

OVERVIEW

Water as a weapon and casualty of armed conflict: A review of recent water-related violence in Iraq, Syria, and Yemen

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Abstract

Violence over water resources has persisted in various forms for thousands of years, driven by complex ideological, religious, economic, and strategic factors. Scarce and valuable freshwater has played a role in conflicts as a contributing factor, a target or tool, or a weapon. The focus of this review is on specific instances of violence around water and water systems conflict in Syria, Iraq, and Yemen, where water resources and human-built water systems have been both weapons and targets of conflict. A new cycle of violence in the region, growing in extent and severity, began approximately three decades ago and is described here in the context of broader regional water challenges and theoretical issues around environmental security. New data and definitions and an analysis of the types of event and sources of information are also provided in the context of international humanitarian law. This assessment confirms and expands upon previous work that evaluates trends toward the weaponization of water and the targeting of water systems in Middle East conflicts. Initial recommendations for reducing these trends are provided.

This article is categorized under:

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KEYWORDS

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1 | INTRODUCTION

Water and wastewater treatment and delivery systems, together with the institutions and experts who manage them, are a foundational aspect of modern civilization. Sophisticated water systems reduce and eliminate water-related illnesses and deaths, protect against extreme hydrologic events, and provide reliable water to grow food for literally billions of people. They have reduced poverty and the demands on women and girls forced to do backbreaking work collecting and carrying domestic water. And they are central to the efforts to meet the sustainable development goals for 2030 adopted by the UN and global community (United Nations, 2016b). Conflict and violence that affects freshwater resources and built water systems threaten all of these benefits.

Conflict has been prevalent in Middle East for thousands of years (Hatami & Gleick, 1994),¹ for long-standing, complex, and evolving religious, ideological, and political reasons. Around 2,500 BC, in the first recorded interstate dispute over water, irrigation water was used as a weapon in a dispute between Lagash and Umma, near the Tigris and Euphrates rivers in ancient

Mesopotamia (Cooper, 1983). In the past half century, long episodes of violence have fractured the region, entangling multiple international, national, and subnational groups. Iraq and Iran have been involved in cycles of war between 1980 and 1988. The first Gulf War in 1990 and 1991 involved Iraq, Kuwait and other Gulf nations, and an alliance of outside powers including the United States. The 2003–2011 conflict in Iraq initially involved primarily the United States and United Kingdom, but it continues to this day with tensions and violence among various subnational groups and political adversaries. The current Syrian civil war began in March 2011 with internal demonstrations calling for democratic reform and the release of political prisoners and then expanding with the formation and intervention of what has become known as the Islamic State (IS)² and the participation of Turkey, Russia, Iran, Gulf nations, the United States, and others. Similarly, the splintering and disintegration of Yemen has been underway for decades but has accelerated in recent years with both internal conflict and the intervention of outside parties providing arms and direct and indirect military and financial support, including Iran, Saudi Arabia and the Gulf States, the United States, and the United Kingdom.

Over this period, spiraling conflict, internal fracturing of society, and massive violence have devastated the region's population and institutions, produced millions of refugees, and destroyed infrastructure vital for the functioning of society, including systems built to collect, treat, and distribute safe and affordable drinking water and collect, treat, and dispose of sewage. This paper catalogues, reviews, and analyzes new data on violence related to water resources and water systems over the past several decades in Iraq, Syria, and Yemen. Additional examples could be added from other countries in the region, and from other countries around the world, but these are beyond the scope of this analysis. More comprehensive data covering water and conflict are available at the Water Conflict Chronology, an open-source database managed by the Pacific Institute.³ This review also looks at international laws of war and offers some recommendations for reducing the use of water as weapons and the targeting of water systems during conflicts.

2 | OVERVIEW OF THE HYDROCLIMATOLOGY AND BUILT WATER SYSTEMS IN THE MIDDLE EAST

The Middle East is a water-scarce region, measured by both absolute water availability and availability per person. It is climatologically hot and dry, with mild winters and a Mediterranean climate characterized by a wetter winter and spring and a drier summer and fall. Coastal areas are more humid and extensive areas of desert are found in the region, with extreme temperature variability. Climatic conditions in the northern African countries experience rainfall in the winter months with a hot and dry summer season. Gulf countries have a more severe desert climate with extreme summer temperatures and limited rainfall. Further north, countries in the eastern Mediterranean watersheds, including Syria, Lebanon, Israel, Jordan, Iraq, and Iran have milder and wetter climates. There are a small number of major perennial rivers and many more ephemeral streams that flow only during the wet season. Groundwater—typically fossil groundwater systems with slow recharge rates—exists throughout the region but is incompletely characterized or mapped. Both surface watersheds and groundwater systems are shared across political borders.

Overall water availability in the region is highly variable. Measured on a per-capita basis, the UN FAO AQUASTAT data report annual average renewable water availability (including both surface and groundwater) in Yemen and Jordan to be less than 125 cubic meters per person per year ($\text{m}^3 \text{p}^{-1} \text{year}^{-1}$); Iran and Iraq have on average 1,700 and 2,500 $\text{m}^3 \text{p}^{-1} \text{year}^{-1}$ (Table 1). These data reflect current climatic conditions and do not account for observed or anticipated climate changes. Simple metrics of scarcity developed by Falkenmark and others suggest that regions with 500 to 1,000 $\text{m}^3 \text{p}^{-1} \text{year}^{-1}$ face chronic water scarcity; regions with less than 500 $\text{m}^3 \text{p}^{-1} \text{year}^{-1}$ face fundamental constraints to human development and well-being (Falkenmark, Lundqvist, & Widstrand, 1989). Reviews and discussions of more integrated approaches and alternative metrics to defining water scarcity, including hydrologic, social, and economic factors, also note the extreme vulnerability of this region (Jaeger et al., 2013; Showstack, 2011).

The arid nature of the region imbues its few major rivers with special importance (Figure 1). Some of the earliest human civilizations formed along the Nile River in Egypt and in the region between the Euphrates and Tigris rivers classically referred to by scholars of antiquities as Mesopotamia. Similarly, the Orontes, Jordan, and Litani rivers also played an important role in early human history and continue to be critical resources for modern communities.

Every major river in the region crosses an international border and is shared by two or more countries. Table 2 shows some of the major rivers discussed in this paper, the countries that share the watershed, and the fraction of the area of each watershed within those countries.

Beginning in the late 1960s and accelerating through the end of the century, dams for hydropower, irrigation, and water storage were built on most of the major rivers. Old flood irrigation systems were being replaced with more modern control and water-delivery technologies to permit more food to be grown with less water. Water and wastewater plants were built to

TABLE 1 Total annual renewable water resources per capita ($\text{m}^3 \text{ person}^{-1} \text{ year}^{-1}$)

Country/Area	Cubic meter per person per year: 2014
Iran	1,730
Iraq	2,470
Israel	221
Jordan	123
Occupied Palestinian Territory	179
Syrian Arab Republic	910
Yemen	78

Notes: Actual water availability on an annual basis depends on variable hydrometeorological conditions as well as the role of upstream entities that may control river flows and water withdrawal and use in shared international river basins.

Source: FAO (2016).

provide safe water services for rapidly growing urban populations. Desalination plants were built in regions where surface or groundwater supplies were increasingly inadequate to meet demands, especially in the Gulf nations and more recently in Israel. By the end of the twentieth century, most countries in the region were in the process of building modern water institutions and infrastructure, though the extent of water development was, and continues to be, uneven.

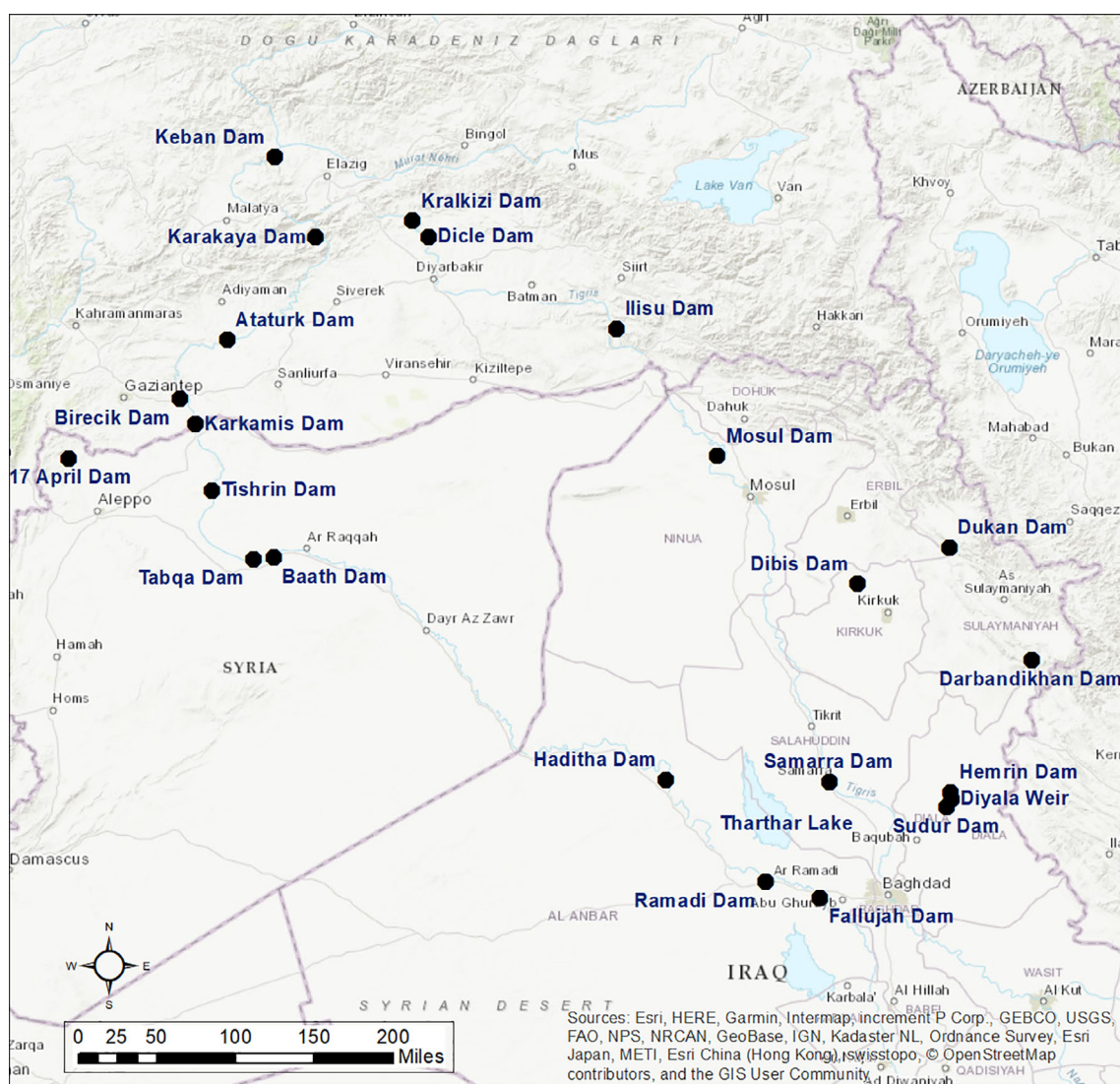


FIGURE 1 The Tigris and Euphrates basin with major dams in Turkey, Syria, and Iraq. *Source:* This figure was prepared by the Pacific Institute for this article

TABLE 2 Selected major international rivers in the Middle East

River basin	Countries sharing the basin	Percentage of watershed within country
Tigris/Euphrates	Iraq	40.5
	Turkey	24.8
	Iran	19.7
	Syria	14.7
	Jordan	0.25
	Saudi Arabia	0.01
Asi/Orontes	Turkey	49.9
	Syria	44.3
	Lebanon	5.7
Jordan	Jordan	48.13
	Israel	21.3
	Syria	11.5
	West Bank and Golan Heights	11
	Egypt	6.5
	Lebanon	1.3
Nile	Sudan	63.7
	Ethiopia	11.7
	Egypt	8.99
	Uganda	7.9
	Tanzania	4.0
	Kenya	1.7
	Congo DR	0.7
	Rwanda	0.7
	Burundi	0.4
	Eritrea	0.1
	Central African Republic	0.04

Notes: The numbers have been rounded and may not add up to 100%. They do not reflect unresolved disputes over specific political borders, disputed territory, or changes in country names.

Sources: Wolf, Natharius, Danielson, Ward, and Pender (1999), Gleick, Cooley, Palaniappan, Morikawa, and Morrison (2008).

In 2000, just prior some of the recent severe violence described below and before the launch of the millennium development goals, the United Nations reported that Syria and Iraq were in a transition toward improved coverage and had extensively expanded access to water and sanitation, especially in urban areas, to between 80% and 90% (Table 3). More recent UN assessments continue to report improvements in access in these countries, but these data fail to reflect the recent population displacements and destruction of water-related infrastructure and institutions. More broadly, the 2017 UN Joint Monitoring Programme report noted that nearly 500 million people live in regions (within and outside of the Middle East) where conflict, violence, and instability risk reversing progress toward universal access to water and sanitation and that people living in these regions were twice as likely to lack basic sanitation and four times as likely to lack basic drinking water as populations in non-fragile situations (United Nations Joint Monitoring Programme, 2017).

3 | LINKS BETWEEN WATER AND CONFLICT: A BRIEF LITERATURE REVIEW

Analyses of links between resources and conflict, including water, extend back several decades. The core hypothesis is that political instability and violence, especially at the local or regional level, can be extensively *influenced* by economic, demographic, and social factors that are themselves sensitive to resource and environmental conditions (Barnett & Adger, 2007;

TABLE 3 Water and sanitation coverage in Syria, Iraq, Yemen (Year 2000)

Country	Total population (thousands)	Urban population (thousands)	Rural population (thousands)	% Urban water supply coverage	% Rural water supply coverage	% Total water supply coverage	% Urban sanitation coverage	% Rural sanitation coverage	% Total sanitation coverage
Syria	16,125	8,783	7,342	94	64	80	98	81	90
Iraq	23,115	17,756	5,359	96	48	85	93	31	79
Yemen	18,112	4,476	13,636	85	64	69	87	31	45

Notes: More recent data are available from the 2017 UN Joint Monitoring Programme reports, but these fail to reflect the impacts of the ongoing conflicts.

Source: Data from World Health Organization and United Nations Children's Fund (2000).

Conca, 2006; Gleick, 1989, 1993; Homer-Dixon, 1991; Hsiang & Burke, 2014; Ratner, Meinzen-Dick, May, & Haglund, 2013; Ullman, 1983). Dinar (2004) introduces a set of studies looking at data sets and economic, statistical, and analytical approaches for evaluating conflict and cooperation over water. Wheeler and Gober (2015) review the broader questions of population dynamics, a changing climate, and ecological water needs in questions of water security.

One specific consequence of the continuing political chaos and instability in the Middle East has been the use of water as both targets and weapons of conflict. The literature on links between water and conflict in this region is extensive, with early theory and history (e.g., Gleick, 1994; Hatami & Gleick, 1994), and more recent assessments that look at the conflicts in Syria, Yemen, Iraq, and elsewhere in the context of water, climate, demographics, and other factors (Gleick, 2014; Kelley, Mohtadi, Cane, Seager, & Kushnir, 2015; King, 2015; Selby, Dahi, Fröhlich, & Hulme, 2017; Sowers, Weinthal, & Zawahri, 2017). In particular, Sowers et al. (2017) and King (2015) look at the issue addressed here: targeting of water systems and the use of water as a weapon. As noted in the introduction above, water has been used as a weapon or casualty of war in the Middle East for thousands of years, going back to irrigation disputes in ancient Mesopotamia.

The focus below is on cases where water infrastructure in the form of pipes, sanitation plants, water treatment, pumping, and distribution systems, and dams have been directly targeted, and where water has been used as a weapon to flood towns, disrupt agricultural and hydroelectricity production, and deprive local populations of potable supplies through both accidental and intentional deprivation and contamination. Specific instances of violence around water or water infrastructure in Syria, Iraq, and Yemen are described.

4 | METHODS, DEFINITIONS, DATA RESOURCES

A comprehensive database of water and conflict events is maintained at the Pacific Institute, a nonprofit water research institute in Oakland California. These data extend back over 4,500 years, are global, and coded by region, date, type of conflict, and location with full citations for each event. The three major categories of water conflicts are “trigger,” “weapon,” and “casualty.” Some events fall into multiple categories (see Table 4).

(King, 2015) chose to further disaggregate examples where water has been used as a weapon into five subcategories based on intent (strategic weaponization, tactical weaponization, psychological terrorism, extortion or incentivization, and unintentional weaponization). Because of the limited number of examples, and because of the difficulty and subjective challenges of determining “intent,” I have not attempted to separate the examples below into these subcategories. Other researchers may choose to try to do so.

TABLE 4 Water conflict chronology categories of conflict

Each entry in the Water Conflict Chronology is coded as one or more of the following actions of states, nonstate groups, individuals, or a combination of actors in the context of fresh water resources or managed water systems and infrastructure.

“Trigger” Water as a trigger or root cause of conflict: where economic or physical access to water, or scarcity of water, triggers violence.

“Weapon” Water as a weapon of conflict: where water resources, or water systems themselves, are used as a tool or weapon in a violent conflict. Examples include manipulating a hydro dam to release damaging flood waters or withhold water supply to dependent communities; or contaminating a water resources to poison a population or deprive it of water;

“Casualty” Water resources or water systems as a casualty of conflict: where water resources, or water systems, are intentional or incidental casualties or targets of violence.

Source: The Water Conflict Chronology (<http://www.worldwater.org>).

5 | SOURCES AND UNCERTAINTIES

Special comments are needed about the sources and uncertainty of information available for assessing environmental security issues. Sources of information on water-related conflicts include a range of global conflict databases, academic and military reports, on-the-ground assessments from international governmental and nongovernmental organizations, and media accounts. For example, the Transboundary Freshwater Dispute Database developed a framework for exploring the links between freshwater and international cooperation and conflict (Yoffe et al., 2004). Other relevant data are described at the open-source Water Conflict Chronology site, the Global Terrorism Database, the Armed Conflict Location and Events Dataset, and the Social Conflict in Africa Database. The UN and international aid organizations issue periodic reports on resource and humanitarian issues in conflicts zones. And real-time reports are taken from a wide range of media sources.

While even peer-reviewed assessments and reports are subject to bias and error, reports from news media in conflict zones can often be both incorrect and vital—providing close to real-time information and detail. The importance of regional media information from the Middle East is discussed in more detail in Caspi and Rubenstein (2017). When possible, the data here are taken from multiple sources, including both western and Middle Eastern media. In addition, the classic challenge of the “fog of war” applies to reporting from conflict zones where uncertainty over the identity and actions of multiple conflicting parties can be high and determining intentionality of objectives and targeting may be impossible.

Data from the timeline include examples where water and water systems appear to have been, or were explicitly acknowledged to have been, intentionally targeted in attacks or used as weapons. In other cases, water systems have been mistaken for military targets, or damaged incidentally during military actions. And in some cases, no intentionality can be determined. In April 2014, the IS destroyed an oil pipeline, causing severe contamination of part of the water supply for Baghdad but no information is available on whether the contamination was unintentional or an explicit strategic objective. Conversely, in a report to the UN Security Council in 2016, the UN Secretary General reported that control of dams on the Tigris and Euphrates rivers was an explicit tactic of the IS (United Nations, 2016a; Vishwanath, 2015). Von Lossow reports that the IS issued a video explicitly urging its followers to use water as a weapon and “poison the drinking water” of its enemies (von Lossow, 2016). At the same time, the Syrian government has been accused of cutting off water supplies to regions under rebel control and reducing flows or cutting dam releases during battles with the IS or rebel groups and denying clean water to suburbs of Damascus sympathetic to opposition groups. I include each incident and the best information about the parties involved but no judgment is offered on intention unless formal or informal statements of intent are available. As noted later, intent may only be relevant in the context of enforcement of international legal constraints.

According to Vishwanath (2015), with supporting assessments from King (2015) and others, between 2013 and 2015, the IS launched around 20 major attacks against Syrian and Iraqi water infrastructure – including flooding villages, threatening to flood Baghdad, closing the dam gates in Fallujah and Ramadi, cutting off water to downstream communities and farmland, destroying crops, and allegedly poisoning water in small Syrian towns. In 2014 and 2015, the IS seized major dams along the rivers, including Fallujah, Haditha, Mosul, Samarra, Ramadi and al-Thawra (see Figure 1 for a map of the region with the major Tigris and Euphrates river dams). They halted water releases from the Fallujah and Ramadi dams and diverted water to flood downstream populations, inundate hundreds of square kilometers of land, and cut water supplies to millions of people in the cities of Babil, Najaf, Qadisiya, and Karbala (Financial Action Task Force, 2015). In some cases, however, water has been used as a positive tool of conflict, with the IS providing hydroelectricity and more reliable access to water for short periods to towns and areas under their control to boost local support for their efforts (Vishwanath, 2015).

The use of water as a tool of conflict, however, extends far beyond the strategic value of large, centralized water supply or hydropower facilities on rivers. Water systems critical for supplying cities and towns with safe water and sanitation, and irrigation systems needed for supporting the agricultural sector, have been targets and casualties of the long conflicts. Municipal water systems vital for providing civilian populations with basic services have been extensively destroyed, contributing to the dislocation and migration of large number of people.

Below I provide a summary and partial timeline of water-related violence and conflict in Iraq, Syria, and Yemen drawn from these various sources. Two more focused examples of water and violence in the city of Aleppo, Syria and in Yemen are also provided here.

6 | CASE STUDIES AND A MIDDLE EAST TIMELINE

Using publicly available data I provide here a timeline of violence associated with water systems in Syria, Iraq, and Yemen with a focus on the time period of the late twentieth century to mid-2018. I have not included additional examples where water

is a trigger or contributor to conflict; rather I focus only on the use of water or water systems as tools or “weapons” or where water systems have been a target or “casualty” of conflicts, independent of the root causes of the violence. At least one citation is provided for each event.

6.1 | Chronology of water as a weapon or casualty of conflict in Syria, Iraq and Yemen, 1980–2018

1980s and early 1990s: Saddam Hussein cuts water to the marshes at the intersection of the Tigris and Euphrates rivers to punish communities opposed his regime (Wood, 1993).

Early 1990s: During the first Persian Gulf War in the early 1990s, Kuwait's water supply and wastewater infrastructure are attacked by Iraq (Finch, 1996).

March–April 2003: In the 2003 invasion of Iraq, United States forces seize Haditha dam to prevent it from being destroyed. Destruction of the dam would have caused major flooding and cut Iraq's hydroelectricity production (Massih, 2014; Shamout, 2014).

November–December 2012: On November 26, 2012, after the onset of the Syrian civil war, fighters opposed to the government of Syrian president Bashar al-Assad capture Tishrin dam on the Euphrates River cutting off government supply lines to Raqqa and Aleppo and controlling hydroelectricity production (Gulf News, 2012). In September 2014, the IS takes control of the dam and holds it until December 2015 (described below).

February–May 2013: In early February 2013, Syrian groups opposed to the government capture the Baath and Tabqa dams on the Euphrates River. Over time, these groups split into several disparate and conflicting organizations and the three major northern Syrian dams on the Euphrates (Tishrin, Tabqa, and Baath) are taken over by the IS as part of their efforts to control the key Euphrates river towns of Maskana, Raqqa, Deir el-Zour and al-Bukamal. Tabqa dam provides electricity for much of southeastern Syria and controls substantial amounts of water feeding into Iraq (Cooke, 2016). During this period, the IS pursues a similar objective in Iraq, capturing the Euphrates towns of Qaim, Ramadi, Fallujah, and Rawah giving them control over the water resources behind Haditha and Tharthar dams (Vishwanath, 2015).

January–April 2014: Mosul dam in Iraq becomes a target of conflict when Kurdish forces are accused of diverting water from Lake Assad—the reservoir behind the dam—and Turkey is accused of reducing flows in the Euphrates into the reservoir. At the same time, the IS is accused of targeting water supplies for refugee camps holding refugees from the town of Mosul after they cut off water and power supplies there (Vidal, 2014).

January–April 2014: The IS takes control of Fallujah dam in Iraq and reportedly diverts water to attack government forces, inundating land up to 100 km away and causing severe flooding in the city of Abu Ghraib. Between Fallujah and Abu Ghraib, the United Nations estimates 12,000 families lost their homes and 200 km² of farmland are damaged along with almost the entire harvest and large numbers of livestock. These actions also cut off water for millions of people downstream in the cities of Karbala, Najaf, and Babil (Financial Action Task Force, 2015; United Nations Security Council, 2017; Vidal, 2014), and led U.N. Secretary-General Ban Ki-moon to call the use of water as a weapon in Fallujah a “dangerous trend” (Massih, 2014).

April 2014: On April 17, 2014, the IS destroys an oil pipeline near Bayji, Iraq causing an oil spill that contaminated the water supply to Baghdad, according to the Iraqi Ministry of Water Resources (Lewis, 2014).

May 2014: Turkey is accused by Syria of cutting water flows on the Euphrates. Data from the Raqqa Media Centre show reductions in flow of water into Syria at the beginning of May for 6 days. In June, river flow drops gradually until it stops completely by the middle of the month (al-Masri, 2014).

June 2014: By June 2014, the IS controls Iraqi dams or areas around the dams at Fallujah, Mosul, Samarra, and Ramadi and is interrupting water supplies to Shiite areas in the lower Euphrates and Tigris watersheds. The IS stops releases from Ramadi dam in June, depriving Khalidiyah and Habbaniyah—under the control of Iraqi government—of water (Al Marashi, 2015). In the Shiite areas of Diyala province, water supplies are disrupted several times. Water deliveries are blocked in the Christian town of Qaraqosh and 50,000 residents are expelled (MacKenzie, 2014; Vidal, 2014; von Lossow, 2016).

August 2014: Mosul dam, Iraq's largest dam on the Tigris river, is captured by the IS on August 7, 2014, after battles with Kurdish forces. The United States, Iraqi, and Kurdish forces launch a major effort to recapture the dam concerned that the destruction or intentional manipulation of the dam could threaten populations downstream with massive flooding. The control of Mosul dam also gives the IS control of nearly 75% of Iraq's electricity generation capacity. IS forces are driven from the dam a few weeks later (Reuters, 2014; Vishwanath, 2015; Weaver, 2014).

August–September 2014: Syrian government forces conduct air strikes on IS positions in the eastern Syrian city of Raqqa, hitting the city water plant and cutting off local water supplies. In September 2014, conflict between Syrian government forces and militant groups destroys pipelines supplying water to the Yarmouk refugee camp in south-western Syria (Trieber, 2015).

June–September 2014: The U.S. and Iraqi forces launch efforts to prevent the IS from seizing Haditha dam on the Euphrates river because of its strategic value for providing both water and electricity (Cooper, Fahim, & Chivers, 2014; Vidal, 2014).

September 2014: In September 2014, the IS takes over control of Tishrin dam in Syria from other anti-government forces (Middle East Eye, 2015).

September–October 2014: The IS cuts flows from the Sudur dam in Iraq to Balad Ruz—a predominantly Shiite part of Diyala province—forcing the local government to hire trucks to bring potable water to residents. The IS uses water as a weapon in the Shirwain area of Diyala province to try to stop a military advance by Iraqi government forces, flooding nine villages and cutting off access to water to communities not under their control. The head of a local council in the same region accuses the IS of altering local water flows to flood homes and farmland in a similar effort to halt Iraqi military advances (Cunningham, 2014).

December 2014: The UN Security Council reports that IS deliberately contaminated drinking water with crude oil in the Balad district of the Salahaddin Governorate (United Nations Security Council, 2017). By the end of 2014, Oxfam estimates that the civil war has damaged more than a third of Syria's water treatment facilities, contributing to contamination of drinking water and worsening outbreaks of water-related diseases (Oxfam, 2014).

Between 2014 and 2015: Extensive examples of IS poisoning and destroying water wells are reported (Schwartzstein, 2019).

January 2015: Iraqi forces retake Sudur dam and the surrounding area, restoring water flows to Balad Ruz (Adnan, 2015).

January 2015: The IS shuts off water and power to the area of Deir Az-Zor south of Raqqa, Syria below the Baath dam, affecting 300,000 people (Hollander, 2015).

March 2015: Unconfirmed reports indicate that the IS took chlorine from water-treatment plants in Iraq for the purpose of weaponizing it (Tilghman, 2015).

January to April 2015: A long series of airstrikes by Saudi and coalition airforces on Yemeni water systems is conducted during this period (Clifford & Trieber, 2016), including:

April 17, 2015: An airstrike on a water tank in al-Hazamat, Sa'ada City, Yemen (UN Office for the Coordination of Humanitarian Affairs, 2015).

April 18, 2015: An Oxfam-run warehouse with water equipment in Sa'ada City, Yemen is attacked in an airstrike. The warehouse stored equipment for a water project funded by the European Union (Dransfield, 2015).

April 22, 2015: A water tank and pipes are damaged at the al-Jumhouria hospital in Yemen (UN Office for the Coordination of Humanitarian Affairs, 2015).

April 26/27, 2015: Airstrikes reportedly hit warehouses belonging to the Shamlan mineral water company in Ta'izz City, Yemen (UN Office for the Coordination of Humanitarian Affairs, 2015).

May–June 2015: Ramadi dam is captured by the IS, which then cuts releases of water for the irrigation systems and treatment plants in the predominantly Shiite downstream agricultural provinces of Babil, Karbala, Najaf, and Qadisiya, threatening Iraq's food security (United Nations Security Council, 2017; von Lossow, 2016). These actions also facilitate the movement of IS forces across the dewatered river bed during attacks on Husaybah, Khalidiyah, and the Habbaniya (von Lossow, 2016). Water flows are also cut to the Iraqi marshes, displacing local residents (Vishwanath, 2015).

July 2015: Groups opposed to the Syrian government threaten to cut drinking water supplies to Damascus from the Ayyin Al Fija spring, demanding an end to military operations (NOW News, 2015; von Lossow, 2016).

July 2015: Twenty people die in IS attacks on Haditha dam, Iraq (Mamoun, 2015).

August 30, 2015: An airstrike hits a water tank on Al-Sham bottling plant in Hajjah, Yemen. According to the Houthi-run Defense Ministry, the airstrike kills 34 people. A spokesman for the Saudi-led coalition told media that the target was a military camp used to make explosives and train personnel (Clifford & Trieber, 2016).

December 2015: On December 26, Syrian Democratic Forces—an alliance of Syrian Kurds and Arab rebel groups—supported by U.S. coalition aircraft recapture the Tishrin dam on the Euphrates River from the IS (Reuters, 2015).

December 30, 2015: An airstrike destroys a beverage factory in Sana'a, Yemen (al-Kibsi & Easter, 2015).

January 2016: IS renews attacks in Haditha, Iraq, near the major dam on the Euphrates, after the loss of Ramadi by the militants (Cunningham, 2016).

January 2016: Airstrike damages a seawater desalination facility near Mocha, Yemen (Clifford & Triebert, 2016).

June 2016: Iraqi forces recapture Fallujah dam after 2 years of control by the IS (Iran Daily, 2016).

July–August 2016: An estimated two million people in Aleppo, Syria including 900,000 children, are left without public water supplies after attacks on electrical networks and water distribution systems (UNICEF, 2016).

September 2016: Airstrikes in the town of Arhab in the Sanaa governorate and in Hodeida governorate in Yemen destroy a water drilling site, killing over 30 and wounding over 40 (Human Rights Watch, 2016).

January 2017: Fighting in Yemen damages water infrastructure in several cities. Attacks in and around the town of Al Mokha kill and injure scores of civilians and halt most services, including the water supply system (UN Office for the Coordination of Humanitarian Affairs, 2017).

February 2017: In response to the advance of the Syrian Arab Army, the IS floods villages they control in the Deir Hafer Plain of east Aleppo by pumping water from Lake Assad into the Al-Jar channel (Fadel, 2017).

May–June 2017: U.S.-backed Syrian militias (SDF) and Kurdish forces recapture the town of Tabqa and Syria's largest dam (of the same name) from the IS (Al Jazeera News, 2017; Francis, 2017).

March 2018: Turkish forces and allied Syrian militias take control of Afrin dam in the Kurdish region of Erbil, Syria (Rudaw Media Group, 2018).

April 2018: The UN Children's Fund reported that the Al-Hamazat water system in Sa'ada governorate, Yemen is destroyed, along with a solar energy system that provided power for the water system. The same water system was destroyed in 2015 and rebuilt by UNICEF in 2017 (UNICEF, 2018).

While not the subject of this case study, it is worth noting that the IS strategy of controlling key water resources, or using them as weapons of conflict, is not isolated to Iraq and Syria. For example, in December 2016, IS militants reportedly attacked the pumping stations and distribution pipes of the major Libyan water project—the Great Manmade River (GMR)—that provides water for Benghazi, Siret, and Tripoli (United Nations Security Council, 2017).

6.2 | Case 1: Aleppo, Syria

Before the war, Aleppo—Syria's largest city—had a population of around 3 million. The United Nations estimated that 94% of residents were connected to the public water system. The city has seen intense and persistent fighting and violence against Aleppo's water system began early in the civil war. In September 2012, fighting between government forces and rebels badly damaged a major pipeline supplying water to Aleppo, cutting access to drinking water (BBC News, 2012). By 2014 there were reports of the deliberate targeting of water systems and the destruction of the municipal water and power systems left half the population without safe water and sanitation and forced residents to buy water from unregulated private vendors, dig wells into often unprotected groundwater, or get water from aid organizations. The water pumping station at Al-Khafsah, Aleppo failed on May 10, 2014, cutting off water supply to half of the city causing “panic and chaos” (Shamout, 2014). At this time, even portions of the city still connected to the municipal water system were often getting only 1 hr of water per day due to fighting around the main Sulaiman al-Halabi Water Supply Station (UN Habitat, 2014). Loss of access to safe and reliable water, together with the crippling of solid waste and sanitation systems, led to an epidemic of scabies and lice by December 2014 and serious contamination of drinking water. At the time of a UN Habitat assessment, nearly two thirds of eastern Aleppo's residents faced difficulties getting safe drinking water (REACH Resource Centre, 2015).

In 2015, fighters from Jabhat al-Nusra, the Syrian branch of Al-Qaeda, reportedly bombed the main pipeline carrying water to the city of Aleppo from the Euphrates River and more than 100 people were sickened by contaminated water (Reznick, 2016). In November 2015, there is evidence—including footage and reports from the Russian Ministry of Defense—that Russian Federation forces bombed water plants at Abū 'Amr near Deir ez-Zor and the al-Khafsah water treatment facility in Aleppo, reportedly mistaking them for oil production facility (Triebert, 2015). The al-Khafsah treatment plant draws water from the Euphrates river and is called “one of the most important in Syria, producing an average of 18 million liters of drinking water daily.” According to UNICEF, “The bombing caused severe damage and cut off piped water supplies on which approximately 3.5 million people depend. Water pumping operations have since been partially restored, but more than 1.4 million people in rural Aleppo continue to suffer interruptions to their supply” (Triebert, 2015).

UNICEF reported in September 2016 that water was still being used as a weapon by all sides. Attacks by the Syrian army damaged the pumping plant supplying 200,000 people in rebel-held parts of eastern Aleppo; in retaliation, a pumping plant

supplying water to around 1.5 million people in the western part of the city was deliberately shut off (BBC News, 2016). In March 2017, the pumping plant supplying eastern Aleppo was recaptured by Syrian army forces (BBC News, 2017).

6.3 | Case 2: Water, conflict, and health in Yemen

The war in Yemen, involving both internal and external groups, began in 2015 and has seen the widespread targeting and destruction of Yemen's civilian infrastructure, including water treatment and sanitation systems. Much of the destruction of water-related infrastructure has resulted from aerial bombing from a coalition of Saudi, United Arab Emirates, and other Gulf air forces. One estimate is that between March 2015 when the war began and early 2018, Saudi and alliance airstrikes attacked water and electrical infrastructure in Yemen more than 100 times (Kennedy, 2017; Watson, 2018). Some specific documented examples are included in the timeline in Chronology section above.

As of June 2018 and the preparation of this review, over 1.3 million people had been displaced and the health care system could not provide basic services. One direct consequences of these attacks was a very severe and persistent outbreak of cholera—a water-related disease directly associated with the failure to provide safe water and sanitation (Balakrishnan, 2017). The UN Office for the Coordination of Humanitarian Affairs estimated that more than half of the nearly 30 million Yemenis needed water and sanitation assistance and between late September 2016 to March 2018, *Lancet* reported over a million suspected cholera cases and 2,385 deaths countrywide (Camacho et al., 2018). A resurgence of cholera in mid-2018 and again in early 2019 suggests these numbers may rise substantially.

7 | INTERNATIONAL HUMANITARIAN LAWS (THE “LAWS OF WAR”) RELATING TO CIVILIAN WATER INFRASTRUCTURE AND SYSTEMS

International laws of war—or international humanitarian laws—provide a framework relevant to attacks on civilian water systems and infrastructure. In theory those legal guidelines prohibit intentionally targeting civilians, limit military attacks to military objectives, and require that collateral damage against civilians not be excessive in relation to any military advantage gained. In practice, as the examples presented above show, these constraints have not been effective. A comprehensive review of international law in this area is provided by Gleick (2019).

Prohibitions on using water as a weapon or intentionally targeting core civilian infrastructure are rooted in custom, religious rules, and ethical codes of behavior extending back thousands of years. In the modern era, codes of conduct during war began to be developed for international laws and agreements in the late 1800s. The first Geneva Convention in 1864, the 1868 St. Petersburg Declaration, and the 1874 Brussels Protocol all included language protecting civilians and civilian property and banning actions lacking a clear military purpose (Nijhoff, 1915; Schindler & Toman, 1988). These early declarations informed the more comprehensive international law that began to take shape with the 1899 and 1907 Hague Conventions and Declarations.

Following the Second World War, efforts were made to develop a wider range of legal protections for civilians and infrastructure. The 1949 Fourth Geneva Convention (United Nations Documents, 1949) prohibits deliberate or indiscriminate destruction of property belonging to individuals or “the State, or to other public authorities” (Article 53) and “extensive destruction and appropriation of property, not justified by military necessity and carried out unlawfully and wantonly” (Article 147). More explicit protections for water-related infrastructure were put in place in the 1977 Protocols to the Geneva Convention (United Nations Documents, 1977). Protocol I provides protection for victims of “international armed conflicts” while Protocol II protects victims of “noninternational armed conflicts.” Both include language requiring the protection of civilian water systems:

It is prohibited to attack, destroy, remove or render useless objects indispensable to the survival of the civilian population, such as foodstuffs, agricultural areas for the production of foodstuffs, crops, livestock, *drinking water installations and supplies and irrigation works*, for the specific purpose of denying them for their sustenance value to the civilian population or to the adverse Party, *whatever the motive, whether in order to starve out civilians, to cause them to move away, or for any other motive*. (Protocol I Article 54, paragraph 2, emphasis added)

Further, militaries are to avoid attacking such installations so as not “*to leave the civilian population with such inadequate food or water as to cause starvation or force its movement*” (Protocol I, Article 54, paragraph 3, emphasis added).

The humanitarian justification for these protections rests on the understanding that access to basic civilian services, such as safe water and sanitation and irrigation, is critical for human health, and conversely, the destruction of those systems can contribute to massive human suffering. These laws suggest that actions that destroy critical civilian infrastructure, without a justifiable direct military objective, are explicit violations of international humanitarian law and the laws of war, worthy of investigation and perhaps prosecution as war crimes.

Despite these agreements and laws, the data and cases presented here show extensive and persistent violations of the principles protecting civilians and civilian water infrastructure, though the majority of cases described here are by subnational actors, not by nation states, which suggests a problem with the effectiveness and application of these principles and laws when applied to substate actors.

Only one recent example is available of an effort by the international legal system to penalize gross violations of these international laws: Omar Hassan Ahmad Al Bashir, president of the Republic of the Sudan has been indicted by the International Criminal Court (ICC) of crimes against humanity for actions he ordered in the Sudanese civil war. The charges include the use of water as a weapon via the intentional contamination of wells and water pumps by forces under his control (ICC, 2018). The ICC, however, has (as of this writing) so far been unable to bring Al-Bashir to justice. Given the apparent inability of the international legal system to prevent or penalize these violations, I conclude that either the current set of constraints are insufficient to prevent conflicting forces from using water as a weapon or target of violence, or enforcement of them is inadequate, or both.

8 | CONCLUSIONS AND RECOMMENDATIONS

Data from media reports, governmental and international nongovernmental sources, military and humanitarian organization assessments, and direct field reports have identified a substantial number of cases over the past few decades where water or water systems have been used as weapons of conflict or targeted and attacked directly or indirectly during conflicts. This paper collects and reviews data on these cases in the Middle East, focused on Iraq, Syria, and Yemen over the past three decades. Details are provided for over 45 instances, including specific examples for the Syrian city of Aleppo and from Yemen. A review of related international humanitarian law identifies formal constraints on the use of military force against civilians or critical civilian infrastructure, including specifically water systems, but observations on the extent, severity, and persistence of these cases suggests that international law is insufficient or inadequately enforced.

Recommendations for tackling this problem fall into three main areas: (a) physical and structural approaches to strengthen and protect civilian water resources and systems in zones of conflict; (b) greater awareness, training, and oversight of national and subnational armed forces on the laws of war; and (c) the development of strategies to strengthen and enforce international law to protect access to basic water and sanitation services for all communities in conflict zones. A follow-on assessment to evaluate these solutions is underway through the Water, Peace, and Security Partnership, a joint effort of IHE Delft, World Resources Institute, Deltares, Hague Centre for Strategic Studies, Wetlands International, International Alert, Oregon State University, and the Pacific Institute.

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CONFLICT OF INTEREST

The author has declared no conflicts of interest for this article.

ENDNOTES

¹ The term “Middle East” is used here to refer to the region in the eastern Mediterranean, northwestern Africa, and Persian/Arabian Gulf region. Also sometimes called the Near East or West Asia or Middle East/North Africa (MENA), the term Middle East is now common vernacular in the region.

It typically includes the countries of Bahrain, Cyprus, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Northern Cyprus, Oman, Palestine, Qatar, Saudi Arabia, Syria, Turkey, United Arab Emirates, and Yemen, and occasionally includes parts of northern Africa, including Libya.

² The term “Islamic State” is used here but the political dynamics of the organization evolves rapidly. Other common terms include the Islamic State of Iraq and the Levant (ISIL), The Islamic State of Iraq and Syria (ISIS), and its Arabic language acronym Daesh: داعش

³ The Water Conflict Chronology is available at www.worldwater.org.

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