspects
1914	Hindiya dam on the Euphrates	Iraq	For flood control and irrigation purposes
1920	Treaty regarding utilization of the waters of the Euphrates and the Tigris Rivers	France and Great Britain	
1930	Turco-French Protocol	Turkey and France	Coordinates any plans to use the waters of the Euphrates;
1946	Treaty of Friendship and good Neighbourly Relations	Turkey and Iraq	extended the principle of mutual cooperation over water development in both rivers. Sharing of related data.
1951	Ramadi Habbaniya dam on the Euphrates	Iraq	For flood control and irrigation purposes.
1960s	Start of the construction of the "Third River"	Iraq	565 km canal between the Euphrates and the Tigris (completed in 1992).
1960s	Construction of several canals	Iraq	linking lake Thartar to the Euphrates, and connecting the lake with the Tigris.
1973	The Keban Dam	Turkey	First dam on the Euphrates for Turkey. Construction started in the 1960s. For hydropower purposes.
1973	The Tabqa dam	Syrian Arab Republic (with the help of the USSR)	First dam on the Euphrates for the Syrian Arab Republic, to meet water and energy needs.
1975	Filling of the Tabqa dam conflict	Syrian Arab Republic and Iraq (Saudi Arabia and possibly USSR mediated)	Major sources of conflict between Syrians and Iraqis addressed. Finally the Syrian Arab Republic released more water from the dam to Iraq.
1976	Release of 350 m3/s from the Euphrates downstream	Turkey	Prevented tension between the Syrian Arab Republic and Iraq, regarding the filling of the Tabqa Dam.
1977	Southeastern Anatolia Project (GAP)	Turkey	Turkey announced plans for GAP, which included 22 dams and 19 hydropower installations on the Euphrates-Tigris.
1983	Establishment of Joint Technical Committee for Regional Waters	Turkey, Iraq, and the Syrian Arab Republic	Dealing with water issues between the basin riparian countries, to ensure principles of consultation and notification as required by international law. This group disintegrated after 1993 without any progress having been made.
1984	Turkey proposes a "Three-staged plan"	Turkey (indirectly Syrian Arab Republic and Iraq)	For optimal, equitable and reasonable utilization of the transboundary watercourses of the Euphrates-Tigris basin. Conforms to the principle of equitable utilization.
1985	Haditha Dam	Iraq	Dam on the Euphrates river to produce hydropower.
1986	Bath Dam	Syrian Arab Republic	Second dam on the Euphrates for the Syrian Arab Republic. Small-scale electric generation and small amount of water for irrigation.
1987	Informal agreement guaranteed 500 m3/s of the Euphrates from Turkey to the Syrian Arab Republic	Turkey and the Syrian Arab Republic	The Syrian Arab Republic has accused Turkey of violating this agreement a number of times.

1988	Karakaya Dam	Turkey	Second dam on the Euphrates. First dam built under the GAP. For production of hydropower.
1990	Agreement between the Syrian Arab Republic and Iraq to share the Euphrates water	Syrian Arab Republic and Iraq	The Syrian Arab Republic agrees to share the Euphrates' water with Iraq on a 58 percent (Iraq) and 42 percent (the Syrian arab Republic) basis. Corresponds to a flow of 9 km3/year.
1992	Completion of the Ataturk Dam	Turkey	Third dam on the Euphrates for Turkey, the most important one under the GAP project. For irrigation and hydropower. The filling of the dam, shutting off the river flow for a month, causes conflict with Syrians and Iraqis.
1997-1998	Dicle Dam, Kralkizi Dam near Diyarbakir and Batman Dam on the Batman River.	Turkey	Dicle Dam for power and irrigation (1997), Kralkizi Dam for power (1997), Batman Dam for power and irrigation (1998)
2001	Joint Communiqué	GOLD (Syrian Arab Republic), and GAP-RDA (Turkey)	Supporting training, technology exchange, study missions, and joint projects.
2002	Bilateral agreement concerning the installation of a Syrian pump station on the Tigris River	Syrian Arab Republic and Iraq	For irrigation purposes.
2004	UNEP-hosted meeting on information-sharing on transboundary waters	Iraq & Iran	UNEP-hosted meeting in Geneva to discuss transboundary waters and build cooperation, disagreements centered on the shared Mesopotamian marshlands.
2008	Cooperation on water issues by establishing a water institute	Turkey, the Syrian Arab Republic and Iraq	18 water experts from each country to work toward the resolution of water-related problems.
2009	Memorandum of Understanding	Iraq & Turkey	Agreement between the Ministry of Environment and Forestry of Turkey and the Ministry of Water Resources of Iraq covered various water issues including the exchange of data, information and expert knowledge, the efficient use of water resources and the strengthening of the JTC
2009	Memorandum of Understanding	Syrian Arab Republic & Iraq	Agreement on establishment of the pumping station for water withdraws from the Tigris River in Syria
2015	Strategy for Land and Water Resources of Iraq	Iraq	Strategy developed by the Ministry of Water Resources in Iraq that identified and ranked projects that allow for the optimum utilization of water and land resources in Iraq from 2015 to 2035
2018	Advanced Survey of Hydrogeological Resources in Iraq, Phase II	Iraq	ASHRI II Project was a UNESCO sponsored effort to develop a geographical information system for the sustainable management of groundwater resources in Iraq
2018	Ilisu Dam	Turkey	Rock-filled dam on the Tigris river near the village of Illisu in Turkey. For hydroelectric power production, flood control and water storage.
2018	Daryan Dam & Sardasht Dam	Iran	Two embankment dams constructed on the Sirvan River (Daryan) just north of Daryan in Kermanshah Province and on the Lesser Zab River (Sardasht). The

			Daryan Dam was built for irrigation and hydroelectric power, Includes the Nawsud Water Diversion Tunnel. The Sardasht Dam is for hydroelectric power.