

Water, Drought, Climate Change, and Conflict in Syria

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ABSTRACT

The devastating civil war that began in Syria in March 2011 is the result of complex interrelated factors. The focus of the conflict is regime change, but the triggers include a broad set of religious and sociopolitical factors, the erosion of the economic health of the country, a wave of political reform sweeping over the Middle East and North Africa (MENA) and Levant region, and challenges associated with climate variability and change and the availability and use of freshwater. As described here, water and climatic conditions have played a direct role in the deterioration of Syria's economic conditions. There is a long history of conflicts over water in these regions because of the natural water scarcity, the early development of irrigated agriculture, and complex religious and ethnic diversity. In recent years, there has been an increase in incidences of water-related violence around the world at the subnational level attributable to the role that water plays in development disputes and economic activities. Because conflicts are rarely, if ever, attributable to single causes, conflict analysis and concomitant efforts at reducing the risks of conflict must consider a multitude of complex relationships and contributing factors. This paper assesses the complicated connections between water and conflict in Syria, looks more broadly at future climate-related risks for water systems, and offers some water management strategies for reducing those risks.

1. Introduction

Syria's political difficulties and the ongoing civil war there are the result of complex interrelated factors, including religious and sociopolitical tensions, the erosion of the economic health of the country, and a wave of political reform sweeping over the Middle East and North Africa (MENA) and Levant regions. As described here, water and climatic conditions are also relevant because of the role they have played in the deterioration of Syria's economic conditions.

There is a long history of conflicts over water—documented in history, myths, legends, and more modern academic analysis and media reporting. Much of this work focuses on conflict between nation-states (Gleick 1993; Yoffe et al. 2003; Tose et al. 2000; Wolf 2007). Early examples of these connections can be found in the Middle East and Levant region (typically defined as the eastern Mediterranean between Turkey and Egypt, including parts of modern southern Turkey, Syria, western Lebanon, Jordan, Israel, and Palestine) (Gleick 1994;

Kliot 1994; Lonergan 1997). Data and analysis related to water conflicts have been developed by researchers in various places, including the Pacific Institute, Oregon State University, Uppsala University, the Peace Research Institute of Oslo, and others. For example, the Pacific Institute maintains an online, searchable chronology of such conflicts going back around 4500 years (the Water Conflict Chronology can be found at <http://www.worldwater.org/conflict.html>).

Water-related conflicts occur in many forms, including disputes over access to water and the control of water systems, the targeting of water infrastructure and systems during conventional conflicts and terrorist actions, and the use of water as a weapon. In recent years, there has been an increase in violence over the role that water plays in development disputes and economic activities. Conflicts of any kind are rarely, if ever, attributable to single causes. As such, any analysis or efforts at reducing the risks of conflict must consider a multitude of complex relationships and contributing factors, including water. One recent example of a major conflict with complicated but direct connections to water is the unraveling of Syria and the escalation of massive civil war there. This paper reviews these links, discusses the growing threat to regional water systems from climatic changes,

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and offers strategies for reducing the risks of water-related violence.

2. Historical background: Mesopotamia, water, and conflict

This is not the first time that water and other environmental and resource factors have influenced or played a role in contributing to violent conflict in the MENA or Levant regions, as well reviewed elsewhere (Gleick 1993, 1994; Homer-Dixon 1999; Gleditsch et al. 2006; Wolf 2007). The earliest recorded conflict over water there occurred over 4500 years ago, when a dispute over access to irrigation water led Ullama, king of the city-state of Lagash in ancient Mesopotamia, to cut off water to deprive neighboring Umma. His son, Il, also diverted water from irrigation systems feeding Umma (Jacobsen 1969; Cooper 1983). Lloyd (1961) in his history of the Tigris and Euphrates region describes numerous events from around 2700 years ago when water was used as a weapon or tool during conflicts. Sargon II, the Assyrian king from 720 to 705 BC, destroyed a sophisticated irrigation system of the Haldians during a military campaign. Sennacherib of Assyria intentionally diverted irrigation canals on the Euphrates River to wash over Babylon around 690 BC (Lloyd 1961). In 612 BC, a coalition of Egyptian, Persian, and Babylonian forces attacked and destroyed Ninevah, the capital of Assyria, by diverting the Khosr River to create a flood (Lloyd 1961). The ancient historian Berossus describes efforts of Nebuchadnessar (605–562 BC) to defend Babylon by digging canals and preventing the diversion of the Euphrates (Burstein 1978), while Herodotus describes how, just a few decades later, Cyrus the Great successfully invaded Babylon in 539 BC by diverting the Euphrates into the desert above the city and marching his troops down the dry riverbed (Rawlinson 1933). Other MENA examples where water and conflict are linked are described in Hatami and Gleick (1994).

In modern times, we see similar political tensions tied to water and examples where water has been a target or tool of conflicts. Pressures on Syrian water resources have been growing for a nearly a quarter century. Water is a scarce resource in the area—one of the driest in the world. Syria receives, on average, less than 250 mm of rainfall annually and is considered water scarce in assessments of water availability by several different research groups (Falkenmark 1986; UNEP 2008; Reig et al. 2013). The Food and Agriculture Organization of the United Nations (FAO) estimates that total renewable water availability, including both renewable surface and groundwater, in the country is around $16.8 \text{ km}^3 \text{ yr}^{-1}$ of which nearly 60% originates from outside of its

borders (Frenken 2009). All of the country's major rivers (the Tigris, Euphrates, Orontes, and Yarmouk/Jordan) are shared with neighboring countries. There have been tensions between Jordan and Syria since the early 1990s over the construction and operation of Syrian dams on the Yarmouk River. Turkey and Syria have a long-standing dispute over the management of the Euphrates River. Those tensions have worsened over the past several decades as average annual flows in the Euphrates at the Turkish–Syrian border have declined substantially since 1990, coinciding with both the completion of the Ataturk Dam and an apparent decrease in precipitation in the region. Figure 1 shows average annual flows of the Euphrates River ($\text{m}^3 \text{ s}^{-1}$) from 1937 to 2010 measured at Jarabulus, Syria, just downstream of the Turkish–Syrian border. As this figure shows, average flows have been dropping over this period. Figure 2 shows the standard z score of the flows measured as the deviation of annual flow from the mean discharge, divided by the standard deviation of flows over the full period of record.

Population dynamics also play an important role in climatic and hydrologic vulnerability (Vörösmarty et al. 2000), and regional population growth in Syria has been rapid (Fig. 3). Syria's population has increased from around 3 million in 1950 to over 22 million in 2012, decreasing the country's total per capita renewable water availability (excluding water committed to be delivered to downstream parties on shared rivers) from over 5500 m^3 per person per year to under 760 by 2012—a level categorized as “scarce.”

3. Recent drought, agriculture, water management stresses, and links to conflict

In addition to having relatively little overall freshwater in proportion to demands, Syria, like the region as a whole, experiences high natural hydrologic variability. Over the past century (from 1900 to 2005), there were six significant droughts in Syria, where the average monthly level of winter precipitation—the major rainfall season—dropped to around one-third of normal. Five of these droughts lasted only one season; the sixth lasted two (Mohtadi 2013). Starting in 2006, however, and lasting into 2011, Syria experienced a multiseason, multiyear period of extreme drought that contributed to agricultural failures, economic dislocations, and population displacement (Worth 2010). This dry period has continued and is now being described as the “worst long-term drought and most severe set of crop failures since agricultural civilizations began in the Fertile Crescent many millennia ago” [Gary Nabhan, as cited by Femia and Werrell (2012)].

In the current civil war, some analysts have argued that factors related to drought, including agricultural

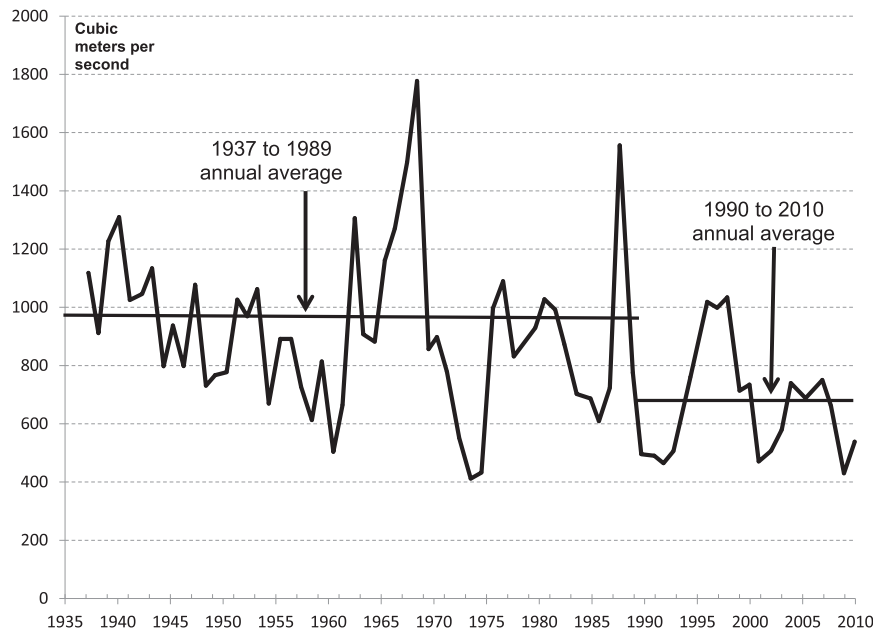


FIG. 1. Annual average discharge of the Euphrates River measured at Jarabulus just downstream of the Turkey–Syria border from 1937 to 2010 (UN-ESCWA 2013).

failure, water shortages, and water mismanagement, have played an important role in contributing to the deterioration of social structures and spurring violence (Femia and Werrell 2013; FAO 2012; Mhanna 2013). In particular, the combination of very severe drought, persistent multiyear crop failures, and the related economic

deterioration led to very significant dislocation and migration of rural communities to the cities. These factors further contributed to urban unemployment and economic dislocations and social unrest.

As early as 2008, a diplomatic cable from the U.S. embassy in Damascus, Syria, to the State Department in

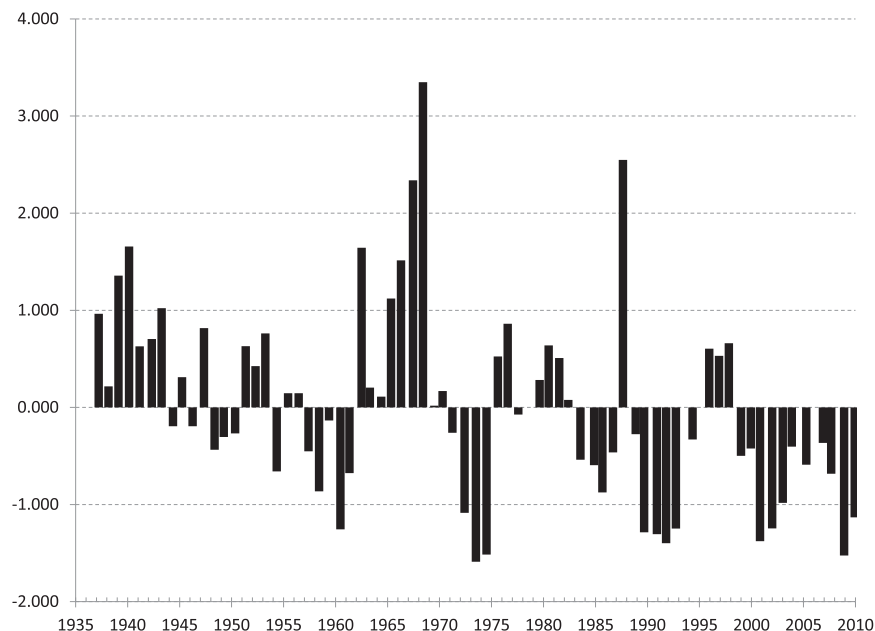


FIG. 2. Standard z score of flows in the Euphrates River measured at Jarabulus calculated as the difference between annual flow and the mean, normalized by the standard deviation of discharge, over the full period 1937–2010.

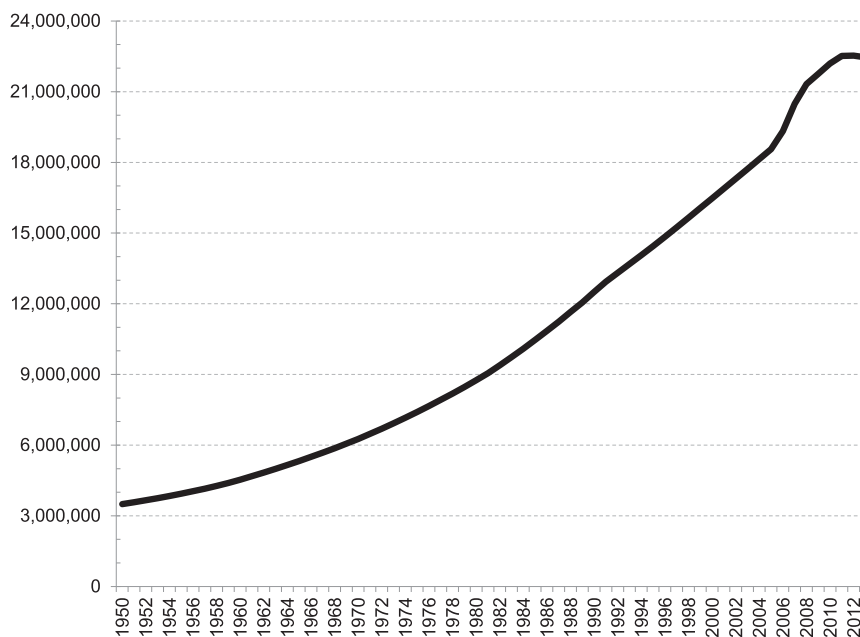


FIG. 3. Population in Syria from 1950 to 2013 (U.S. Department of Commerce 2013).

Washington, D.C., warned of the implications of the drought, with a summary of local opinions and concerns as well as insights from the FAO (these observations were cited in the diplomatic cable, published at <http://wikileaks.org/cable/2008/11/08DAMASCUS847.html>; the accuracy of this cable's contents has not been verified but these statements are in the public record). That cable describes a briefing by FAO Syrian Representative Abdullah bin Yehia on drought impacts, which he described as a “perfect storm” when combined with other economic and social pressure. Concerns expressed at that time also noted that the population displacements “could act as a multiplier on social and economic pressures already at play and undermine stability in Syria.” In July 2008 the Syrian Minister of Agriculture stated publicly to United Nations (UN) officials that the economic and social fallout from the drought was “beyond our capacity as a country to deal with.” (This quote comes from the diplomatic cable: <http://wikileaks.org/cable/2008/11/08DAMASCUS847.html>).

Between 2006 and 2009, around 1.3 million inhabitants of eastern Syria were affected by agricultural failures. An estimated 800 000 people lost their livelihoods and basic food supports (Solh 2010). During this period, yields of wheat and barley dropped 47% and 67%, respectively, and livestock populations plummeted (ACSAD 2011). A return of drought in 2011 worsened the situation. By late 2011, the UN estimated that between two million and three million people were affected, with a million driven into food insecurity. More than 1.5 million people—mostly agricultural workers and family farmers—moved from

rural land to cities and camps on the outskirts of Syria's major cities of Aleppo, Damascus, Dara'a, Deir ez-Zour, Hama, and Homs.

The FAO conducted a series of agricultural and food assessments in March and August 2011, and again in June 2012. Each found poverty and food insecurity to be increasing. The most recent food “needs assessment” identified three million people in “urgent need” of food assistance and concluded that “agricultural water use is unsustainable” (FAO 2012, p. 6).

These conditions were further worsened by water management decisions, poor planning, and policy errors. The Bashar al-Assad regime traditionally provided large subsidies for the production of water-intensive crops, such as wheat and cotton. Most of Syrian irrigated agriculture is in need of modernization, still relying on highly inefficient flood irrigation. Overall, less than one-fifth of the irrigated area used modern sprinklers or drip systems (Fig. 4). Half of all irrigation comes from groundwater systems (Table 1), which are reportedly overpumped (Salman and Mualla 2003), leading to dropping groundwater levels and rising production costs. Wada et al. (2012) estimates that 78% of all groundwater withdrawals in Syria are unsustainable—pumped at a rate exceeding recharge. Water withdrawals upstream by Turkey for its own agricultural production in the southern Anatolia region, and broader changes in regional hydrology (see Fig. 5a and the discussion below) have further contributed to a reduction in surface flows inside of Syria (Fig. 1). All of these factors added to growing economic and political uncertainty. The early warnings

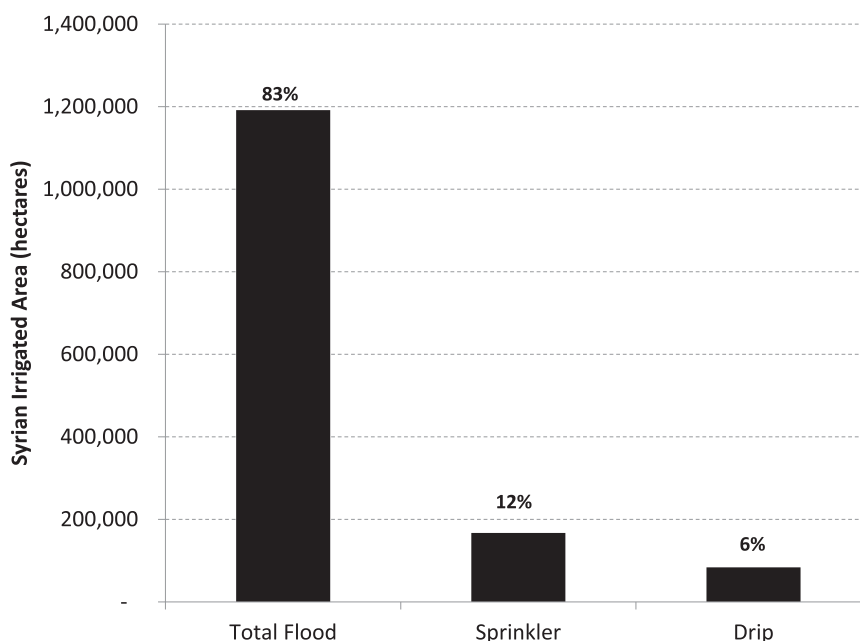


FIG. 4. Syrian irrigated area (ha) by traditional flood, sprinkler, and drip systems. Prior to the civil war, over 80% of irrigated lands used traditional and often inefficient flood irrigation (FAO 2012).

were prescient: some of the earliest political unrest began around the town of Dara'a, which saw a particularly large influx of farmers and young unemployed men displaced off their lands by crop failures.

Saleeby (2012), writing in *Jadaliyya*, a magazine from the Arab Studies Institute, further tied together the economic and environmental conditions and the subsequent political unrest. She argued that “the regime’s failure to put in place economic measures to alleviate the effects of drought was a critical driver in propelling such massive mobilizations of dissent.” Saleeby (2012) notes that the Assad regime made great strides in improving

access to water, building water infrastructure that brought benefits to rural communities, and expanded agricultural production. But she also notes that the benefits of the expansion of irrigated agriculture in the Levant also produced some unanticipated costs, including a worsening of pressures on local water shortages in rural areas and salinization of farmland.

These effects and other coupled human–environmental factors, such as land development patterns, energy–food–water interactions, and effects of industrialization on water quality, are well understood to increase vulnerability to climatic variability, such as droughts and floods

TABLE 1. Total irrigated area (ha) in Syria, in 2011, by traditionally irrigated methods and modern methods (FAO 2012).

Region	Flood: Traditionally irrigated area				Modern irrigation area			Grand total irrigated area
	Pumped		Gravity		Total flood	Sprinkler	Drip	
	Private wells	Government projects	Rivers and springs	Total				
Daar'a	13 075	20 992	—	34 067	5 116	16 891	22 007	56 074
Damascus	44 543	—	16 665	61 208	3 329	18 062	21 391	82 599
Homs	22 655	27 518	2 693	52 866	6 198	13 259	19 457	72 323
Hama	55 798	7 979	5 001	68 778	32 464	3 803	36 267	105 045
Idleb	44 515	11 164	3 013	58 692	28 839	10 377	39 216	97 908
Aleppo	101 213	89 358	27 732	218 303	34 478	14 503	48 981	267 284
Al Raqqa	51 407	93 128	43 968	188 503	4 715	1 351	6 066	194 569
Deir Ezzor	25 420	38 173	86 967	150 560	137	1 143	1 280	151 840
Al Hassake	313 248	—	45 303	358 551	51 925	4 412	56 337	414 888
Totals	671 874	288 312	231 342	1 191 528	167 201	83 801	251 002	1 442 530

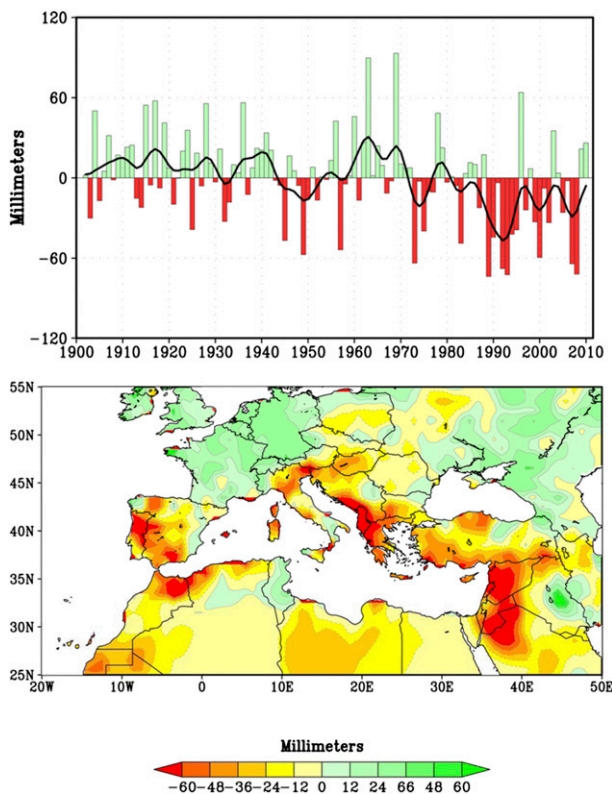


FIG. 5. (a) Millimeters of rain in the winter period from 1902 to 2010, showing a drop in rainfall in the 1971–2010 period (Hoerling et al. 2012). (b) Reds and oranges highlight the areas around the Mediterranean that experienced significantly drier winters during 1971–2010 than the comparison period of 1902–2010 (Hoerling et al. 2012).

(Turner et al. 2003). Contributing to the problem was extensive exploitation of groundwater (Salman and Mualla 2003), which has led to substantial drops in water levels and in some areas, contamination by salts and nitrates, making local wells (e.g., in the ar-Raqqa region) unfit for human use. In all of these cases, trends toward privatization of agricultural lands also “corroded customary law over boundary rights” (Saleeby 2012), further worsening local tensions. These complex factors contributed to the extent and severity of the unrest:

“It is logical to conclude that escalating pressures on urban areas due to internal migration, increasing food insecurity, and resultant high rates of unemployment have spurred many Syrians to make their political grievances publically known. One might look to the city of Deir ez-Zor, one of Syria’s most dangerously dry areas, to locate deeply rooted seeds in the harvest of dissent. The northeastern city experienced one of the strongest sieges by the Syrian army at the beginning of Ramadan after popular uprisings spread across its parched expanse. As a local activist told *Syria Today*, the citizens of Deir

ez-Zour “are suffering and complain that they have had no help from the authorities who tell them what type of crops they have to plant, and have a monopoly on buying up what they produce.” Also among the cities whose residents’ livelihoods were most crippled by recent drought was Daraa, historically a “bread basket” of Syria. Additionally, Hama remains a major destination for drought-displaced farmers despite suffering its own water scarcity woes. In all three centers of popular uprisings lie important narratives of livelihoods lost and families left wanting” (Saleeby 2012).

Additional connections between water and conflicts in Syria

In addition to the role that hydrologic conditions and water availability and use play in contributing to economic and political disruptions, there are examples throughout history of the intentional and incidental targeting of water systems during conflicts that start for other reasons, or the use of water and water systems as weapons and tools of conflict (Gleick 1993). As unrest in Syria developed, violence worsened and impacts on urban water distribution systems were reported together with specific, intentional attacks on water systems because of their strategic value. During fighting around the city of Aleppo in 2012, the major pipeline delivering water to the city was badly damaged and in September the city of about three million people was suffering shortages of drinking water (BBC 2013a). In late November 2012, anti-Assad Syrian rebels overran government forces and captured the Tishrin hydroelectric dam on the Euphrates River after heavy clashes (Mroue 2012). The dam supplies several areas of Syria with electricity and is considered of major strategic importance to the Syrian regime. In February 2013, anti-Assad forces captured the Tabqa/al-Thawrah dam, which is the largest hydroelectric dam in the country and provides much of the electricity to the city of Aleppo (BBC 2013b). These kinds of secondary impacts of conflict—the targeting of water systems—highlight the strategic value of water supply, hydroelectricity, and flood control in water-short regions.

4. The role of climate change stresses

As early as 2008, there were indications that drought frequency and intensity in the eastern Mediterranean area had changed from historical climatic norms. Mathbout and Skaf (2010) used two drought indices [the standard precipitation index (SPI) and the effective drought index (EDI)] to identify an increasing tendency in annual and seasonal drought intensity in all regions corresponding with an increasing number of dry days in the rainy season. Romanou et al. (2010) show statistically significant

increases in evaporative water demand in the eastern Mediterranean region between 1988 and 2006, driven by apparent increases in sea surface temperatures. A research paper published in 2012 further suggested that climate change is already beginning to influence droughts in the area by reducing winter rainfall and increasing evapotranspiration (see Figs. 5a,b) (Hoerling et al. 2012). That study suggested that winter droughts are increasingly common and that human-caused climate change was playing a role. Martin Hoerling, one of the study authors, stated, “The magnitude and frequency of the drying that has occurred is too great to be explained by natural variability alone” (NOAA 2013).

Whether current conditions are evidence of human-induced climate change, the indications for the future water resources of the Middle East and North Africa, including Syria, are not promising. On top of political unrest and economic dislocations, the region faces challenges posed by growing populations, the lack of international agreements over shared water resources, growing withdrawals of water by all the riparians, poor water management, and the increasing risks of climate change. Analysis on the links between possible climatic changes and international security and conflict has been developing for more than two decades, including work on the connections between conflict and stresses from population growth, water scarcity, and agricultural production (see, e.g., Gleick 1989, 2010; Barnett and Adger 2007; Schmidhuber and Tubiello 2007; Malone 2013). Recently, the U.S. Department of Defense assessed these risks as part of the Quadrennial Defense Review Report (U.S. Department of Defense 2010; Parthemore and Rogers 2010). Among their conclusions, “assessments conducted by the intelligence community indicate that climate change could have significant geopolitical impacts around the world, contributing to poverty, environmental degradation, and the further weakening of fragile governments. Climate change will contribute to food and water scarcity, will increase the spread of disease, and may spur or exacerbate mass migration” (U.S. Department of Defense 2010, p. 85).

A 2008 assessment from the World Bank warned of climate risks in the MENA region and links to drought frequency and intensity (World Bank 2013): “According to the latest IPCC [Intergovernmental Panel on Climate Change] assessment, the climate is predicted to become even hotter and drier in most of the MENA region. Higher temperatures and reduced precipitation will result in higher frequency and severity of droughts, an effect that is already materializing in the Maghreb.”

A review (Lelieveld et al. 2012) of the implications of the intermediate climate scenarios (scenario A1B) developed for the IPCC for the eastern Mediterranean and Levant region further supports strong warming of

between 3.5° and 7°C by the period 2070–99, compared to the reference period of 1961–90. Rare hot summer conditions are projected to become far more prevalent, with a concomitant increase in evapotranspiration water demand. Equally worrisome are projected decreases in annual precipitation and worsening water scarcity for southern Turkey and Syria. Overall, this study projected increases in water scarcity.

In a more focused hydrologic assessment, downscaled climate change data from transient experiments with regional climate models were used to assess the potential effects of climate change on water availability in the area of the Fiegh spring system near Damascus (Smiatek et al. 2013). This water system is one of the largest springs in the world and serves as the drinking water source for nearly three million people. The analysis focused on differences in annual, seasonal, and monthly temperature, precipitation, and water availability measured as spring discharge between present climate (taken as the 1961–90 average) and two future periods (2021–50 and 2070–99), and identified potentially serious reductions in water availability from increased evapotranspiration demand and decreased precipitation. The relative change in mean discharge for the climate ensemble showed a decrease during the peak flow from March to May of up to –20% in the period 2021–50 and almost –50% in the period 2069–98, compared to the past climatic mean. Decreases of this magnitude would have dramatic effects on local water availability.

A broader climate assessment for the Tigris–Euphrates River basins evaluated the hydrologic impacts of climate changes under a range of emissions scenarios using dynamically downscaled output of three general circulation models [ECHAM5; Community Climate System Model, version 3 (CCSM3); and Hadley Centre Coupled Model, version 3 (HadCM3)] under three separate IPCC emissions scenarios (A1F1, A2, and B1) (Bozkurt and Lutfi Sen 2013). All simulations resulted in higher temperatures and evaporative demand in the basins, with the greatest increases in the highland areas, where precipitation is greatest. Precipitation changes were variable, with decreases in the northern portions of the watersheds and increases in the southern portions. In all the simulations, decreases in snowfall due to higher temperatures were noted, consistent with many other studies of the impacts of climate change on mountain hydrology. Statistically significant reductions of 25%–55% in annual surface runoff from the headwaters regions of the Euphrates–Tigris watersheds were seen in all simulations, along with a shift in the timing of runoff. The authors noted that these runoff changes “suggest that the territories of Turkey and Syria within the basin are most vulnerable to climate change as they will experience

significant decreases in the annual surface runoff. Eventually, however, the downstream countries, especially Iraq, may suffer more as they rely primarily on the water released by the upstream countries” (Bozkurt and Lutfi Sen 2013, p. 149).

The implications of these hydrological changes for Syria’s economy and political situation are far more difficult to project, because of the complicating factors of global trade, agricultural practices and technologies, management decisions about both water allocations and agricultural land decisions, and more. One effort to assess the economic risks to Syria of climatic changes linked downscaled global climate models, crop models, global economic models, and subnational dynamic equilibrium tools (Breisinger et al. 2013), and concluded that despite the ability to adapt to expected changes, the local impacts of climate change included declining yields and a reduction in both national economic growth and household income, even without factoring in the likely changes in water availability described above.

5. Strategies for reducing climate and water-related conflict risks

Reducing the risks of water-related conflicts requires reducing the pressures on water resources that contribute to economic, social, political, and environmental disruptions. In the MENA region, the heavy dependence of local economies and employment on agricultural production means that efforts to improve the productivity of water use to produce higher yields and income with less water will help cut pressure on the shared waters of the Tigris and Euphrates Rivers. In Syria, the added likelihood of rising temperatures and reduced surface flows due to climate changes make it even more urgent that long-term agricultural reforms be put in place when some kind of political stability returns, including sustainable groundwater management, more modern irrigation technologies, and a review of crop types and planting patterns. Overpumping of groundwater is not sustainable, but few regions of the world have managed to bring abstraction and recharge into balance. Doing so through economic, regulatory, and management policies is necessary if long-term sustainable water use is going to be a reality. Equally important, however, is the need for successful negotiation of international agreements on allocations and use of the major transnational rivers and discussions about proposals for new dam and irrigation projects on the Tigris and Euphrates Rivers. Few such agreements are in place in the MENA region and growing demands for these resources will make it progressively more difficult to reach agreements over time.

As a further complication, few international water agreements include mechanisms for addressing changing

social, economic, or climatic conditions. Negotiations over the allocation of the Tigris and Euphrates Rivers, for example, could include adjustable allocations strategies, water quality standards, response strategies for extreme events such as droughts and floods, amendment and review procedures in the event of disputes, and joint management institutions (Cooley and Gleick 2011).

6. Conclusions

The Syrian conflict that began in 2012 has many roots, including long-standing political, religious, and social ideological disputes; economic dislocations from both global and regional factors; and worsening environmental conditions. This paper argues that key environmental factors include both direct and indirect consequences of water shortages, ineffective watershed management, and the impacts of climate variability and change on regional hydrology. Severe multiyear drought beginning in the mid-2000s, combined with inefficient and often unmodernized irrigation systems and water abstractions by other parties in the eastern Mediterranean, including especially Syria, contributed to the displacement of large populations from rural to urban centers, food insecurity for more than a million people, and increased unemployment—with subsequent effects on political stability. There is some evidence that the recent drought is an early indicator of the climatic changes that are expected for the region, including higher temperature, decreased basin rainfall and runoff, and increased water scarcity. Absent any efforts to address population growth rates, these water-related factors are likely to produce even greater risks of local and regional political instability, unless other mechanisms for reducing water insecurity can be identified and implemented. In the region as a whole, new dam construction, growing water withdrawals, and limited political cooperation on water issues may become even more important in coming years. Among the key options available to policy makers are improvements in water-use efficiency and productivity in agriculture, better management and monitoring of groundwater resources, and comprehensive international agreements on managing and sharing the rivers that cross political borders.

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REFERENCES

- ACSAD, 2011: Drought vulnerability in the Arab Region: Case study; Drought in Syria—Ten years of scarce water (2000–2010).

- ISDR and the Arab Center for the Studies of Arid Zones and Dry Lands, 74 pp. [Available online at http://www.unisdr.org/files/23905_droughtsyriasmall.pdf.]
- Barnett, J., and W. N. Adgerb, 2007: Climate change, human security and violent conflict. *Polit. Geogr.*, **26**, 639–655, doi:10.1016/j.polgeo.2007.03.003.
- BBC, cited 2013a: Aleppo water supply cut as Syrian fighting rages. [Available online at <http://www.bbc.co.uk/news/world-middle-east-19533112>.]
- , cited 2013b: Syria crisis: ‘Powerful’ minibus explosion kills 13. [Available online at <http://www.bbc.co.uk/news/world-us-canada-21409661>.]
- Bozkurt, D., and O. Lutfi Sen, 2013: Climate change impacts in the Euphrates–Tigris basin based on different model and scenario simulations. *J. Hydrol.*, **480**, 149–161, doi:10.1016/j.jhydrol.2012.12.021.
- Breisinger, C., T. Zhu, P. Al Riffai, G. Nelson, R. Robertson, J. Funes, and D. Verner, 2013: Economic impacts of climate change in Syria. *Climate Change Econ.*, **4**, 1350002, doi:10.1142/S2010007813500024.
- Burstein, S., 1978: *The Babyloniaca of Berossus*. Undena Publications, 37 pp.
- Cooley, H., and P. H. Gleick, 2011: Climate-proofing transboundary water agreements. *Hydrol. Sci. J.*, **56**, 711–718, doi:10.1080/02626667.2011.576651.
- Cooper, J. S., 1983: *The Lagash-Umma Border Conflict: Reconstructing History from Ancient Inscriptions*. Undena Publ., 61 pp.
- Falkenmark, M., 1986: Fresh waters as a factor in strategic policy and action. *Global Resources and International Conflict: Environmental Factors in Strategic Policy and Action*, A. H. Westing, Ed., Oxford University Press, 85–113.
- FAO, 2012: Syrian Arab Republic Joint Rapid Food Security Needs Assessment (JRFSNA). FAO Rep., 26 pp. [Available online at http://www.fao.org/giews/english/otherpub/JRFSNA_Syrian2012.pdf.]
- Femia, F., and C. Werrell, cited 2013: Syria: Climate change, drought, and social unrest. The Center for Climate and Security. [Available online at <http://climateandsecurity.org/2012/02/29/syria-climate-change-drought-and-social-unrest/>.]
- Frenken, K., Ed., 2009: Irrigation in the Middle East region in figures: AQUASTAT survey—2008. FAO Water Rep. 34, 402 pp. [Available online at <http://www.fao.org/docrep/012/i0936e/i0936e00.htm>.]
- Gleditsch, N. P., K. Furlong, H. Hegre, B. Lacina, and T. Owen, 2006: Conflicts over shared rivers: Resource scarcity or fuzzy boundaries? *Polit. Geogr.*, **25**, 361–382, doi:10.1016/j.polgeo.2006.02.004.
- Gleick, P. H., 1989: The implications of global climatic changes for international security. *Climatic Change*, **15**, 309–325, doi:10.1007/BF00138857.
- , 1993: Water and conflict: Fresh water resources and international security. *Int. Secur.*, **18**, 79–112, doi:10.2307/2539033.
- , 1994: Water, war, and peace in the Middle East. *Environment*, **36**, 6–12, doi:10.1080/00139157.1994.9929154.
- , 2010: Climate change, exponential curves, water resources, and unprecedented threats to humanity. *Climatic Change*, **100**, 125–129, doi:10.1007/s10584-010-9831-8.
- Hatami, H., and P. H. Gleick, 1994: Conflicts over water in the myths, legends, and ancient history of the Middle East. *Environment*, **36**, 10–11, doi:10.1080/00139157.1994.9929156.
- Hoerling, M., J. Eischeid, J. Perlwitz, X. Quan, T. Zhang, and P. Pegion, 2012: On the increased frequency of Mediterranean drought. *J. Climate*, **25**, 2146–2161, doi:10.1175/JCLI-D-11-00296.1.
- Homer-Dixon, T. F., 1999: *Environment, Scarcity, and Violence*. Princeton University Press, 253 pp.
- Jacobsen, T., 1969: A survey of the Girsu (Tello) region. *Sumer*, **25**, 103–108.
- Kliot, N., 1994: *Water Resources and Conflict in the Middle East*. Routledge, 309 pp.
- Lelieveld, J., and Coauthors, 2012: Climate change and impacts in the eastern Mediterranean and the Middle East. *Climatic Change*, **114**, 667–687, doi:10.1007/s10584-012-0418-4.
- Lloyd, S., 1961: *Twin Rivers: A Brief History of Iraq from the Earliest Times to the Present Day*. 3rd ed. Oxford University Press, 235 pp.
- Loneragan, S., 1997: Water resources and conflict: Examples from the Middle East. *Conflict and the Environment*, N. P. Gleditsch, Ed., NATO ASI Series, Vol. 33, Springer, 375–384, doi:10.1007/978-94-015-8947-5_22.
- Malone, E. L., 2013: Climate change and national security. *Wea. Climate Soc.*, **5**, 93–95, doi:10.1175/WCAS-D-12-00016.1.
- Mathbout, S., and M. Skaf, 2010: Drought changes over last five decades in Syria. *Economics of Drought and Drought Preparedness in a Climate Change Context*, A. López-Francos, Ed., Mediterranean Seminars, 95, CIHEAM, 107–112.
- Mhanna, W., cited 2013: Syria’s climate crisis. [Available online at <http://www.al-monitor.com/pulse/politics/2013/12/syrian-drought-and-politics.html#>.]
- Mohtadi, S., cited 2013: Climate change and the Syrian uprising. [Available online at <http://thebulletin.org/web-edition/features/climate-change-and-the-syrian-uprising>.]
- Mroue, B., 2012: Activists: Syrian rebels seize major dam in North. *Daily Star Lebanon*, 26 November 2012. [Available online at <http://www.dailystar.com.lb/News/Middle-East/2012/Nov-26/196180-activists-syrian-rebels-seize-major-dam-in-north.ashx#ixzz2KA8TTBbj>.]
- NOAA, cited 2013: NOAA study: Human-caused climate change a major factor in more frequent Mediterranean droughts. [Available online at http://www.noaanews.noaa.gov/stories/2011/20111027_drought.html.]
- Parthemore, C., and W. Rogers, 2010: Promoting the dialogue: Climate change and the quadrennial defense review. Center for a New American Security Working Paper, 13 pp. [Available online at http://www.cnas.org/files/documents/publications/QDR&ClimateChange_Parthemore_Rogers_Jan2010_code406_workingpaper_2.pdf.]
- Rawlinson, G., Ed., 1933: *The History of Herodotus*. Dent & Dutton, 365 pp.
- Reig, P., T. Shiao, and F. Gassert, 2013: *Aqueduct Water Risk Framework*. World Resources Institute Working Paper, 16 pp. [Available online at http://www.wri.org/sites/default/files/aqueduct_water_risk_framework.pdf.]
- Romanou, A., G. Tselioudis, C. S. Zerefos, C.-A. Clayson, J. A. Curry, and A. Andersson, 2010: Evaporation–precipitation variability over the Mediterranean and the Black Seas from satellite and reanalysis estimates. *J. Climate*, **23**, 5268–5287, doi:10.1175/2010JCLI3525.1.
- Saleeby, S., cited 2012: Sowing the seeds of dissent: Economic grievances and the Syrian social contract’s unraveling. [Available online at <http://www.jadaliyya.com/pages/index/4383/sowing-the-seeds-of-dissent-economic-grievances-an>.]
- Salman, M., and W. Mualla, 2003: The utilization of water resources for agriculture in Syria: Analysis of current situation and future challenges. *Proc. Int. Seminar on Water Issues of the World Federation of Scientists*, Erice, Sicily, Italy, IPTRID, 11 pp. [Available online at ftp://ftp.fao.org/agl/IPTRID/conf_italy_03.pdf.]

- Schmidhuber, J., and F. N. Tubiello, 2007: Global food security under climate change. *Proc. Natl. Acad. Sci. USA*, **104**, 19 703–19 708, doi:10.1073/pnas.0701976104.
- Smiatek, G, S. Kaspar, and H. Kunstmann, 2013: Hydrological climate change impact analysis for the Fiegh spring near Damascus, Syria. *J. Hydrometeor.*, **14**, 577–593, doi:10.1175/JHM-D-12-065.1.
- Solh, M., 2010: Tackling the drought in Syria. *Nature Middle East*, doi:10.1038/nmiddleeast.2010.206.
- Toset, H. P. W., N. P. Gleditsch, and H. Hegre, 2000: Shared rivers and interstate conflict. *Polit. Geogr.*, **19**, 971–996, doi:10.1016/S0962-6298(00)00038-X.
- Turner, B. I., and Coauthors, 2003: Illustrating the coupled human–environment system for vulnerability analysis: Three case studies. *Proc. Natl. Acad. Sci. USA*, **100**, 8080–8085, doi:10.1073/pnas.1231334100.
- UNEP, 2008: Vital water graphics: An overview of the state of the world's fresh and marine waters. 2nd ed. UNEP and UNE/GRID-Arendal. [Available online at <http://www.unep.org/dewa/vitalwater/index.html>.]
- UN-ESCWA, 2013: Inventory of shared water resources in western Asia. UN-ESCWA and German Federal Institute for Geosciences and Natural Resources, 610 pp. [Available online at <http://www.escwa.un.org/information/pubaction.asp?PubID=1362>.]
- U.S. Department of Commerce, cited 2013: International data base: Population data for Syria. [Available online at <http://www.census.gov/population/international/data/idb/informationGateway.php>.]
- U.S. Department of Defense, 2010: Quadrennial defense review report. U.S. DOD Rep., 105 pp. [Available online at <http://www.defense.gov/qdr/qdr%20as%20of%2026jan10%200700.pdf>.]
- Vörösmarty, C. J., P. Green, and R. B. Lammers, 2000: Global water resources: Vulnerability from climate change and population growth. *Science*, **289**, 284–288, doi:10.1126/science.289.5477.284.
- Wada, Y., L. P. H. van Beek, and M. F. P. Bierkens, 2012: Non-sustainable groundwater sustaining irrigation: A global assessment. *Water Resour. Res.*, **48**, W00L06, doi:10.1029/2011WR010562.
- Wolf, A. T., 2007: Shared waters: Conflict and cooperation. *Annu. Rev. Environ. Resour.*, **32**, 241–269, doi:10.1146/annurev.energy.32.041006.101434.
- World Bank, cited 2013: A strategy to address climate change in the MENA region. [Available online at <http://go.worldbank.org/OIZZFRJZZ0>.]
- Worth, R. F., 2010: Earth is parched where Syrian farms thrived. *New York Times*, 13 October, New York ed., A1.
- Yoffe, S., A. T. Wolf, and M. Giordano, 2003: Conflict and cooperation over international freshwater resources: Indicators of basins at risk. *J. Amer. Water Res. Assoc.*, **39**, 1109–1126, doi:10.1111/j.1752-1688.2003.tb03696.x.