Assessing the Effects of Fresh Water Scarcity on the Operational Environment: A Challenge for Contemporary Operational Planners

A Monograph

by

MAJ Melissa C. Salamanca
US Army

School of Advanced Military Studies
US Army Command and General Staff College
Fort Leavenworth, KS

2018

REPORT DOCUMENTATION PAGE

Form Approved
0MB No. 0704-0188

1. REPORT DATE (DD-MM-YYYY)	2. REPORT TYPE	3. DATES COVERED (From - To)
24-05-2018	Master's Thesis	JUL 2017 - MAY 2018

4. TITLE AND SUBTITLE

Assessing the Effects of Fresh Water Scarcity on the Operational Environment: A Challenge for Contemporary Operational Planners

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

MAJ Melissa C. Salamanca

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

U.S. Army Command and General Staff College
ATTN: ATZL-SWD-GD
Fort Leavenworth, KS 66027-2301

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Advanced Military Studies Program

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for Public Release; Distribution is Unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

Global fresh water scarcity triggers conflict over fresh water and increases the frequency of attempts to control, target, or weaponize it. This monograph aims to examine the challenge of anticipating how water scarcity will affect the operational environment and operations. Due to the severity of the effects of fresh water scarcity and inadequacy of current methods to anticipate them, the Army must do more to evaluate how water scarcity will affect the operational environment and operations. Examples illustrate why this is an important issue, how the Army and civilian sector have dealt with it, and how the Army should address it. Incorporation into plans of measures to preempt or respond to the effects of water scarcity requires that planners have access to accurate assessments of those effects. Current methods for anticipating the effects of complex aspects of the operational environment are too general or linear. Analysis by those in the Operations Research/Systems Analysis functional area, using non-linear predictive tools and complex systems models, is the method recommended for the Army to anticipate the effects of water scarcity on the operational environment.

15. SUBJECT TERMS

Fresh Water Scarcity; Anticipating Effects of Water Scarcity; Water Conflict

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			MAJ Melissa C. Salamanca
(U)	(U)	(U)	(U)	47	19b. TELEPHONE NUMBER (Include area code)

Monograph Approval Page

Name of Candidate: MAJ Melissa C. Salamanca

Monograph Title: Assessing the Effects of Fresh Water Scarcity on the Operational Environment: A Challenge for Contemporary Operational Planners

Approved by:

_____, Monograph Director
Anthony E. Carlson, PhD

_____, Seminar Leader
Eric J. Adams, LtCol

_____, Director, School of Advanced Military Studies
James C. Markert, COL

Accepted this 24th day of May 2018 by:

_____, Director, Graduate Degree Programs
Robert F. Baumann, PhD

Abstract

Assessing the Effects of Fresh Water Scarcity on the Operational Environment: A Challenge for Contemporary Operational Planners, by MAJ Melissa C. Salamanca, US Army, 46 pages.

Global fresh water scarcity triggers conflict over fresh water and increases the frequency of attempts to control, target, or weaponize it. This monograph aims to examine the challenge of anticipating how water scarcity will affect the operational environment and operations. Due to the severity of the effects of fresh water scarcity and inadequacy of current methods to anticipate them, the Army must do more to evaluate how water scarcity will affect the operational environment and operations. Examples illustrate why this is an important issue, how the Army and civilian sector have dealt with it, and how the Army should address it. Incorporation into plans of measures to preempt or respond to the effects of water scarcity requires that planners have access to accurate assessments of those effects. Current methods for anticipating the effects of complex aspects of the operational environment are too general or linear. Analysis by those in the Operations Research/Systems Analysis functional area, using non-linear predictive tools and complex systems models, is the method recommended for the Army to anticipate the effects of water scarcity on the operational environment.

Contents

Acknowledgements

The author would like to acknowledge Dr. Anthony Carlson and Lieutenant Colonel Eric Adams for their invaluable advice and support. The author is also grateful for the opportunity to pursue this education by the United States Army and is a better Officer because of it. Most importantly, the author is indebted to her husband Carlos and her children Diego and Elena, whose support and sacrifices made this endeavor successful.

Acronyms

ADRP	Army Doctrine Reference Publication
AI	Artificial Intelligence
ARCIC	Army Capabilities Integration Center
ATP	Army Techniques Publication
CIA	Central Intelligence Agency
CJCS	Chairman of the Joint Chiefs of Staff
DARPA	Defense Advanced Research Projects Agency
FM	Field Manual
IPB	Intelligence Preparation of the Battlefield
IS	Islamic State
JP	Joint Publication
JSTOR	Journal Storage
NSS	National Security Strategy
OE	Operational Environment
ORSA	Operations Research/Systems Analysis
TC	Training Circular
TRAC	TRADOC Analysis Center
TRADOC	Training and Doctrine Command
UN	United Nations
UNEP	United Nations Environment Programme
US	United States
USAID	United States Agency for International Development
WRI	World Resources Institute

Figures

Introduction and Background

> Environmental scarcity is an emerging mission for the U.S. military; for these nontraditional missions, we need problem solvers and innovators. We have to constantly look beyond the short-term problems and try to identify the security issues that will become critical in the years ahead…As we look to each new crisis, there seems to be an underlying element of water or resource scarcity that seems to make the problem unsolvable.
>
> —General Anthony C. Zinni, USMC (Ret.), *Strategic Water*

Science shows that global fresh water is becoming scarcer. According to data from several scientists, since 1992 global fresh water resources have decreased by over twenty-six percent (see fig. 1).[1] As of 2007, approximately two billion people live in areas where fresh water is scarce.[2] Water scarcity is defined by United Nations Water (UN-Water) "as the point at which the aggregate impact of all users impinges on the supply or quality of water under prevailing institutional arrangements to the extent that the demand by all sectors…cannot be satisfied fully."[3] At least 3.6 billion people live in areas with an economic fresh water shortage, meaning the infrastructure that would allow use of fresh water from aquifers and rivers is not available.[4] Figure 2 shows that in 2014, forty-eight nations were experiencing fresh water stress, scarcity, or absolute scarcity. Twenty-two countries were experiencing water stress, meaning they had between 2,700 and 4,600 liters of renewable water resources per person per day or withdrew between twenty and sixty percent of their renewable water resources per year.[5] Nine countries were experiencing water scarcity, meaning they had between 1,400 and 2,700 liters of renewable water resources per person per day or withdrew between sixty and seventy-five percent of their renewable water resources per year.[6] Seventeen countries were experiencing absolute water scarcity, meaning they had less

[1] William J. Ripple et al., "World Scientists' Warning to Humanity: A Second Notice," *BioScience* 67, no. 12 (December 2017): 1027.

[2] *Coping with Water Scarcity: Challenge of the Twenty-First Century* (Geneva: United Nations-Water, 2007), 4.

[3] Ibid.

[4] Ibid.

[5] *Water Stress* (Rome: Food and Agriculture Organization of the United Nations, 2014), 1.

than 1,400 liters of renewable water resources per person per day or withdrew greater than seventy-five percent of their renewable water resources per year.[7] By 2016, "two-thirds of the global population (4.0 billion people) live under conditions of severe water scarcity at least 1 month of the year…Half a billion people in the world face severe water scarcity all year round."[8] The World Economic Forum's *Global Risks Report 2017* identified water crises as the third most impactful global risk and highlighted the interconnectedness of water crises with other global risks (see fig. 3).[9] Water crises can initiate or worsen other global risks, especially in areas that are already geopolitically weak. The following are examples of increasing global fresh water scarcity:

1. Lake Chad in Africa used to cover over 9,700 square miles and now covers 580 square miles.[10]

2. Since the 1960s, irrigation projects on tributaries of the Aral Sea, a lake between Kazakhstan and Uzbekistan, have reduced its size by over seventy percent.[11]

3. Droughts in Kenya caused thirty-five percent of pastoralists to move to cities for food aid.[12]

4. In Kyrgyzstan, glaciers that supply fresh water shrank twenty percent from 1970 to 2011, may shrink thirty-five percent more by 2030, and will likely be gone by 2100.[13]

5. In Peru, half the world's tropical glaciers melted, significantly reducing water availability.[14]

---

[6] *Water Stress*, 1.

[7] Ibid.

[8] Mesfin M. Mekonnen and Arjen Y. Hoekstra, "Four Billion People Facing Severe Water Scarcity," *Science Advances* 2, no. 2 (February 2016): 1.

[9] *The Global Risks Report 2017: 12th Edition* (Geneva: World Economic Forum, 2017), 6.

[10] Theresa Krinninger, "Lake Chad: Climate Change Fosters Terrorism," *Deutsche Welle*, July 12, 2015, accessed August 29, 2017, http://www.dw.com/en/lake-chad-climate-change-fosters-terrorism/a-18899499.

[11] Nelson E. Hernández, "Water Security Conflicts: A Regional Perspective," *Small Wars Journal*, 2012, accessed April 12, 2018, http://smallwarsjournal.com/jrnl/art/water-security-conflicts-a-regional-perspective.

[12] Lukas Rüttinger et al., *A New Climate for Peace: Taking Action on Climate and Fragility Risks* (Germany: G7, 2015), 41.

[13] "Security Council, in Statement, Says 'Contextual Information' on Possible Security Implications of Climate Change Important When Climate Impacts Drive Conflict," United Nations Security Council, July 20, 2011, accessed September 27, 2017, http://www.un.org/press/en/2011/sc10332.doc.htm.

[14] "Security Council…," 1.

6. In Europe and North America, approximately fifty percent of wetlands are gone.[15]

7. In Jakarta, Indonesia, water infrastructure supplies only part of the population, groundwater over-use causes land to sink, and salt water pollutes groundwater.[16] This sinking phenomenon caused by groundwater over-use also affects Bangkok, Ho Chi Minh City, and Manila.[17]

8. Over one million people in Sri Lanka are experiencing severe water shortages due to its worst drought in four decades.[18]

Figure 4 shows projected changes in global water stress from 2014 to 2040, including the doubling or tripling of water stress in many regions.[19] The Stockholm International Water Institute reported, "by 2075, the number of people in regions with chronic water shortage are estimated to be between 3 and 7 billion; those in regions with high water stress between 4 and 9 billion."[20]

Fresh water scarcity results from a variety of factors. Climate change, including decreasing rainfall and higher temperatures, may cause rivers to become nearly dry. In addition, the increasing global population demands increasing amounts of water for businesses, farms, and homes (see fig. 5) and increasingly pollutes and dams those same water supplies, making water sources unusable and changing the surrounding environment. Fresh water scarcity can lead to decreases in food, energy, and economic

---

[15] *The State of the World's Land and Water Resources for Food and Agriculture: Managing Systems at Risk* (New York: Food and Agriculture Organization of the United Nations and Earthscan, 2011), x.

[16] US Department of the Army, Field Manual (FM) 3-06, *Urban Operations* (Washington, DC: Government Printing Office, 2006), 3-13.

[17] *Global Trends: Paradox of Progress* (Washington, DC: US National Intelligence Council, 2017), 10.

[18] Minelle Fernandez, "Sri Lanka Hit by Worst Drought in Decades," Al Jazeera News, January 22, 2017, accessed October 3, 2017, https://www.aljazeera.com/news/2017/01/sri-lanka-drought-170122092517958.html.

[19] "AQUEDUCT Water Risk Atlas," World Resources Institute, accessed December 5, 2017, http://www.wri.org/our-work/project/aqueduct/.

[20] Malin Falkenmark, *On the Verge of a New Water Scarcity: A Call for Good Governance and Human Ingenuity* (Stockholm: Stockholm International Water Institute, 2007), 6.

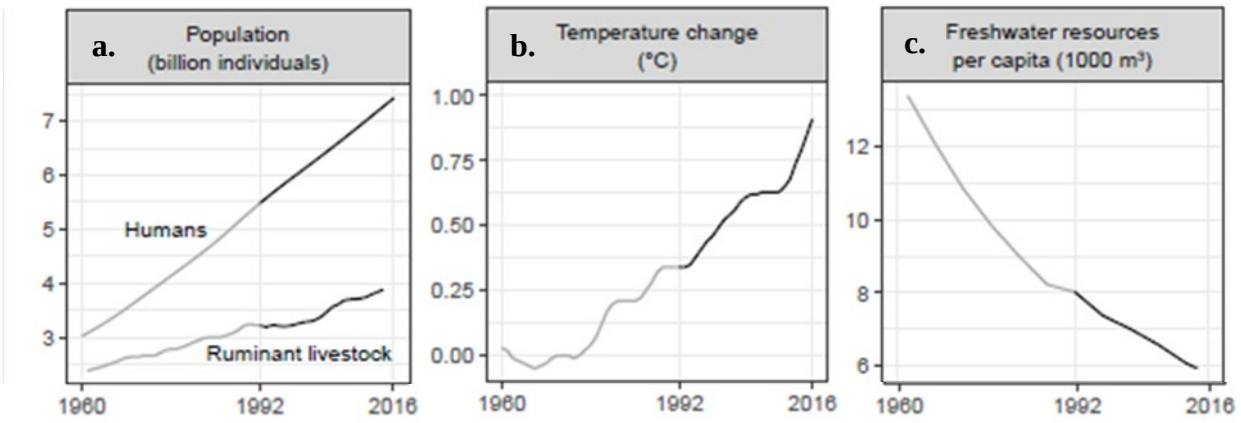

Figure 1. Global population, temperature, and freshwater resources trends over time. Data adapted from William J. Ripple et al., "World Scientists' Warning to Humanity: A Second Notice," *BioScience* 67, no. 12 (December 2017): 1026-1028.

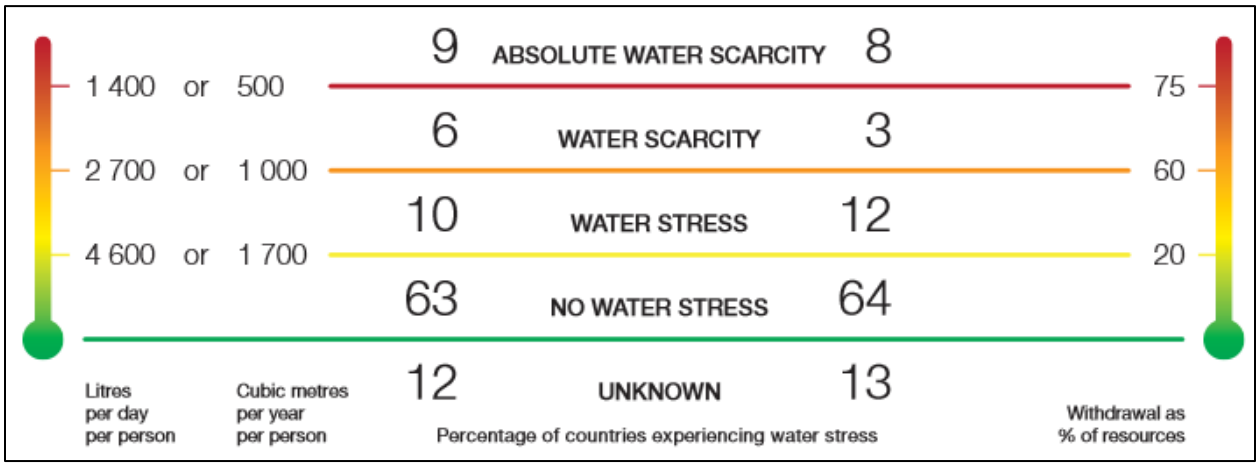

Figure 2. Global water stress. Data adapted from *Water Stress* (Rome: Food and Agriculture Organization of the United Nations, 2014), 1.

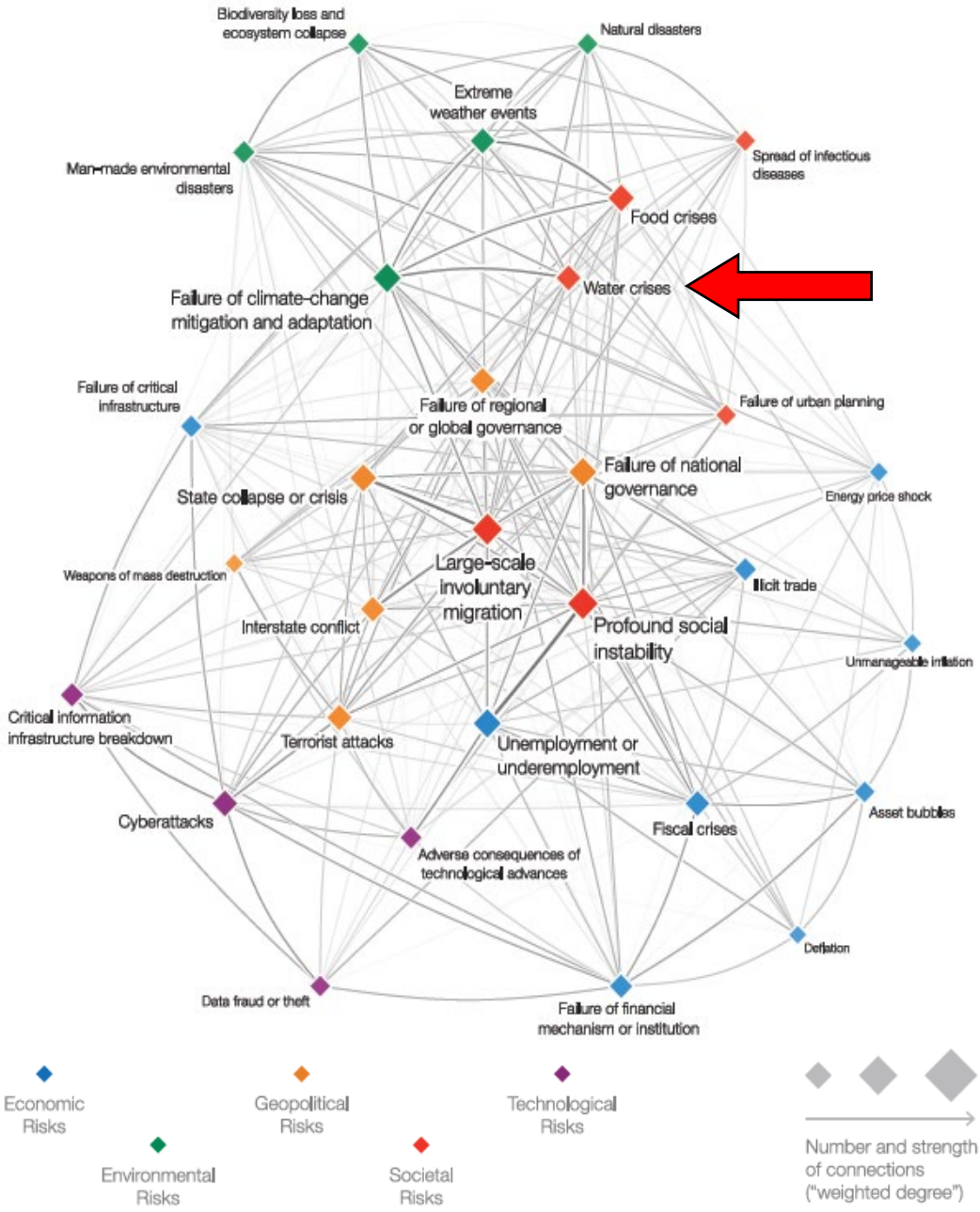

Figure 3. Interconnectedness of global risks. Data adapted from *The Global Risks Report 2017: 12th Edition* (Geneva: World Economic Forum, 2017), 6.

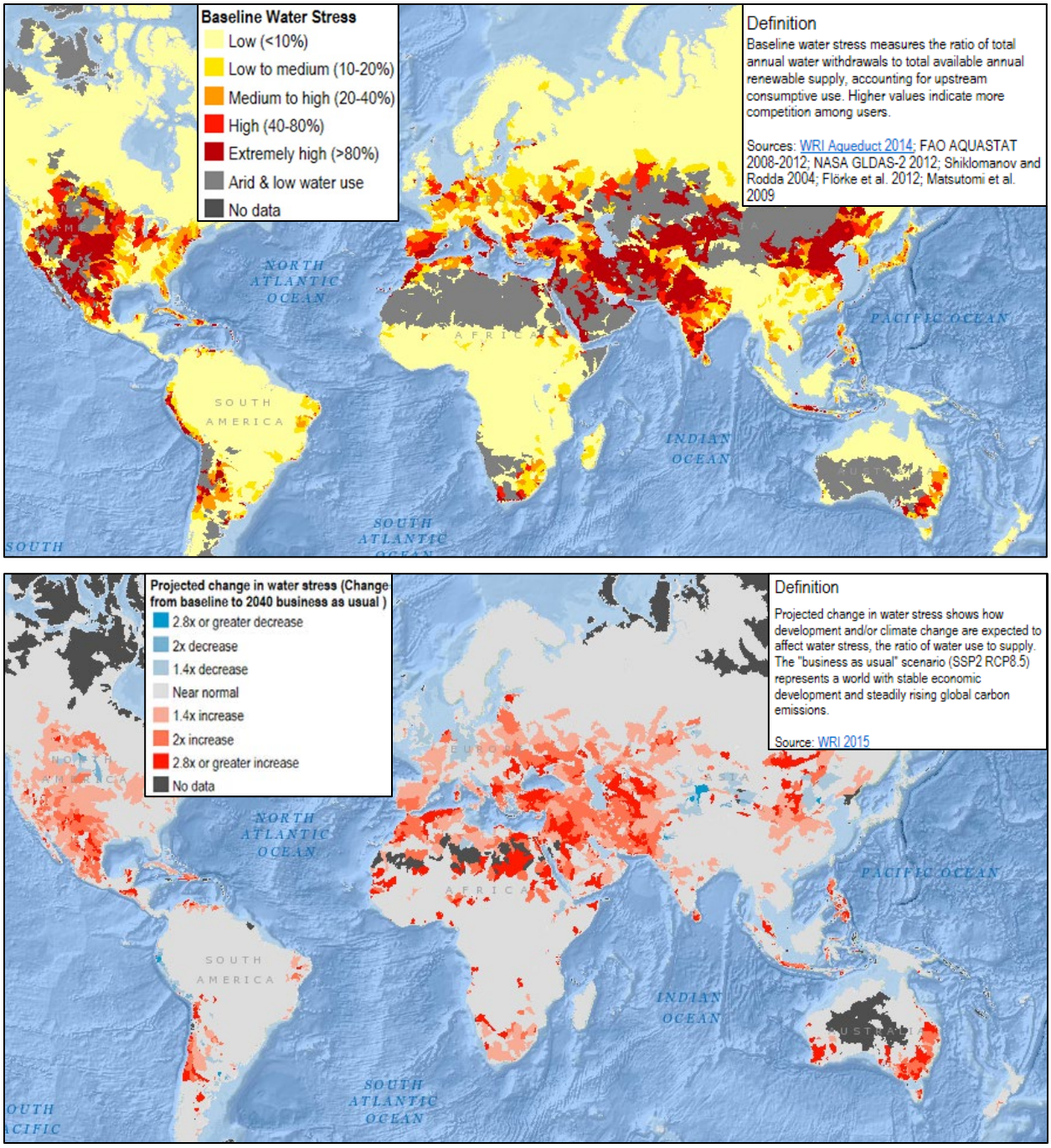

Figure 4. 2014 water stress and projected change in water stress by 2040. Data adapted from "AQUEDUCT Water Risk Atlas," World Resources Institute, accessed December 5, 2017, http://www.wri.org/our-work/project/aqueduct/.

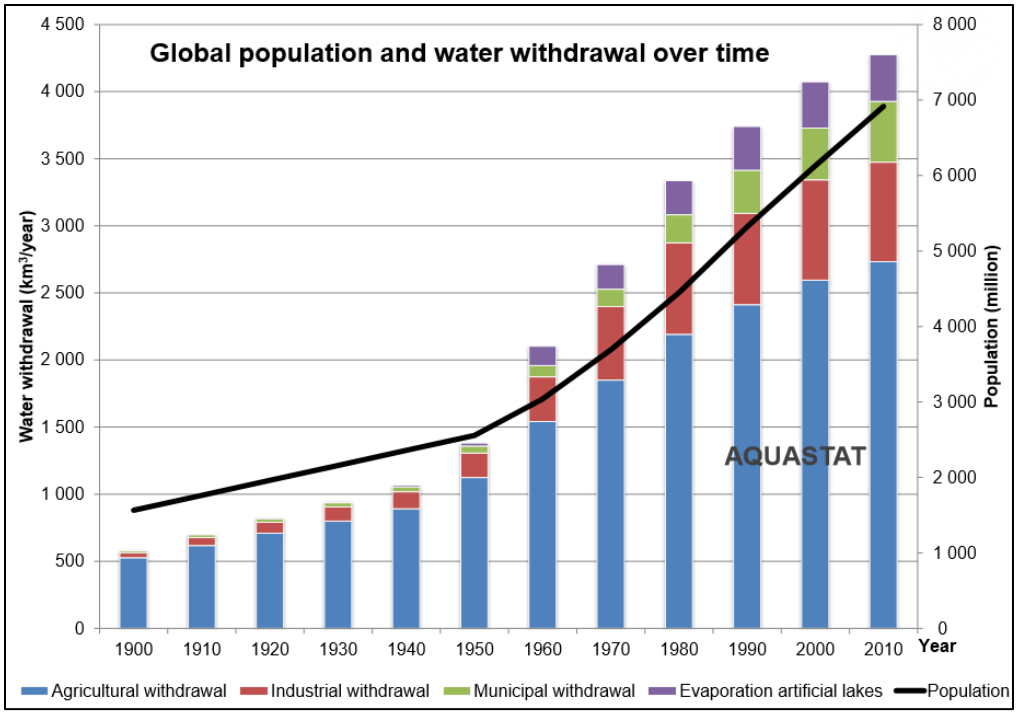

Figure 5. Global population and water withdrawal over time. Data from "Water Uses," Food and Agriculture Organization of the United Nations, 2016, accessed December 7, 2017, http://www.fao.org/nr/water/aquastat/water_use/index.stm.

growth; migrations away from regions lacking access to fresh water; and competition and conflict over fresh water sources. Corn, the most produced crop in the world, is food for people and animals and widely used to produce ethanol. However, the World Resources Institute (WRI) reported that due to high water stress, when fresh water demand is high in relation to supply, about one-third of the world's corn crop is in jeopardy.[21] This constitutes just one example of fresh water scarcity leading to a decrease in food and fuel that could in turn trigger starvation, migrations, competition, and conflict.

The Intergovernmental Panel on Climate Change estimated that "between 350 and 600 million Africans would be at risk of increased water stress by the middle of the century, while yields from rain-fed agriculture could be slashed by up to 50 percent by 2020."[22] UN-Water projects that "with the

[21] Francis Gassert and Andrew Maddocks, "High Water Stress Jeopardizes One-Third of World's Corn Crop," World Resources Institute, June 11, 2014, accessed November 14, 2017, http://www.wri.org/blog/2014/06/high-water-stress-jeopardizes-one-third-world%E2%80%99s-corn-crop.

[22] "Security Council…," 1.

existing climate change scenario, by 2030, water scarcity in some arid and semi-arid places will displace between 24 million and 700 million people."[23] The fact that "people who are forced to migrate due to the effects of climate change do not currently meet the definition of a refugee, meaning they are left without the rights and legal protections conferred by such a classification" compounds the challenging situation of those people.[24] In addition, because the consequences of water scarcity may be long-term or permanent, these "environmental refugees" may remain permanently displaced, intensifying any resultant competition or conflict.[25]

Natural resources and conflict have been, and will continue to be, linked. Resource shortages are often an indicator of conflict initiation, severity, and endurance. In some areas, "water may be so far below the surface, or so limited, that wells are normally inadequate to support any great number of people. Because potable water is absolutely vital, a large natural supply may be both tactically and strategically important."[26] As a result, state and non-state actors will likely attempt to control fresh water sources or weaponize them in areas experiencing fresh water scarcity. When conflicts related to fresh water scarcity or adversarial use of fresh water occur in or near an area where the United States (US) military is operating, they can influence the operational environment's (OE) dynamics and affect the success of operations.

Due to the ongoing global fresh water scarcity crisis, the Army must do more to identify and evaluate how fresh water scarcity will shape the future OE and operations. Recognition and documentation of historical, contemporary, and anticipated issues surrounding fresh water scarcity are increasing in the civilian academic and security sectors and in many US government agencies. A search

---

[23] "Water Scarcity," UN Water, accessed September 27, 2017, http://www.unwater.org/water-facts/scarcity/.

[24] Brian La Shier and James Stanish, "Issue Brief: The National Security Impacts of Climate Change," *Environmental and Energy Study Institute*, December 20, 2017, accessed April 12, 2018, http://www.eesi.org/papers/view/issue-brief-the-national-security-impacts-of-climate-change.

[25] Ibid.

[26] US Department of the Army, Field Manual (FM) 90-3, *Desert Operations* (Washington, DC: Government Printing Office, 1993), 1-10.

of the JSTOR digital library revealed ten times more books and research reports dedicated to the subject of water scarcity from 2000 to 2017 than from 1982 to 1999.[27] The prevalence of government and non-government organizations working to address water scarcity also increased in recent years. The US Water Partnership, formed in 2011, is a group of government agencies, non-governmental organizations, and corporations whose mission is "to unite and mobilize best of U.S. expertise, resources and ingenuity to address global water challenges, with a special focus on developing countries where needs are greatest."[28] The Interagency Water Working Group, formed in the US State Department in 2001, manages work on water issues throughout the executive branch. In 2011, then-US Secretary of State Hillary Clinton "signed a Memorandum of Understanding on water cooperation with the World Bank, on behalf of 17 agencies, with the goal of expanding joint efforts to create a more water-secure future for the world."[29] The US Department of Defense's 2014 *Quadrennial Defense Review* acknowledged climate change promotes water scarcity, which in turn increases tensions and the likelihood for small conflicts to escalate.[30] The Senator Paul Simon Water for the World Act of 2014 required the US President, for the first time, to submit to Congress by October 1, 2017 a US Government Global Water Strategy.[31] The strategy recommends a whole of government approach to improving access to and management of fresh water resources in order to decrease conflicts over fresh water.[32] The US Department of State – US Agency for International Development (USAID) Fiscal Year 2018-2022 Joint Strategic Plan pledges support for the

[27] Data compiled by the author based on a search of the JSTOR digital library, December 1, 2017.

[28] "About Us," US Water Partnership, 2016, accessed December 1, 2017, http://www.uswaterpartnership.org/.

[29] "Water in the U.S. Government," US Department of State, accessed December 1, 2017, https://2009-2017.state.gov/e/oes/water/government/index.htm.

[30] *Quadrennial Defense Review 2014* (Washington, DC: US Department of Defense, 2014), 27, 30.

[31] Senator Paul Simon Water for the World Act of 2014. H. Res. 2901, 113th Cong., *Congressional Record*, Vol. 160, daily ed. (December 19, 2014): Public Law 113–289.

[32] Ibid.

US Global Water Strategy and recognizes water scarcity as an environmental threat due to its potential to generate armed conflict and displace populations.[33]

Doctrinal Review

In contrast, Army and joint doctrine have shortchanged the challenge of fresh water scarcity. However, recognition of global water scarcity in doctrine is slowly increasing. US Army Field Manual (FM) 3-0, *Operations*, first mentioned increasing global demand for water, and the potential for it to cause conflict, in 2008. It acknowledged that "demand for water doubles every 20 years" and "by 2015, 40 percent of the world's population will live in water-stressed countries, increasing the potential for competition over a resource that has already led to conflict in the past."[34] The most recent version of FM 3-0, published in 2017, goes further by also discussing the immense water requirements of the Army in combat, the challenges of conducting water re-supply, and the need for planners to consider the effects of water requirements and scarcity on operations. During Operation Desert Shield, a division required an average of 213,000 gallons of water per day.[35] FM 3-0 (2017) states, "Water can be as critical…as ammunition."[36] It encourages planners to consider "sources of water and the means to transport it"; "the need for the early deployment of well-digging, water production, purification, and distribution assets and units"; and "the impact of the accidental or intentional release of toxic industrial materials and use of chemical munitions on the available water supply."[37] The manual does not, however, suggest a reliable tool or method for anticipating the effects of fresh water scarcity.

---

[33] *Joint Strategic Plan: FY 2018-2022* (Washington, DC: US Department of State and US Agency for International Development, 2018), 27, 39, 49.

[34] US Department of the Army, Field Manual (FM) 3-0, *Operations* (Washington, DC: Government Printing Office, 2008), 1-2.

[35] US Department of the Army, Field Manual (FM) 3-0, *Operations* (Washington, DC: Government Printing Office, 2017), 2-5.

[36] Ibid., 7-21.

[37] Ibid., 4-8, 7-21.

FM 34-130, *Intelligence Preparation of the Battlefield* (IPB), last published in 1994, recognizes water as key terrain, emphasizes that planners should consider the effects of water sources when describing the battlefield's effects, and describes how planners should consider water sources as an insurgent support function when determining threat courses of action.[38] The current IPB publication, US Army Techniques Publication (ATP) 2-01.3, published in November 2014, adds that water treatment and distribution facilities are structures that need to be analyzed to determine "how the location, functions, capabilities, and consequences of…use can support or hinder the operation" and acknowledges that "using a structure for military purposes often competes with civilian requirements."[39] It implores staffs to identify and provide for the immediate water needs of the populace and analyze the capability of local entities to provide water to the populace.[40] It also cautions that the Army's "dependency on local water sources can make movement predictable and expose the force to enemy attack."[41] Nowhere does it suggest anticipating, or a method to anticipate, the effects of actual or potential water scarcity, including its ability to cause conflict, its potential use as a weapon, or the effects of those possibilities on operations.

Army doctrine on stability operations also addresses natural resource challenges. FM 3-07, *Stability Operations*, published in 2008, states that although natural resources, including fresh water, may not directly cause instability, they can contribute to unrest and foster instability.[42] FM 3-07 also characterizes the state of natural resources as a longstanding condition that does not change quickly or easily.[43] Therefore, the issue for the Army is to understand and plan for how to mitigate the effects on the

[38] US Department of the Army, Field Manual (FM) 34-130, *Intelligence Preparation of the Battlefield* (Washington, DC: Government Printing Office, 1994), 6-2, 6-18.

[39] US Department of the Army, Army Techniques Publication (ATP) 2-01.3, *Intelligence Preparation of the Battlefield* (Washington, DC: Government Printing Office, 2014), 4-31.

[40] US Army, ATP 2-01.3 (2014), 4-32, 7-15.

[41] Ibid., 9-9.

[42] US Department of the Army, Field Manual (FM) 3-07, *Stability Operations* (Washington, DC: Government Printing Office, 2008), D-9.

environment and on operations caused by natural resources that are contributing to instability, as opposed to trying to solve the natural resources problem. The Army does not have the time or resources to do so, especially given other high priority missions. A challenge arises when humanitarian organizations are not able to provide for the immediate humanitarian needs of a population, of which fresh water is one, because according to US Army Doctrine Reference Publication (ADRP) 3-07, *Stability*, published in 2012, it is the role of the Army in those circumstances to provide for those needs.[44] Nowhere in stability operations doctrine does it suggest how the Army might best go about assessing the impact of natural resource issues, such as fresh water scarcity, on its operations.

Urban operations doctrine contains the most comprehensive examination of the topic of water scarcity and its potential effects on the OE and on operations. Joint Publication (JP) 3-06, *Joint Urban Operations*, published in 2013, recognizes the prevalence of water scarcity in urban environments and the danger of the weaponization of water:

> For instance, if the water flow into a city can be controlled, an adversary can intentionally limit that flow and create an urgent need that a joint force must address. This manipulation of the water supply serves as a potentially lethal weapon (people can become dehydrated or overheated) as well as a weapon of influence (fear of having an adversary control a critical need). As a weapon's platform, this same water supply can be tainted with a biological agent that can infect anyone who drinks it, creating disease of epidemic proportions as well as considerable terror in the population.[45]

FM 3-06, *Urban Operations*, published in 2006, states, "Commanders operating in an urban environment need to know the water supply origins and its treatment, purification, distribution, and vulnerabilities" and recognizes that "across the spectrum of operations, controlling and protecting a limited water supply is, or may become, an essential operational consideration during urban operations."[46] It goes on to advocate for an expanded definition of "threat" in order to encompass everything that might negatively affect

[43] US Army, FM 3-07 (2008), D-9.

[44] US Department of the Army, Army Doctrine Reference Publication (ADRP) 3-07, *Stability* (Washington, DC: Government Printing Office, 2012), 2-17.

[45] US Department of Defense, Joint Staff, Joint Publication (JP) 3-06, *Joint Urban Operations* (Washington, DC: Government Printing Office, 2013), II-8.

[46] US Army, FM 3-06 (2006), 3-13.

operations, including water shortages.[47] The challenge is to analyze each threat to determine how they can impede operational success. This is a challenge because it requires "extensive coordination and cooperation with urban civil authorities, law enforcement, and numerous governmental and nongovernmental organizations."[48] It is also a challenge because there is no recommended way for the Army to anticipate how, when, or where threats such as water shortages will arise.

Other current doctrine and publications that mention water scarcity include US Army Training Circular (TC) 2-91.4, *Intelligence Support to Urban Operations*, published in 2015. It reiterates the problem that the Army will increasingly face when operating in areas of fresh water scarcity:

> Water is an essential resource. As populations grow, demand for potable water increases. In some areas of the world, the supply of fresh water is inadequate to meet these demands. By 2025, between 2.7 and 3.5 billion people may live in water-deficient countries. In developed nations, water companies provide the population with clean water. In much of the developing world, no formal water authorities exist. Sewage, industrial waste, and pollution pose threats to the water supply.[49]

JP 3-24, *Counterinsurgency*, published in 2013, and ATP 3-34.5, *Environmental Considerations*, published in 2015, observe that competition over strategic resources, including water, has frequently generated conflict.[50] ATP 3-34.5 urges planners to "consider the possibility of environmental-driven conflicts within areas of responsibility" and to make plans that "address potential trouble spots and the effect that environmental considerations may have on military action."[51] As part of planning, JP 3-57, *Civil-Military Operations*, published in 2013, suggests that Joint Force Commanders "should identify early indicators and warnings of changes in the OE and allocate resources to monitor these changes in

[47] US Army, FM 3-06 (2006), B-10-B-11.

[48] Ibid., B-11.

[49] US Department of the Army, Training Circular (TC) 2-91.4, *Intelligence Support to Urban Operations* (Washington, DC: Government Printing Office, 2015), 1-38.

[50] US Department of the Army, Army Techniques Publication (ATP) 3-34.5, *Environmental Considerations* (Washington, DC: Government Printing Office, 2015), 1-5; US Department of Defense, Joint Staff, Joint Publication (JP) 3-24, *Counterinsurgency* (Washington, DC: Government Printing Office, 2013), II-5.

[51] US Army, ATP 3-34.5 (2015), 1-5.

order to anticipate changes in force requirements."[52] It identifies water shortages as a possible indicator of escalation that could require changes in force requirements.[53] FM 3-90-1, *Offense and Defense*, published in 2015, reminds the Army, "deliberately making…water unfit for consumption is unlawful under the terms of the Geneva Conventions" and would therefore apply to any state actor using water in such a way.[54] ADRP 3-90, *Offense and Defense*, published in 2012, identifies the requirement for commanders to establish "a command environmental program with policies and responsibilities to integrate environmental considerations into operations to prevent negative impacts on the mission, friendly units, and civilian activities within the AO."[55] This is one of the only places in Army doctrine stating the purpose of integrating environmental considerations is to prevent negative effects on operations. In order to take effective action to prevent those effects, there must be an accurate way to anticipate them.

The incorporation into operational plans of measures to preempt or respond to the effects of fresh water scarcity requires that planners have the opportunity to coordinate for, and have access to, accurate assessments of the anticipated effects of fresh water scarcity on the OE so they can then anticipate the resultant effects on Army operations. However, current methods for analyzing and anticipating the effects of the numerous and complex aspects of the OE are too general or linear. More advanced methods are required. Given the growing problem of global fresh water scarcity and the under-acknowledgement of its effects on future operations, it is past time to examine why this is an important issue for the Army to address, how the Army has addressed it, and how the Army should address it. The author hopes that the research and findings of this monograph will assist future planners, in the Army and in other agencies and

[52] US Department of Defense, Joint Staff, Joint Publication (JP) 3-57, *Civil-Military Operations* (Washington, DC: Government Printing Office, 2013), I-6.

[53] Ibid., I-7.

[54] US Department of the Army, Field Manual (FM) 3-90-1, *Offense and Defense Volume I* (Washington, DC: Government Printing Office, 2015), 9-19.

[55] US Department of the Army, Army Doctrine Reference Publication (ADRP) 3-90, *Offense and Defense* (Washington, DC: Government Printing Office, 2012), 2-9.

organizations, to plan more accurately to preempt and mitigate the effects of fresh water scarcity on the OE and on future operations.

Fresh Water Scarcity as a Significant Issue for the Army

In a "debate on 'maintenance of international peace and security: the impact of climate change,'" the UN Security Council "noted that 'conflict analysis and contextual information' on, among others, the 'possible security implications of climate change' was important when climate issues drove conflict, challenged implementation of Council mandates or endangered peace processes."[56] Similarly, the potential of fresh water scarcity and related conflicts to shape the future OE and undermine the success of operations makes it an important issue for Army planners to examine.

Fresh Water Scarcity and Conflict

In 2018, the United Nations Environment Programme (UNEP) found that "over the last 60 years, at least 40 percent of all internal conflicts have been linked to the exploitation of natural resources, whether high-value resources such as timber, diamonds, gold, and oil, or scarce resources such as fertile land and water."[57] They also found that when natural resources were part of conflicts, those conflicts were two times as likely to relapse.[58] UNEP called climate change "the ultimate 'threat multiplier' aggravating already fragile situations and potentially contributing to further social tensions and upheaval."[59] FM 3-24.2, *Tactics in Counterinsurgency*, asserts that water conflicts can be a root cause leading to insurgencies in rural areas.[60] In his book *The Battle for Manila*, Richard Connaughton wrote, "Utilities such as

[56] "Security Council…," 1.

[57] "International Day for Preventing the Exploitation of the Environment in War and Armed Conflict 6 November," United Nations, accessed January 7, 2018, http://www.un.org/en/events/environmentconflictday/.

[58] Ibid.

[59] "Climate Change and Security Risks," United Nations Environment Programme, accessed January 7, 2018, https://www.unenvironment.org/explore-topics/disasters-conflicts/what-we-do/risk-reduction/climate-change-and-security-risks.

[60] US Department of the Army, Field Manual (FM) 3-24.2, *Tactics in Counterinsurgency* (Washington, DC: Government Printing Office, 2009), 2-11.

electricity and water are as much weapons of war as rifles, artillery pieces, or fighter aircraft."[61] FM 7-100.1, *Opposing Force Operations*; TC 7-100.2, *Opposing Force Tactics*; and TC 2-91.4, *Intelligence Support to Urban Operations*, recognize the potential for an adversary to use chemical, biological, or radiological agents to contaminate water supplies.[62] The following examples, including inter- and intra-state conflicts over fresh water, adversarial use of fresh water, and ways in which fresh water scarcity has affected military operations in the past, illustrate the various types of conflict caused, exacerbated, or otherwise affected by fresh water scarcity and its effects.

Conflicts over fresh water

There are countless examples of conflicts over, involving, or exacerbated by fresh water scarcity dating back as far as 2500 BC.[63] The US Office of the Director of National Intelligence issued a report in 2012 that rated "management capacity" for seven river basins located in North Africa, the Middle East, and South Asia based on the "strength and resilience of institutional factors, such as treaties and river basin organizations that can provide stability, increase cooperation, and mitigate political grievances over water."[64] However, only two of the seven river basins were given positive ratings of their ability to avoid and manage future water crises."[65] From 2000-2017, there were at least two hundred twenty three conflicts related to fresh water involving at least seventy-seven nations.[66]

---

[61] Richard Connaughton, *The Battle for Manila* (Novato, CA: Presidio Press, 1997), 103.

[62] US Department of the Army, Field Manual (FM) 7-100.1, *Opposing Force Operations* (Washington, DC: Government Printing Office, 2004), 11-5, 11-11; US Department of the Army, Training Circular (TC) 7-100.2, *Opposing Force Tactics* (Washington, DC: Government Printing Office, 2011), 13-7-13-8; US Army, TC 2-91.4 (2015), 1-38, 2-8.

[63] Peter H. Gleick, "Water Conflict Chronology List," *Pacific Institute for Studies in Development, Environment, and Security*, 2017, accessed April 9, 2018, http://www2.worldwater.org/conflict/list/.

[64] *Global Water Security: Intelligence Community Assessment 2012-08* (Washington, DC: US Office of the Director of National Intelligence, 2012), v.

[65] Ibid.

[66] Gleick, 1.

US Africa Command identified drought and disease as causes of humanitarian crises that have the potential to destabilize communities.[67] Fresh water scarcity has been a cause of persistent conflict in the Chad Basin. Cameroonians and Nigerians fight over who has territorial rights to the dwindling water supply in Lake Chad as do fishers, farmers, and herders over the diversion of that same water supply, resulting in hundreds of deaths each year.[68] Chad's President stated that Lake Chad serves as a base for the terrorist group Boko Haram, which finds the area to be fertile recruiting ground because of the desperation of people suffering from limited resources, unemployment, and lack of future prospects.[69] Climate- and drought-related migration is at least partially responsible for the resource competition and war that began in 2003 in the Darfur region of Sudan.[70] In 2007, then-secretary general of the UN, Ban Ki-moon, characterized the crisis in Darfur as "an environmental crisis – a conflict that grew at least in part from desertification, ecological degradation and a scarcity of resources, foremost among them water."[71] Competition over water has also been a significant driver of conflicts in the Central African Republic, Kenya, and Chad.[72] In February 2017, there were deaths during a clash over water in Kenya because of a drought that has led thousands of people to compete for limited water and pasture.[73] The influx of thousands of refugees into Kenya, over five hundred thousand refugees and internally displaced people each in Chad and Central African Republic, and hundreds of thousands more across other African nations exacerbate these issues.

---

[67] La Shier and Stanish, 1.

[68] Ahmad Salkida, "Africa's vanishing Lake Chad," AfricaRenewal, April 2012, accessed August 29, 2017, http://www.un.org/africarenewal/magazine/april-2012/africa%E2%80%99s-vanishing-lake-chad; Krinninger, 1.

[69] Krinninger, 1.

[70] La Shier and Stanish, 1.

[71] Ban Ki-moon, "What I Saw in Darfur," *Washington Post*, September 14, 2007, accessed August 29, 2017, http://www.washingtonpost.com/wp-dyn/content/article/2007/09/13/AR2007091301680.html.

[72] "Security Council…," 1.

[73] "Where Conflict and the Environment Collide: Voices from the Field," United Nations Environment Programme, April 25, 2017, accessed August 29, 2017, https://www.unenvironment.org/news-and-stories/story/where-conflict-and-environment-collide-voices-field.

Fresh water scarcity as a source of conflict is not limited primarily to Africa. Tensions between Israel and Arab nations over water started in 1953 when Israel tried to divert the Upper Jordan River to the Negev Desert.[74] Syria planned to use that water for irrigation and drinking water.[75] Israel bombed Syrian construction sites and exerted control over the region's water when it occupied the Golan Heights and the West Bank.[76] Many consider this a trigger for the 1967 Six Day War. Fresh water resources in that region include the Jordan River and the Mountain Aquifer. Although controlled by Israel, both are actually transboundary, which means, "under international law, they should be shared in an equitable and reasonable manner by Israel and Palestine."[77] More recently, a five-year drought in Syria led to decreased agricultural production, lack of employment, and the migration of approximately one and a half million people to urban areas that became sites of the 2011 uprising.[78] These migrations create water problems for other nations as well. The flood of refugees from Syria arriving in Jordan caused that government to pump more water from the already diminished supply in its aquifers.[79] The World Economic Forum's *Global Risks Report 2017* identified large-scale involuntary migrations as the second most likely global risk.[80] Water scarcity contributed to recent uprisings in other ways as well. According to a 2017 report by CNA Analysis and Solutions, lengthy "droughts in Russia, Ukraine, and parts of China led to widespread increased wheat prices, including in Arab nations dependent on imports. The rise in food prices, experts

[74] Lisdey Espinoza Pedraza and Markus Heinrich, "Water Scarcity: Cooperation or Conflict in the Middle East and North Africa?" *Foreign Policy Journal*, September 2, 2016, accessed April 8, 2018, https://www.foreignpolicyjournal.com/2016/09/02/water-scarcity-cooperation-or-conflict-in-the-middle-east-and-north-africa/.

[75] Christiane Fröhlich and Ulrich Ratsch, "Water Scarcity and Violent Conflict," in *Global Change: Enough water for all?* ed. José L. Lozán et al. (Hamburg: Wissenschaftliche Auswertungen, 2007), 242.

[76] Ibid.

[77] Pedraza and Heinrich, 1.

[78] Stockholm International Water Institute, *The Water Report 2016*, ed. Torkil Jønch Clausen et al. (Stockholm: Torgny Holmgren, 2016), 12.

[79] US National Intelligence Council, 111.

[80] *The Global Risks Report 2017: 12th Edition*, 4.

conclude, was a factor (among many) in the political upheaval that swept the Arab regions, leading to government collapse in Tunisia, Egypt, and Libya, and eventually the civil wars in Syria and Yemen."[81] In 2015, the Interior Ministry of Yemen blamed water-related violence for as many as four thousand deaths per year and a Yemeni newspaper estimated that water is the cause of seventy to eighty percent of rural conflicts.[82] The UN Food and Agriculture Organization estimated the civil war in Yemen left approximately twenty million Yemenis without drinking water.[83] There have been many protests in Iran after millions lost their incomes due to drying of rivers and lakes and poor water resource management practices, "including inefficient irrigation techniques, decentralized water management, subsidies for water-intensive crops like wheat, and dam building."[84]

The increasing frequency and severity of droughts in northern China, combined with rapidly growing populations, has also resulted in tension and conflict over fresh water resources. The population of Beijing increased from eight to twenty-two million in the last three decades.[85] To supply water to its growing population, the government of Beijing has taken control of nearly all rivers flowing through its city.[86] It shares the Juma River with neighboring Hebei Province but has made multiple plans in the past to control more of that water by raising dams on the river and digging numerous wells to tap groundwater under the river.[87] Appeals from Hebei Province slowed these efforts, however, due to the absence of a cooperative resolution process, Beijing nevertheless dug a canal that diverted both surface and subsurface

[81] *The Role of Water Stress in Instability and Conflict* (Arlington, VA: CNA Analysis and Solutions, 2017), 24.

[82] Gleick, 1.

[83] Ibid.

[84] *The Role of Water Stress*, 24.

[85] Michael Eng and Ma Jun, *Building Sustainable Solutions to Water: Conflicts in the United States and China* (Washington, DC: Woodrow Wilson International Center for Scholars, 2006), 171.

[86] Ibid.

[87] Ibid.

Juma River water away from Hebei Province.[88] Even more severe has been the conflict over water from the Zhang River. The Great Leap Forward caused an increase in the creation of water facilities to support agricultural production.[89] This led to heightened water withdrawals, which in turn created water shortages and conflict, including the formation of militias.[90] The shootings, mortar attacks, bombings, and firefights over fresh water in this region resulted in hundreds of people injured and over one million dollars of infrastructure damage.[91] Despite attempts at market-based solutions, water supply requirements in this area continue to go unmet and attempts to control the water continue.[92] The potential exists worldwide for tensions and conflicts over fresh water. Cooperative management agreements exist for only about "half of the world's 263 international river basins…as well as only a handful of the more than 600 transboundary aquifer systems."[93] Furthermore, the "agreements are not sufficiently adaptive to address emergent issues such as climate change, biodiversity loss, and water quality."[94] There are currently disputes over water in the Mekong, Indus, Nile, Amu Darya, Jordan, and Brahmaputra river basins, among others.[95]

Adversarial use of fresh water

Seemingly as numerous as conflicts over water are attempts by state and non-state actors to control, target, or weaponize water. These challenging events also have the potential to influence future operations. In South America, recent attacks on fresh water infrastructure include a 2014 attack on a water treatment plant in Venezuela, where an unidentified group contaminated the water supply with diesel

[88] Eng and Jun, 172.

[89] Ibid.

[90] Ibid.

[91] Ibid.

[92] Ibid.

[93] US National Intelligence Council, 25.

[94] Ibid.

[95] Ibid.

fuel.[96] In 2015 in Colombia, the Revolutionary Armed Forces of Colombia (FARC) destroyed a water facility with an explosive device.[97] That attack resulted in approximately thirteen thousand people living temporarily without water.[98]

In Syria, people still feel the effects of the 2006-2011 drought and, in contravention of international law, opposition groups have used control of fresh water infrastructure as a weapon.[99] Intentional water cuts affected approximately two million people in Aleppo and Damascus in 2015.[100] Although Damascus City receives water from the Wadi Barada, some of its supply lines pass through areas controlled by opposition groups who have closed those lines.[101] Officials estimate there has been a fifty percent reduction in access to fresh water since the beginning of the Syrian civil war.[102] In 2015, Al-Qaeda caused hundreds of people to become ill from contaminated water after they bombed the primary pipeline bringing Euphrates River water to Aleppo.[103] Since 2014, Syrian rebel groups have repeatedly cut off water to Damascus, prompting shortages and rationing of water.[104] The rebel groups also threatened to blow up the spring that supplies the water if government forces enter the area.[105]

Controlling fresh water resources is a key component of the Islamic State's (IS) strategy to create a caliphate in Syria and Iraq.[106] IS regards Tigris and Euphrates River dams as "strategic targets but also

---

[96] Gleick, 1.

[97] Ibid.

[98] Ibid.

[99] Stockholm International Water Institute, 11-12.

[100] Ibid., 12.

[101] Ibid.

[102] Gleick, 1.

[103] Ibid.

[104] Ibid.

[105] Ibid.

[106] Pedraza and Heinrich, 1.

as powerful weapons of war."[107] Fresh water resources appear to be as important to IS as land and their "quest for hydrological control" commenced with the seizure of the Tabqa dam in 2014, which supplies water and electricity to Syria.[108] IS continued this quest in multiple operations to seize the largest dams in Iraq, the Mosul and Haditha dams on the Tigris and Euphrates Rivers, respectively, which supply over ninety-five percent of Iraq's water.[109] If IS gained and maintained control of those two dams, not only could it control the supply of water and electricity, it could also threaten to destroy or actually destroy the dams (which would kill millions of people), to achieve further aims.[110] These possibilities were major contributors to the Battle of Haditha Dam in 2003, as well as the rush to repair Mosul Dam after IS occupation. Communities downstream from Ramadi Dam on the Euphrates River in Iraq have suffered water shortages since IS redirected water to enable military movements across the river.[111] In 2016, in Mosul and other areas, IS cut electricity to pumping stations and destroyed water pipelines, resulting in over five hundred thousand people living without water.[112] In Iraq in 2014, in order to deny water supplies and hydroelectricity and force government forces to lift a siege, IS seized the Falluja Dam and closed its floodgates, resulting in flooding around Falluja and cutting off the downstream water supply.[113] IS also built an earthen berm near the Falluja Dam to control the water supply and divert it into canals, thereby flooding Shiite communities and forcing residents to evacuate.[114] In 2017, IS pumped water from Lake Assad to flood villages in east Aleppo in response to the Syrian Arab Army's advance.[115]

[107] Pedraza and Heinrich, 1.

[108] Ibid.

[109] Ibid.

[110] Ibid.

[111] Gleick, 1.

[112] Ibid.

[113] Ibid.

[114] Ibid.

[115] Ibid.

Also in this region, Turkey built dams, and has others planned, that could reduce the amount of water in the Tigris and Euphrates Rivers available for Iraq and Syria.[116] Turkey has used this water as a coercive political tool.[117] In Syria, for example, Turkey leveraged their control of fresh water to prevent the Syrian government from supporting the Kurdistan Worker's Party (PKK).[118] There is a sharing agreement in place regarding Euphrates River water, but not for Tigris River water.[119] Regional political unrest hinders attempts at negotiating additional agreements over water.[120] Yemen's water supplies have also suffered at the hands of both state and non-state actors. In 2013, a gang sabotaged a main water pipeline.[121] In 2016, almost twenty million people could not access fresh water because of Saudi Arabian attacks on Yemen's power and water infrastructure.[122] The WRI estimates that the Middle East will likely be home to fourteen out of the thirty-three of the world's most water-stressed countries by 2040 and therefore "water stress is an underlying conflict multiplier that will not go away."[123] If that is the case, water stress is an underlying conflict multiplier that will continue to shape the OE and influence military operations.

Water stress is also a conflict multiplier in Africa. Ethiopia's filling of the reservoir of its Grand Ethiopian Renaissance Dam and other developments upstream on the Nile from Egypt will cause Egypt to experience new water challenges.[124] In 2014, South Sudan experienced the destruction of a water pipeline

---

[116] Joshua Busby, *Water and US National Security* (New York: US Council on Foreign Relations, 2017), 4.

[117] Fröhlich and Ratsch, 243.

[118] Ibid.

[119] Busby, 4.

[120] Ibid.

[121] Gleick, 1.

[122] Ibid.

[123] Kitty van der Heijden, Betsy Otto, and Andrew Maddocks, "Beyond Conflict, Water Stress Contributed to Europe's Migration Crisis," World Resources Institute, November 3, 2015, accessed March 2, 2018, http://www.wri.org/blog/2015/11/beyond-conflict-water-stress-contributed-europe's-migration-crisis.

[124] US National Intelligence Council, 111.

to its UN mission, which served a large displaced population.[125] Both sides of the conflict in Mali have used water in an adversarial way. Islamic militants in the country cut the water supply of Timbuktu and Malian forces reportedly dump bodies in rural wells.[126] Al-Shabaab has also cut off water to cities in Somalia in attempts to demonstrate its power.[127] In Libya in 2013, militants cut water to Tripoli and attacked a pumping station on Libya's "Great Man Made River," further disrupting Tripoli's water supply.[128]

Adversarial use of fresh water is also a concern for US forces operating on the Korean peninsula. Although upstream water development projects jeopardize the availability of fresh water in South Korea, no agreement exists between the two countries regarding joint development of their shared fresh water resources.[129] On multiple occasions and in violation of existing agreements about notification of water release, North Korea has unexpectedly released water from its dams, causing flooding, evacuations, and deaths in South Korea.[130] The Imnam Dam, also known as the Mount Geumgang Dam, just over the border in North Korea on the Han River, impounds 2.6 billion tons of water, which, if released, would flood the South Korean capital of Seoul only 120 miles away from the dam.[131] In response to this possibility, South Korea built what may be the only dam in the world with the sole purpose of defense, the Peace Dam.[132] North Korea could release water from its dams intentionally or a release could occur as

[125] Gleick, 1.

[126] Ibid.

[127] La Shier and Stanish, 1.

[128] Gleick, 1.

[129] Lynne Kurilovitch, "Green Power: Got Water?" *New Mexico Institute of Mining and Technology Master of Science Teaching*, 2011, accessed December 12, 2017, http://infohost.nmt.edu/~lynnek/w10sp/modLoader.php?mod=07&sec=5&pg=11.

[130] Jun Ji-Hye, "N. Korea discharges water from dam without notice," *The Korea Times*, July 6, 2016, accessed December 12, 2017, http://m.koreatimes.co.kr/pad/news/view.jsp?req_newsidx=208774.

[131] Kurilovitch, 1.

[132] Ibid.

the result of an apparent accident. Either way, such an incident would cause extensive loss of life and infrastructure damage and possibly spark conflict. If it happened during military operations, it would result in the loss of combat power in terms of personnel, basing, equipment, and mobility and would be a huge crisis the military would need to deal with in conjunction with, or before resuming, combat operations.

Also in this region, along the Mekong River, China and Laos built dams to control water supply and Thai farmers diverted water, severely reducing fresh water supply in Cambodia and Vietnam, which are already experiencing drought.[133] India also experiences challenges related to water from state and non-state groups. In 2014, a drought in northern India led bandits to coerce local villagers to deliver water to them under threat of death.[134] Twenty-eight villages obeyed the order and "take turns paying what the bandits call a daily 'water tax.'"[135] India also threatened to withdraw from its Indus Waters Treaty with Pakistan because of attacks on the Indian military in 2016.[136]

Past effects of fresh water scarcity on the military

Water scarcity has had many different types of effects on military operations. Iran and Afghanistan have a long-standing water-sharing agreement over the Helmand River.[137] However, years of conflict have damaged the Hamoun wetlands that the two nations share.[138] As part of operations in Afghanistan, the United States undertook projects to rebuild Afghanistan's agricultural system and water infrastructure.[139] The unanticipated consequence of this was that it "undermined Iran's water security and

[133] Busby, 4.

[134] Gleick, 1.

[135] Ibid.

[136] Busby, 4.

[137] Ibid.

[138] Ibid.

[139] Ibid.

contributed to Iranian support for the Taliban."[140] Therefore, "Iran blames Afghanistan for the diversion of water and is opposed to Afghanistan's completion of various dam projects in Nimruz Province," which sparked cross-border conflicts over water in that area.[141]

In Syria in 2017, Syrian and US forces conducted an attack to re-take control of the Tabqa Dam from IS because it serves as a regional source of hydroelectric power and as a Euphrates River choke point.[142] Control and safety of Iraqi dams continue to be challenges for US forces. In 2014, Mosul Dam was again under IS control, leading US and Kurdish forces to conduct many weeks of operations to re-take the dam.[143] The US-led coalition also conducted several air strikes against IS in 2014 to re-gain or maintain control of dams, including Mosul Dam, Fallujah Dam, and Haditha Dam.[144] These operations also destroyed the previously mentioned IS-built earthen berm near the Fallujah Dam.[145]

In Jordan, fresh water scarcity led US Marine Corps forces operating there to produce their own water instead of relying on local supplies.[146] Also in Jordan, when "hacked pipes began to exacerbate water scarcity and threatened to enflame conflict in some communities, the United States helped deliver water from alternative aquifers so vulnerable communities would not be without it."[147] Both of these alternative solutions required additional allocations of time, money, personnel, and equipment those forces had to plan for and coordinate concurrent with other operations. Fresh water scarcity will play a role in any part of the globe in which the Army operates and affect nearly every operation it conducts. As

[140] Busby, 4.

[141] Ibid.

[142] Gleick, 1.

[143] Ibid.

[144] Ibid.

[145] Ibid.

[146] Cheryl Pellerin, "After Long Deployment, Leaders Praise Navy-Marine Team," US Department of Defense, January 17, 2013, accessed April 12, 2018, http://archive.defense.gov/news/newsarticle.aspx?id=119033.

[147] Beth Ellen Cole, et al., *Preserving Stability Amidst Regional Conflagration: US Engagement in Jordan 2011 to 2016* (Washington, DC: United States Institute of Peace, 2017), 19.

conflicts, tensions, and enforcement issues over fresh water continue unabated, as well as instances of the weaponization of fresh water, they risk provoking renewed conflict. The Army must therefore identify and monitor those issues in the OE and assess how they will alter future operations.

Potential Future Effects of Fresh Water Scarcity

When events like those above occur in or near an area where the Army is operating, they shape the OE and may impinge on the success of operations. The Army may have to divert time, personnel, and resources to alleviate water shortages or to deescalate conflicts over water. As articulated in FM 3-06, *Urban Operations*, requirements on the Army "to protect, restore, or maintain critical infrastructure may divert substantial amounts of resources and manpower needed elsewhere and place additional constraints on subordinate commanders," especially because "civilian infrastructure is often more difficult to secure and defend than military infrastructure."[148] Additionally, "the potentially large and sprawling nature of many systems (such as water…), make their protection a challenge."[149] TC 2-91.4, *Intelligence Support to Urban Operations*, acknowledges that although "U.S. forces may gain no marked tactical advantage by controlling this [water supply] system…its protection minimizes the population's hardship and thus contributes to overall mission success."[150] The Army may not be able to rely on local water sources and, if they do, risk compromise or denial of those water sources. Fresh water scarcity may limit a unit's freedom of movement, capability to conduct operations, and make rigorous operations in hot environments impossible to conduct or support.[151]

FM 3-24, *Insurgencies and Countering Insurgencies*, argues that planners need to anticipate the potential effects of Army operations on areas already experiencing resource shortages.[152] If Army

[148] US Army, FM 3-06 (2006), 2-20.

[149] Ibid.

[150] US Army, TC 2-91.4 (2015), 1-38.

[151] US Army, FM 90-3 (1993), G-6.

[152] US Department of the Army, Field Manual (FM) 3-24, *Insurgencies and Countering Insurgencies* (Washington, DC: Government Printing Office, 2014), 3-3.

operations "inadvertently divert or impede access to resources, such as water," this "in turn may cause real shortages or upset the balance of power by allowing greater access to these resources by one group and harming another."[153] Effects such as these, resulting from ill-informed operations, consequently make those operations even more difficult. Therefore, in order to avoid exacerbating the resource-scarce situation and imposing additional obstacles to operational success, the Army must evaluate the status of fresh water in the OE, anticipate the effects of Army operations on those resources, and forecast the effects of the status of fresh water resources on Army operations. It may then need to ensure it has the capability to supply its own fresh water instead of relying on local supplies.

If terrorist or insurgent groups are recruiting or running an information campaign based on water shortages, the Army may first have to resolve the water shortage issue to delegitimize the terrorist or insurgent narrative. However, the Army may not be qualified or equipped to resolve water shortages, requiring it to coordinate with other governmental or non-governmental organizations. Scarcity of fresh water for drinking, hygiene, and sanitation can initiate or exacerbate the spread of disease, which could affect the local population and Soldier welfare, making operational success difficult or impossible. This is a risk in Yemen, for example, where "conflict zones, high water prices, and damaged infrastructure have aggravated already grim water problems, leaving 80 percent of the population without access to reliable fresh-water sources. Without adequate infrastructure, water stored for domestic use can become contaminated and expand the breeding habitats for mosquitos, malaria, dengue fever, and cholera."[154] Displacements and migrations caused by fresh water scarcity may drive new and needy groups into a unit's area of operations, triggering conflict with existing groups that the Army has to deal with, humanitarian issues, or the need to reassess the new dynamics and effects such a migration might produce. Fresh water scarcity may also dictate additional key terrain for the Army to monitor and protect, such as dams and water treatment facilities, as suggested in FM 3-06, *Urban Operations*.[155]

[153] US Army, FM 3-24 (2014), 3-3.

[154] US National Intelligence Council, 111.

Different types of conflict and control over, as well as nefarious use of, fresh water will dictate different operational requirements. If the Army is operating in an area where there is active conflict or tensions over fresh water, it may have to work with local authorities to minimize the conflict before it can conduct further operations. It also may need to thwart the perception that it is siding with one side over another. If efforts at reducing the conflict fail, it may have to plan its operations so the conflict affects them as minimally as possible and will need to incorporate force protection measures related to the conflict into all plans. If the Army is operating in an area where the local or national government is controlling water resources in a way that is detrimental to operational success, the Army may need to cooperate with the local government to develop solutions more conducive to the needs of the population and the success of operations. In dealing with a national government, the Army may require the diplomatic assistance of its own government or outside agencies. If the Army is operating in an area where an adversarial non-state actor is controlling, targeting, or weaponizing fresh water, it will likely need to plan ways to target that adversary with minimal damage to water infrastructure. It may have as one of its initial operational aims to take back control of water resources or infrastructure under adversary control. Once in control, it may have to assign elements permanently to protect those water resources and infrastructure to prevent their weaponization.

Current Practices to Anticipate the Effects of Fresh Water Scarcity

Peter Gleick, the Director of the *Pacific Institute for Studies in Development, Environment, and Security*, stated, "we have more tools at the international level to resolve disputes between nations. We have diplomats. We have treaties. We have international organisations that reduce the risk that India and Pakistan will go to war over water but we have far fewer tools at the sub-national level."[156] The following

[155] US Army, FM 3-06 (2006), 10-11.

[156] Suzanne Goldenberg, "Why Global Water Shortages Pose Threat of Terror and War," *The Guardian*, February 8, 2014, accessed April 12, 2018, https://www.theguardian.com/environment/2014/feb/09/global-water-shortages-threat-terror-war.

two sections examine the military and non-military tools and practices that exist for anticipating the effects of fresh water scarcity.

Military Practices

In 2015, the US Department of Defense acknowledged that "the ability of the United States and other countries to cope with the risks and implications of climate change requires monitoring, analysis and integration of those risks into existing overall risk management measures, as appropriate for each combatant command."[157] More recently, US Secretary of Defense James Mattis stated, "Climate change is impacting stability in areas of the world where our troops are operating today. It is appropriate for the Combatant Commands to incorporate drivers of instability that impact the security environment in their areas into their planning."[158] However, practices to do so still lag behind these sentiments.

While framing the OE and anticipating its effects on operations is a task and concern of all in the Army, the responsibility for those functions often falls mostly on those in the intelligence field. Description of the OE and its effects is most often associated with step two of IPB, *Determine Environmental Effects on Operations*. The anticipation of how an adversary might use fresh water resources would most appropriately be associated with step four of IPB, *Determine Threat Courses of Action*. Although IPB doctrine does not discuss anticipation of water scarcity or its effects, it does contend that a consequence of failure to conduct step two or four of IPB accurately is that "the enemy commander may have the information needed to exploit the opportunities the operational environment provides in a way the friendly commander did not anticipate."[159] To avoid that end, the Army needs a more accurate way to anticipate the effects of water scarcity on the OE and on future operations.

[157] "DoD Releases Report on Security Implications of Climate Change," US Department of Defense, July 29, 2015, accessed April 12, 2018, https://www.defense.gov/News/Article/Article/612710/.

[158] La Shier and Stanish, 1.

[159] US Army, ATP 2-01.3, (2014), 4-1, 6-2.

The mission of the Defense Advanced Research Projects Agency (DARPA) is "to make pivotal investments in breakthrough technologies for national security."[160] Although DARPA occasionally mentions climate challenge as a US national security concern, there do not appear to be projects directed at anticipating of the effects of climate change or water scarcity. At the strategic level, DARPA's participation in developing tools and practices for anticipating the effects of water scarcity on the military would help to legitimize the efforts of operational units.

The purpose of the Army Capabilities Integration Center (ARCIC) is to "innovate to ensure that Army forces are prepared to provide multiple options for combatant commanders; present multiple dilemmas to enemies; integrate efforts of multiple partners; and operate across multiple domains."[161] At the Army level, this presents a potential venue through which to develop tools and practices for anticipating the future effects of water scarcity. However, it does not seem to have addressed this issue, even though it does recognize the problems associated with climate change, resource competition, and water scarcity. The same seems to be true for the Army Training and Doctrine Command's (TRADOC) Analysis Center (TRAC), whose mission is "to produce relevant and credible operations analysis to inform decisions."[162]

At the strategic level, "tensions arising from the military's desire to insulate its operations from climate risks and the fiscal priorities of influential groups within Congress will likely color future national security budget negotiations."[163] As of 2015, US Central Command reported to Congress that its theater campaign plans and deliberate planning processes include current and historic climate conditions as well as warning indicators for future climate conditions, including water scarcity, which it acknowledges as "a

[160] "Mission," Defense Advanced Research Projects Agency, accessed April 12, 2018, https://www.darpa.mil/about-us/mission.

[161] "ARCIC," Army Capabilities Integration Center, 2018, accessed April 12, 2018, http://www.arcic.army.mil/Directorates/Headquarters.

[162] "TRAC's Mission," TRADOC Analysis Center, accessed April 12, 2018, http://www.trac.army.mil/.

[163] La Shier and Stanish, 1.

recurring issue in the AOR."[164] However, there is no mention of how US Central Command does this or of what resources the command may need to do so more effectively. This is unfortunate because part of the purpose of the report is to "identify…ways in which the Combatant Commands are integrating mitigation of these risks into their planning processes, and a description of the resources required for an effective response."[165]

The military and other groups have used the ScenGen Software developed by Scorpion Computer Services to tackle previous challenges and could use it for scenarios involving fresh water scarcity. ScenGen is "an award winning software program that generates all possible scenarios for any given situation at a very high speed" and has been used by US Special Operations Command, US Army, US Navy, and US Air Force in testing and real mission planning.[166] It operated the Defense Information Systems Agency's Agile Command and Control System twenty times faster than humans.[167] As of January 2018, the US Army awarded a contract to Scorpion Computer Services to use ScenGen with the Army's Unmanned Aerial Systems.[168] The founder of Scorpion Computer Services, Walter O'Brien, claims, "ScenGen's Artificial Intelligence (AI) generates 250 years of human thinking every 90 minutes, so you can be certain that you have considered all possible scenarios for a given situation."[169] The white paper on ScenGen for the military explains that it is useful because it can "save lives by reducing human

[164] *National Security Implications of Climate-Related Risks and a Changing Climate* (Washington, DC: US Department of Defense, 2015), 9.

[165] Ibid.

[166] "STRYKE Industries and Scorpion Computer Services Award Winning ScenGen Software Selected by SOCOM (Special Operations Command) for Live Experiment on Army Base," *PR Newswire*, July 8, 2015, accessed April 12, 2018, https://www.prnewswire.com/news-releases/stryke-industries-and-scorpion-computer-services-award-winning-scengen-software-selected-by-socom-special-operations-command-for-live-experiment-on-army-base-300110526.html.

[167] "ScenGen (Scenario Generator)," Scorpion Computer Services, 2015, accessed April 12, 2018, http://hplusmagazine.com/wp-content/uploads/2015/10/ScenGenWhitePaperV5.pdf.

[168] "Stryke and Scorpion to deliver ScenGen AI for US Army UAS," Army Technology, January 9, 2018, accessed April 12, 2018, https://www.army-technology.com/news/stryke-scorpion-deliver-scengen-ai-us-army-uas/.

[169] "STRYKE Industries…," 1.

error and increasing preparation through enhanced mission planning," "save money by automation of test and evaluation," and "has improved C4ISR (Command, Control, Communications, Computing, Intelligence, Surveillance, and Reconnaissance) security due to proactively closing the holes that hackers exploit."[170] The ability to use this or similar software to anticipate numerous potential future scenarios rapidly could greatly improve the accuracy and comprehensiveness of those anticipated scenarios.

Non-Military Practices

The US Government has done some work to understand and address the effects of fresh water scarcity. The US National Intelligence Council 2012 report, *Global Water Security*, tried to anticipate how fresh water issues would influence US national security in various parts of the world through 2040.[171] A more recent US National Intelligence Council Report, *Paradox of Progress*, analyzed global trends and their implications through 2035. It assessed that water scarcity will become more prevalent and trigger new conflicts, however those involved cannot agree upon methods to diagnose and solve such issues.[172] The same report anticipated that although "historically, water disputes between states have led to more sharing agreements than violent conflicts…this pattern will be hard to maintain" because of dam construction, pollution, disregard for existing treaty provisions, and political and cultural antagonisms.[173] The report further anticipated that issues related to water shortage, when combined with other societal issues present especially in weak states, could hasten state failure.[174]

The United States has numerous organizations and capabilities focused on issues related to climate change, including natural resource competition and scarcity, and its impacts. For example, the

[170] "ScenGen (Scenario Generator)," 1.

[171] *Global Water Security: Intelligence Community Assessment 2012-08* (Washington, DC: US Office of the Director of National Intelligence, 2012).

[172] US National Intelligence Council, 7.

[173] Ibid., 25.

[174] Ibid., 170.

United States produces more satellite information on water than any other nation.[175] The question is whether US organizations and capabilities are used to their full extent and whether they are effectively integrated and available across government and the private sector. USAID, for example, conducts projects and analysis on water issues, but they primarily involve sanitation and hygiene.[176] According to the Council on Foreign Relations, "the U.S. government has not sufficiently mobilized to prepare for water-related challenges" because it "has not fully utilized the capabilities of U.S. civil society, universities, and the private sector to anticipate and address water-related problems around the world."[177] A 2017 report of the National Intelligence Council recommended "investments in data, methods, modeling, and surveillance of critical human and natural-support systems—such as infrastructure, energy, water, and air quality" because they "could spark emergent technologies in sustainability, increasing community and environmental resilience" and would likely result in "widespread private sector demand for mitigation technologies and services."[178] If the United States does not devote enough time and resources to the use of its advanced capabilities in these sectors to identify likely areas of water scarcity and its effects, the US Military, and international community as a whole, may be caught flat-footed when future conflicts develop.

The WRI agrees: "tackling a complex challenge like water stress requires the latest data and the tools to use that data."[179] It describes the India Water Tool, an online system containing extensive data on India's water.[180] Using this tool, "companies, governments, civil society groups, researchers and others can analyze groundwater and surface water quantity and quality, projections for water supply and demand, and more, drawing on Indian government data and global satellite data, all in one easy-to-use

[175] Busby, 2.

[176] Ibid.

[177] Ibid.

[178] US National Intelligence Council, 69.

[179] van der Heijden, Otto, and Maddocks, 1.

[180] Ibid.

website."[181] Other countries facing fresh water scarcity could use this tool as a model for creating similar systems that would provide insight on future challenges. Such systems could also help US Army planners more accurately anticipate and address the effects of fresh water scarcity on the OE and on future operations. In addition, other "similar global-level tools already exist for different water-related issues, including WRI's Aqueduct Water Risk Atlas and World Wildlife Fund's Water Risk Filter."[182] To develop their data, WRI "used a number of climate models and socioeconomic scenarios to project future water stress under three different scenarios—'business-as-usual,' 'optimistic,' and 'pessimistic'—in 167 countries in 2020, 2030, and 2040."[183]

Former US Central Intelligence Agency (CIA) Director Leon Panetta advocated advancing research on climate-related issues and "oversaw the formation of the Center for Climate Security and the restart of Medea, a program where intelligence operatives and civilian scientists collaborated to better understand the impacts of environmental change."[184] Medea allowed scientists the use of classified intelligence assets, such as "satellites, sensors, and ocean and tidal readings from Navy submarines," so that it could more accurately monitor and record climate change and its effects and collaborate more closely with national security agencies on related issues. This effort ended in 2015 after lawmakers criticized the program for potentially preventing CIA assets from looking at "more immediate security concerns."[185]

The goal of the Defense Science Study Group of the Science and Technology Division of the Institute for Defense Analyses is to encourage interest in national security issues and challenges among scientists in order to enable the full application of science and technology to those challenges. The

[181] van der Heijden, Otto, and Maddocks, 1.

[182] Ibid.

[183] Carolyn Kenney, *Climate Change, Water Security, and U.S. National Security* (Washington, DC: Center for American Progress, 2017), 5.

[184] La Shier and Stanish, 1.

[185] Ibid.

proceedings of its recent symposium contains the statement, "the environment around us and Earth's changing climate influence the security of our nation…it is even more important today than it was 30 years ago to introduce new generations of emerging leaders across the entire spectrum of science and technology to these pressing defense challenges and for them to be engaged with the national security community."[186] DARPA has expressed its support for this group, which therefore has an opportunity to increase the importance placed, and effort expended, by government on climate-related issues.

Recommendations

A 2017 discussion paper from the Council on Foreign Relations indicated that future water-related security issues would exist in areas of strategic interest to the United States but, despite that likelihood, there is insufficient funding and recognition of water issues as a US national security problem.[187] Some of the steps the paper recommends to better deal with water issues include "enhanced priority for water and security at the highest levels in the U.S. government" and "more support for data collection, analysis, and early warning efforts."[188] Comparison of the US National Security Strategies (NSS) from 2015 and 2017 provides an example of the lack of recognition of water issues as a US national security problem. Although the 2015 NSS discusses climate change and the fact that it can drive conflicts over water, the 2017 NSS does not mention climate change, water scarcity, or conflicts related to those factors.

The Climate and Security Advisory Group, in its February 2018 report *A Responsibility to Prepare: Strengthening National and Homeland Security in the Face of a Changing Climate*, offered some of the most comprehensive recommendations about the US Government fulfilling its role to more accurately anticipate the effects of climate change on the OE and on future operations. First, it recommends the current Administration "expand efforts to assess risks and challenges that climate change

[186] *Proceedings of the Defense Science Study Group 30th Anniversary Symposium* (Alexandria, VA: Institute for Defense Analyses, 2016), viii.

[187] Busby, 1, 11-15.

[188] Ibid.

poses to the U.S. military's missions, force readiness, and operational plans."[189] This includes recommendations specifically for the US Secretary of Defense and subordinate commands, including the creation and expansion of initiatives to assess the effects of climate change on training, readiness, plans, and missions; assessment and preparation for possible changes to mission requirements and emergent flashpoints; and inclusion of climate risks in wargames.[190] Second, it recommends that climate information be made "actionable by the broader national security enterprise by prioritizing analysis that supports planning processes, resource investments, and procurement decisions in strategically significant regions."[191] This includes recommendations for several parts of the government. The Secretary of Defense should ensure Geographic Combatant Commands have access to climate-related intelligence and research and that they provide models and tools down to the operational level.[192] The Director of National Intelligence should work to better understand the link between climate and security and should gather and support research and actionable intelligence on climate risks.[193] The Administrator of USAID should ensure its conflict prediction models include climate and security variables.[194] The Secretary of Homeland Security should pursue intelligence on fragile nations that have the potential to affect homeland security.[195] Third, it recommends the alignment of "military planning and intelligence community resources to prepare for climate change impacts to the global operating environment."[196] This includes the recommendation that the Chairman of the Joint Chiefs of Staff's (CJCS) assessments of the global OE

[189] *A Responsibility to Prepare: Strengthening National and Homeland Security in the Face of a Changing Climate: Roadmap and Recommendations for the US Government* (Washington, DC: The Climate and Security Advisory Group, 2018), 10.

[190] Ibid., 13.

[191] Ibid., 10.

[192] Ibid., 14.

[193] Ibid.

[194] Ibid.

[195] Ibid.

[196] Ibid., 10.

and Geographic Combatant Commands' Theater Campaign Plans and Theater Security Cooperation Plans should include climate change as a strategic risk and address how climate issues may affect conflict and stability.[197] The CJCS should also address current and anticipated effects of climate change in discussions with the Secretary of Defense, National Security Council, and the President so that those issues can then be included in strategic guidance and plans.[198] It also recommends that National Nuclear Security Administration facilities incorporate climate change impact assessments.[199] For those recommendations to be fulfilled and put into practice by the military, the government must prioritize and resource them.

CNA Analysis and Solutions, a "not-for-profit research and analysis organization dedicated to developing actionable solutions to complex problems of national importance," offers similar recommendations related specifically to fresh water stress.[200] Collaboration between CNA researchers and the fifteen retired admirals and generals of the CNA Military Advisory Board resulted in the report, *The Role of Water Stress in Instability and Conflict*. Consistent with the methods and recommendations discussed above, CNA recommends "a common foresight tool to identify areas of emerging water stress, with a focus on the potential for unrest."[201] It continues, "while there are systems and processes in place at USAID and other agencies to monitor and forecast water stress, track flows, and predict droughts, there is no standard that also addresses the potential for violence and conflict."[202] The CNA report concurs with the Climate and Security Advisory Group that government and military leaders should incorporate water stress in strategic documents and guidance, including its impact on the US strategy to counter violent extremism.[203] It suggests that a global water stress office within the Office of the Secretary of Defense

[197] *A Responsibility to Prepare*, 16-17.

[198] Ibid., 17.

[199] Ibid.

[200] *The Role of Water Stress*, 4.

[201] Ibid.

[202] Ibid.

[203] Ibid.

would better facilitate interagency coordination in response to Combatant Command reports about potential water conflicts in their areas of responsibility.[204]

Best Method

The CNA report "found that water stress has varying roles in conflict that rarely occur linearly."[205] Therefore, detailed analysis using non-linear predictive tools or complex systems modeling is the best method for the Army to anticipate the effects of fresh water scarcity on the OE and on future operations. These types of models allow consideration of the interdependence of the various components of causation; can be tailored to the uniquenesses of a region, ideology, or actor; and result in the most relevant and accurate anticipatory analyses. The Climate and Security Advisory Group asserted, "continuing and expanding investments that address the probability of events will be critical to understanding system interdependencies that could lead to catastrophic scenarios."[206] If the Army was able to incorporate tools such as ScenGen into its planning processes, anticipation of the future effects of water scarcity would be much improved.

Who Should be Responsible

If the US Government and military planners prioritized fresh water scarcity and dedicated and developed the right personnel to conduct data collection, analysis, and early warning, the effects of water scarcity could be incorporated into planning considerations and mitigated. In the Army, the most appropriate functional area to be responsible for the tools and methods used to anticipate the effects of fresh water scarcity is Operations Research/Systems Analysis (ORSA). According to the Department of the Army Pamphlet 600-3, *Commissioned Officer Professional Development and Career Management*, the purpose of the ORSA functional area is to "provide uniquely skilled analysts that assist decision makers in solving complex problems by producing the analysis and logical reasoning necessary to inform

[204] *The Role of Water Stress*, 4.

[205] Ibid., 1.

[206] *A Responsibility to Prepare*, 12.

and underpin critical decisions."[207] ORSA functions include use of "analytic methods and mathematically based procedures to enable leadership decisions in a constantly changing global environment" and the introduction of "quantitative and qualitative analysis to the military's decisionmaking processes by developing and applying probability models, statistical inference, simulations, optimization and economic models."[208] This makes ORSAs the ideal functional area to be responsible for the method recommended above. However, the ORSA functional area is chronically short and under-utilized in the Army.[209] Since the Second World War, ORSAs have "been critical to the military's operational and institutional success."[210] However, more recent "changes to the ORSA career field and a migration of the specialty from the operational Army to the institutional Army have reduced ORSAs' opportunities to directly support the operational commander."[211] Despite the Army's ORSA community being "one of the largest organizations of ORSAs in the world…there has been little if any doctrine development on the strategic, operational, or tactical use of [ORSA] personnel."[212] The Army needs more ORSAs and more of them assigned to at least division level within the operational force. This would ensure ORSAs could exercise effective responsibility for the tools and methods used to anticipate the effects of fresh water scarcity. It would also ensure the information and analysis resulting from the use of those tools and methods gets to operational units and planners. ORSAs should be able to work cooperatively with other members of the joint analytical community and with other functional areas at any assigned level to offer direct support to

[207] US Department of the Army, Department of the Army Pamphlet (DA PAM) 600-3, *Commissioned Officer Professional Development and Career Management* (Washington, DC: Government Printing Office, 2010), 286.

[208] Ibid.

[209] US Army, DA PAM 600-3, (2010), 49.

[210] David F. Melcher and John G. Ferrari, "A View from the FA49 Foxhole: Operational Research and Systems Analysis," *Military Review* 84, no. 6 (November-December 2004): 2.

[211] Ibid.

[212] Jeffrey Libby, "Deployed Analyst Handbook" (PowerPoint presentation, Military Operations Research Society Symposium, Annapolis, MD, June 12-14, 2007).

operational planners and commanders by providing "joint and fully staffed analytical products."[213] The Army should develop doctrine that covers the appropriate strategic, operational, and tactical uses of ORSAs to enable that direct support.

Conclusion

A variety of factors contribute to global fresh water scarcity, which drives negative economic and social effects and magnifies the risk of conflict or adversarial use of fresh water in ways that may affect US Army operations. Although recognition of the problem of fresh water scarcity is increasing in all sectors, very little doctrine and few effective methods exist within the Army to anticipate its effects accurately. Therefore, the Army must do more to identify and evaluate how fresh water scarcity will affect the future OE and operations. Current anticipatory practices are either too linear to be accurate for the complex environments and systems facing the military, do not address the problem of water scarcity specifically, or appear promising but are not widely used by military practitioners. The recommended course of action to address these shortfalls in current practice is to assign responsibility within the ORSA functional area for the management, use, and analysis of the output of non-linear predictive tools and complex systems modeling.

In 2018, the Climate and Security Advisory Group stressed that "given the threats of climate change identified by our nation's defense, national security and intelligence communities, a rise in destructive climate-driven impacts on the United States, and our increased capacity to foresee these risks, our government has a 'Responsibility to Prepare' to meet future challenges."[214] Similarly, the US Army and its operational planners have a responsibility to prepare to meet the future challenge of fresh water scarcity by leveraging the full range of capabilities available within the military, government, and civilian sectors to anticipate, as accurately as possible, how fresh water scarcity will affect the future OE. As

[213] Melcher and Ferrari, 6.

[214] *A Responsibility to Prepare*, 9.

global fresh water scarcity increases, neglect of the responsibility to prepare for its effects will potentially imperil operational success.

Bibliography

A Responsibility to Prepare: Strengthening National and Homeland Security in the Face of a Changing Climate: Roadmap and Recommendations for the US Government. Washington, DC: The Climate and Security Advisory Group, 2018.

Busby, Joshua. *Water and US National Security*. New York: US Council on Foreign Relations, 2017.

Cole, Beth Ellen et al. *Preserving Stability Amidst Regional Conflagration: US Engagement in Jordan 2011 to 2016*. Washington, DC: United States Institute of Peace, 2017.

Connaughton, Richard. *The Battle for Manila*. Novato, CA: Presidio Press, 1997.

Coping with Water Scarcity: Challenge of the Twenty-First Century. Geneva: United Nations-Water, 2007.

Eng, Michael and Ma Jun. *Building Sustainable Solutions to Water: Conflicts in the United States and China*. Washington, DC: Woodrow Wilson International Center for Scholars, 2006.

Falkenmark, Malin. *On the Verge of a New Water Scarcity: A Call for Good Governance and Human Ingenuity*. Stockholm: Stockholm International Water Institute, 2007.

Fröhlich, Christiane and Ulrich Ratsch. "Water Scarcity and Violent Conflict." In *Global Change: Enough water for all?* edited by José L. Lozán et al., 240-243. Hamburg: Wissenschaftliche Auswertungen, 2007.

Gleick, Peter H. "Water Conflict Chronology List." *Pacific Institute for Studies in Development, Environment, and Security*. 2017. Accessed April 9, 2018. http://www2.worldwater.org/conflict/list/.

The Global Risks Report 2017: 12th Edition. Geneva: World Economic Forum, 2017.

Global Trends: Paradox of Progress. Washington, DC: US National Intelligence Council, 2017.

Global Water Security: Intelligence Community Assessment 2012-08. Washington, DC: US Office of the Director of National Intelligence, 2012.

Joint Strategic Plan: FY 2018-2022, Washington, DC: US Department of State and US Agency for International Development, 2018.

Kenney, Carolyn. *Climate Change, Water Security, and U.S. National Security*. Washington, DC: Center for American Progress, 2017.

La Shier, Brian and James Stanish. "Issue Brief: The National Security Impacts of Climate Change." *Environmental and Energy Study Institute*, December 20, 2017. Accessed April 12, 2018. http://www.eesi.org/papers/view/issue-brief-the-national-security-impacts-of-climate-change.

Libby, Jeffrey. "Deployed Analyst Handbook." PowerPoint presentation, Military Operations Research Society Symposium, Annapolis, MD, June 12-14, 2007.

Lorenz, Frederick, and Edward J. Erickson. *Strategic Water: Iraq and Security Planning in the Euphrates-Tigris Basin*. Quantico, VA: Marine Corps University Press, 2014.

Mekonnen, Mesfin M., and Arjen Y. Hoekstra. "Four Billion People Facing Severe Water Scarcity." *Science Advances* 2, no. 2 (February 2016): 1.

Melcher, David F. and John G. Ferrari. "A View from the FA49 Foxhole: Operational Research and Systems Analysis." *Military Review* 84, no. 6 (November-December 2004): 2-6.

National Security Implications of Climate-Related Risks and a Changing Climate. Washington, DC: US Department of Defense, 2015.

Pedraza, Lisdey Espinoza and Markus Heinrich. "Water Scarcity: Cooperation or Conflict in the Middle East and North Africa?" *Foreign Policy Journal*, September 2, 2016. Accessed April 8, 2018. https://www.foreignpolicyjournal.com/2016/09/02/water-scarcity-cooperation-or-conflict-in-the-middle-east-and-north-africa/.

Proceedings of the Defense Science Study Group 30th Anniversary Symposium. Alexandria, VA: Institute for Defense Analyses, 2016.

Ripple, William J. et al. "World Scientists' Warning to Humanity: A Second Notice." *BioScience* 67, no. 12 (December 2017): 1026-1028.

The Role of Water Stress in Instability and Conflict. Arlington, VA: CNA Analysis and Solutions, 2017.

Rüttinger, Lukas et al. *A New Climate for Peace: Taking Action on Climate and Fragility Risks*. Germany: G7, 2015.

"Security Council, in Statement, Says 'Contextual Information' on Possible Security Implications of Climate Change Important When Climate Impacts Drive Conflict." United Nations Security Council, July 20, 2011. Accessed September 27, 2017. http://www.un.org/press/en/2011/sc10332.doc.htm.

The State of the World's Land and Water Resources for Food and Agriculture: Managing Systems at Risk. New York: Food and Agriculture Organization of the United Nations and Earthscan, 2011.

Stockholm International Water Institute. *The Water Report 2016*. Edited by Torkil Jønch Clausen et al. Stockholm: Torgny Holmgren, 2016.

US Congress. House. Senator Paul Simon Water for the World Act of 2014. H. Res. 2901. 113th Cong. *Congressional Record* 160, daily ed. (December 19, 2014): Public Law 113–289.

US Department of Defense, Joint Staff, Joint Publication (JP) 3-06, *Joint Urban Operations*. Washington, DC: Government Printing Office, 2013.

_____, Joint Publication (JP) 3-24, *Counterinsurgency*. Washington, DC: Government Printing Office, 2013.

_____, Joint Publication (JP) 3-57, *Civil-Military Operations*. Washington, DC: Government Printing Office, 2013.

US Department of Defense. *Quadrennial Defense Review 2014*. 2014.

US Department of the Army, Army Doctrine Reference Publication (ADRP) 3-07, *Stability*. Washington, DC: Government Printing Office, 2012.

_____, Army Doctrine Reference Publication (ADRP) 3-90, *Offense and Defense*. Washington, DC: Government Printing Office, 2012.

_____, Army Techniques Publication (ATP) 2-01.3, *Intelligence Preparation of the Battlefield*. Washington, DC: Government Printing Office, 2014.

_____, Army Techniques Publication (ATP) 3-34.5, *Environmental Considerations*. Washington, DC: Government Printing Office, 2015.

_____, Department of the Army Pamphlet (DA PAM) 600-3, *Commissioned Officer Professional Development and Career Management*. Washington, DC: Government Printing Office, 2010.

_____, Field Manual (FM) 3-0, *Operations*. Washington, DC: Government Printing Office, 2008.

_____, Field Manual (FM) 3-0, *Operations*. Washington, DC: Government Printing Office, 2017.

_____, Field Manual (FM) 3-06, *Urban Operations*. Washington, DC: Government Printing Office, 2006.

_____, Field Manual (FM) 3-07, *Stability Operations*. Washington, DC: Government Printing Office, 2008.

_____, Field Manual (FM) 3-24.2, *Tactics in Counterinsurgency*. Washington, DC: Government Printing Office, 2009.

_____, Field Manual (FM) 3-90-1, *Offense and Defense Volume I*. Washington, DC: Government Printing Office, 2015.

_____, Field Manual (FM) 34-130, *Intelligence Preparation of the Battlefield*. Washington, DC: Government Printing Office, 1994.

_____, Field Manual (FM) 7-100.1, *Opposing Force Operations*. Washington, DC: Government Printing Office, 2004.

_____, Field Manual (FM) 90-3, *Desert Operations*. Washington, DC: Government Printing Office, 1993.

_____, Training Circular (TC) 2-91.4, *Intelligence Support to Urban Operations*. Washington, DC: Government Printing Office, 2015.

_____, Training Circular (TC) 7-100.2, *Opposing Force Tactics*. Washington, DC: Government Printing Office, 2011.

van der Heijden, Kitty; Betsy Otto; and Andrew Maddocks. “Beyond Conflict, Water Stress Contributed to Europe’s Migration Crisis.” World Resources Institute, November 3, 2015. Accessed March 2, 2018. http://www.wri.org/blog/2015/11/beyond-conflict-water-stress-contributed-europe’s-migration-crisis.

Water Stress. Rome: Food and Agriculture Organization of the United Nations, 2014.