DEFENSE DOSSIER

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FROM THE EDITORS

Welcome to the December 2018 edition of AFPC's *Defense Dossier* e-journal. In this issue, we focus on the importance of resource security and changing global environmental conditions – both topics which have a real and pronounced impact on foreign policy and international security.

The articles in these pages discuss a multitude of cutting edge topics, from how environmental changes are presenting new challenges for the U.S. military to how terrorists have begun to harness food supplies as a weapon. We also delve into the topic of American energy security, and look ahead with some strategic planning for new crises and threats that could be brought about by the changing global climate.

As always, we hope that you find the analysis in the pages that follow both useful and timely. We wish you and yours a very happy holiday season!

Sincerely,

Ilan Berman
Chief Editor

Richard M. Harrison
Managing Editor

Climate Change and the U.S. Military

Rachel Fleishman and Sherri Goodman

The U.S. faces an array of geostrategic risks more complex and volatile than at any time since the Cold War. As the 2018 *National Defense Strategy* asserts, "(b)oth revisionist powers and rogue regimes are competing across all dimensions of power. They have increased efforts short of armed conflict by expanding coercion to new fronts, violating principles of sovereignty, exploiting ambiguity, and deliberately blurring the lines between civil and military goals."[1]

This risk picture could usefully be portrayed as a series of maps, superimposed upon one another like so many sheets of translucent paper.

■ The base map comprises population centers and the traditional array of national economic, natural and military assets. Competitive dynamics in this layer revolve around ensuring access to energy and resources and protecting citizens and borders.

■ The next layer adds inter-state alliances. Such alliances have historical geopolitical roots but shift in response to emergent interests or threats.

■ A third map overlays resources at risk of depletion or over-use. These include essential fresh water, arable land, fish, forests and energy sources – many of which do not fall neatly within national boundaries. Finite and increasingly sought-after minerals like cadmium for batteries, and rare earth minerals used in phones, computers, and weapons systems, also belong here.

■ The next layer intersperses politicized ethnic and cultural groups as well as emerging sub-national and trans-national interest groups. Modern technology puts knowledge, but also potential destructive power, in the hands of all, and the actions of one group can have unintended consequences on others.

Layers can be added to the list above, but the logic remains the same. Each map is a system with what has been assumed to be predictable actors and interactions. All have one thing in common: the risk in each system is amplified by climate change. Extreme weather, floods, fires, storms and associated climate impacts puncture the map, tearing every layer. Life and property are lost. Resources are stressed or depleted. Economically or politically vulnerable sub-groups are further weakened. Governance structures are tested. When these stresses crescendo into fragility and conflict, leaders and elected officials often turn to the military.

Bracing for Crisis

As the U.S. defense establishment contemplates how climate affects the global risk map, five dynamics emerge. Climatic change induces massive natural disasters; it threatens essential resources and resource regimes; it becomes a catalyst for conflict; it gives rise to "black swan" events with cascading systems effects; and it acts as a drag on U.S. military preparedness and readiness. More detailed analysis of many of the underlying threats can be found in the recent *Epicenters* report published by the Center for Climate and Security.[2]

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Disaster Response

The most direct threat to the base map of national populations and assets is extreme weather. As climate change increases the scale of natural disasters, the U.S. military response is Humanitarian Assistance/Disaster Relief (HA/DR).

The U.S. armed forces are at the forefront of disaster response, both at home and abroad. Following last year's hurricanes in Texas and Louisiana, the Army deployed over 16,000 troops from 23 states.[3] More often, however, HA/DR is a public service offered to allies and nations in need. This year, for example, U.S. Marines spent four months in Guatemala, building temporary shelters and facilities for food, hygiene and medical treatment for those affected when the Fuego volcano erupted in June. And two Navy ships, the *Mercy* and the *Comfort*, have been serving as floating hospitals in the Indo-Pacific and Caribbean region, respectively, for years. Together they have treated hundreds of thousands of patients and supported numerous exercises with American allies.

Threats to essential resources & resource regimes

The resource map is also at risk. Stable resources, meted out by formal or informal governance regimes, are elemental for populations to thrive. Climate events that deplete resources or disrupt their distribution can confound the social structures that depend on them. Whether and how such disruptions devolve into security threats depends on a host of factors.

For example, a study on the uprisings in Syria and Egypt found that one potential antecedent for the Syrian war was an extreme drought from 2006-2010.[4] Exacerbated by climate change and general natural resource mismanagement, the drought precipitated food shortages and a massive rural-to-urban migration. These factors combined with political unrest contributed to social breakdown and ultimately civil war. Contrast this with India, where multi-year drought has been linked to widespread farmer suicide – a social tragedy that has not, as of yet, devolved into a national security threat. A study published last year found farmer suicides rise and fall with the temperature, and suggested a link between climate change and more than 59,000 suicides in the Indian agricultural sector over the past 30 years.[5]

> Scarce essential resources can also be used coercively, as weapons. A prime example is the weaponization of water in the Middle East.

Scarce essential resources can also be used coercively, as weapons. A prime example is the weaponization of water in the Middle East. Recent research has revealed 44 such incidents between 2010-2015, of which the Islamic State was responsible for 21.[6] These ranged from wresting control of the Mosul Dam on the Tigris River and threatening to flood Baghdad in 2014 (which prompted a battle with Iraqi, Kurdish and U.S. forces) to diverting rivers to halt the advance of Iraqi troops. Such manipulation can have severe collateral effects on neighboring populations, increasing their vulnerability to both manipulation and climate change.

Of particular concern going forward is the Hindu Kush Himalayan (HKH) region, the source of ten major Asian river systems which provide water to 1.9 billion people across 16 countries. A meta study based on previously unpublished data[7] highlights threats ranging from gaps in information and data sharing to competition between riparian neighbors. Climate effects will exacerbate these tensions. Strong multinational

governance mechanisms will be critical to ensuring that water is distributed equitably, and disagreements do not escalate into armed conflict.[8]

Climate Change as catalyst for instability and conflict

The U.S. military has long recognized that climate change can be a catalyst for conflict – potentially upsetting relations among traditional actors at the political layer of the risk map. Nowhere is this more true than in the changing Arctic, where a whole new region has opened up in recent years, and which is now rife with geopolitical tension as Russia militarizes its portion of the Arctic and China expands its reach and influence through the Polar Silk Road.

Russia, with the longest Arctic coastline of any nation, now envisions the Northern Sea Route, made more accessible in recent years from climate change, as a "toll road" across the Arctic, offering shorter shipping times for Asian nations, from China to Korea to Singapore. Russia has also deployed more military capabilities to the region in recent years, increasing the risk of direct confrontation with other Arctic states or the sort of "hybrid" conflict that it harnessed against Ukraine beginning in 2014.

China, too, has strategic ambitions throughout the Arctic, including the creation of trade routes via the Polar Silk Road; expanding foreign direct investment in Arctic states; and strategically deploying scientific research. China recognizes that the impacts of climate change on the Arctic will become domestic problems in the near future. As one researcher has noted, "China's coastlines will flood in the next century due to the melting of Arctic ice, which will force the relocation of up to 20 million people, not to mention reduce agricultural production."[9] China also seeks to take advantage of shorter shipping routes to Europe, exploit vast energy and mineral resources across the Arctic, and expand its global influence through foreign direct investment in Iceland, Greenland and numerous other nations.

The changing geopolitics of the Arctic are made possible by retreating sea ice, warmer temperatures, and collapsing permafrost, which have transformed the Arctic region in recent years.

Not only is the Arctic changing rapidly as a result of climate change, small island states around the world, from the Pacific to the Caribbean, also face rising risks from rising sea levels and stronger storms. Numerous small Pacific island nations, from the Maldives to Vanatu, face an existential choice about whether to relocate or risk being overrun in the next major storm. In the meantime, they face a difficult decision regarding accepting massive Chinese or other foreign direct investment to transform their low-lying nations into walled island fortresses, which may extend their viability for an uncertain future – but perhaps do so at the expense of their sovereignty.

In addition, many major coast cities from Miami to Guangzhou, also face a future of stronger and more intense storms from warmer ocean temperatures putting much of their human, natural and built infrastructure at risk.

Black swan events and systems responses

Much has been written about "black swans": events that are unprecedented or unexpected when they occur but are later recognized as logical outcomes of a complex system. With the advent of climate change, black swans have become frequent flyers – with ripple effects at multiple layers of the risk map.

At the macro level, climate change itself is a black swan, because it threatens the implicit bargain upon which the nation-state system is built. Populations "hire," and grant legitimacy to, governments to assure basic food, water, transport, energy, and governance systems. Governments which cannot assure these systems risk the prospect of descent into a more fragile state. By its very nature, climate change makes a government's job harder by disrupting such systems – often, multiple systems at once –thereby risking both population well-being and state stability.

One example is health. Both the U.S. and the UN recognize the spread of pathogens and infectious disease as a security risk. This risk became reality in the United States last year as the Zika virus spread to areas not previously prone to insect-borne disease, such as Texas, Florida and the U.S. Gulf Coast. A warming world will

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magnify the transmission of infectious disease in at least four ways: by speeding the spread of disease; exacerbating existing humanitarian, refugee and conflict scenarios; subjecting defense forces in new or augmented ways; and by inducing further black swan events.[10]

It's a drag: the climate's effect on military readiness

The primary objective of U.S. military forces is to protect the homeland and, in the words of the *National Defense Strategy*, "advance an international order that is most conducive to our security and prosperity."[11] Accomplishing this objective requires readiness: the ability to project not only military force, but other military-enabled capabilities, anywhere on the globe on short notice. The prerequisites of readiness, however, are also vulnerable to climate stress.

Military installations are essentially small cities. Floods, droughts and storms which disable cities can similarly impact military bases. A 2018 Defense Department report estimates that nearly 1,700 U.S. military bases are at risk from climate change.[12] Reinforcing airstrips, ports, and water and energy systems will cost billions. This does not factor in upgrading essential equipment, from ships and planes to personal body protection, to perform in unfavorable weather.

Other major threats to military readiness from climate change include sea level rise and hurricanes, wildfires and extreme heat. The growing intensity of Atlantic hurricanes, including Harvey, Irma and Maria in 2017 and Florence and Michael in 2018, put numerous military bases in their cross-hairs, and caused major damage at bases such as Florida's Tyndall Air Force Base and Camp LeJeune, North Carolina. This state of affairs isn't just a product of catastrophic weather. Warmer ocean temperatures bring more intense storms, combined with sea level rise and coastal erosion to the U.S. Atlantic coast. Many military installations, including in Norfolk Virginia, already experience regular sunny day flooding.

Moreover, military forces support local first responders to U.S. natural disasters, such as the hurricanes of 2017 and 2018, slowing the flow of forces into other theaters of operations, such as Afghanistan. And climate fueled storms and droughts across the globe now compel the deployment of military forces for HA/DR missions from the Pacific to Africa.

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Hostile Environment

Climate change significantly complicates the geostrategic risk map facing the United States. Extreme weather threatens the physical health, safety and well-being of both military personnel and the people they serve. Climate impacts can likewise be a catalyst for conflict in fragile regions, providing openings for strategic competitors to displace American security relationships.

For the military itself, climate stress places growing demands on military forces even as it weakens the force's ability to respond. With increasingly severe climate impacts in the forecast, the U.S. military can and should

leverage big-data analytics and predictive modeling to pinpoint and begin hedging outstanding risks. Such analysis can both bolster operational resilience and provide the basis for coordinated action with other U.S. agencies and allies – essential steps to building international climate security. ■

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Renewables: Bridging the U.S. Energy Security Gap

James Grant

For the world's number one consumer of crude oil and second-largest user of electricity, energy *is* security. The United States requires access to consistent, reliable, and affordable energy resources to guarantee the operation of its military, the functioning of its economy, and the livelihood of its citizens.

But access to dependable energy supplies is not guaranteed. The intricate systems we rely on to acquire, transport, process, and distribute energy are as complex as they are fragile. So long as energy resources need to move from point A to point B, disruption risks will persist. Yet certain measures can be taken to improve the resilience of America's energy network. This includes reducing the probability of disruption events and simultaneously increasing the system's overall capacity to withstand and recover from such disruptions once they occur. Renewable energy resources, if integrated properly, effectively address both. But they must be pursued in tandem with other basic energy security principles, such as: diversifying energy fuels, sources and routes; encouraging indigenous sources of energy supply; safeguarding energy supply routes and distribution networks; enhancing energy efficiency in demand and supply; promoting investment, research, and deployment, of sustainable energy technologies

Assets and Liabilities

Today, the energy we use is overwhelmingly generated through the combustion of fossil fuels. From the diesel in our trucks to the lights in our homes, 68% of the power consumed in the United States today (what is considered "primary energy") comes from hydrocarbons – coal, natural gas, and oil.[1] The reasons for this are manifold: fossil fuels are generally reliable, affordable, abundant, easy to store/transport, and are energy dense (high energy per volume mass).

When it comes to the abundance of hydrocarbons, the United States is particularly well endowed. We possess close to 40 billion barrels of proven oil reserves and 465 trillion cubic feet (tcf) of natural gas (2017 measurements).[2] And due to technological breakthroughs in exploration and extraction technology, reserves of both sources are actually *increasing* every year, and have done so since 2005 despite prolific consumption. Domestic oil and gas reserves are up 20% and 36%, respectively, just since 2016. To put these reserves in perspective, the world consumes approximately 100 million barrels of oil and .36 tcf of natural gas per day. This means that U.S. supplies alone could meet the world's gas demand for almost half a decade – and its oil needs for over a year.

In late November 2018, the United States actually exported more crude oil and petroleum products than it imported for the first time since 1991.[3] While our status as a "net exporter" was short lived (lasting just one week), the occurrence is part of a longer-term trend of declining fossil fuel imports. Skyrocketing oil and gas production from America's massive shale reserves, combined with plateauing domestic demand and the lifting of the national crude oil export ban in 2015, are all contributing factors.

But while growing exports and reduced dependence on foreign suppliers have certainly bolstered the U.S. energy security position, we are not nearly as secure as we believe. The United States still consumes some 20 million barrels of oil – one third of it imported – and 0.09 tcf of gas per day, more than any other country on earth. And despite our massive reserves, persistent bottlenecks in domestic midstream infrastructure limit the amount of this energy to which we actually have access.

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Those touting an age of American "energy independence" or "energy dominance" do a disservice by downplaying the liabilities attached to fossil fuel dependence. Claims of energy dominance can breed complacency, giving U.S. policymakers an unrealistic (and therefore dangerous) perception of our long-term energy security position. Energy security is about much more than just reserves and production.

Our energy supply chains – particularly those relating to fossil fuels – are long and susceptible to numerous points of failure. Reliance on foreign governments and price volatility in the global marketplace are among the greatest threats. Catastrophic weather events, the closure of trade routes/energy choke-points, limited capacity of critical infrastructure, and direct attacks (kinetic or cyber) add yet more risks to America's vast fuel needs. To mitigate such dangers, the United States must embrace alternative "point of use" fuels with the ability to shrink supply lines and offer improved resilience in the face of conventional supply interruptions.

Energy and the U.S. Military

To achieve operational military successes, the Department of Defense (DoD) relies on one mission-critical resource: energy. It is no surprise, then, that the Defense Department is the single largest institutional consumer of energy in the world. In FY 2017, the DoD consumed over 85 million barrels of fuel to power ships, aircraft, combat vehicles, and contingency bases, and did so at a cost of roughly $8.2 billion. [4] The U.S. Air Force – the most prolific energy consumer of the military's service branches – burns through an estimated 2.5 billion gallons of jet fuel each year. Indeed, petroleum-based liquid fuels account for approximately two-thirds of DoD energy use.[5]

Approximately 30% of DoD energy consumption is dedicated to powering its 500 fixed installations (300,000 buildings) across the world.[6] These installations – the backbone of American military readiness – support the maintenance and deployment of weapons systems and the training and mobilization of combat forces. They also provide direct support for combat operations and serve as staging platforms for humanitarian and homeland defense missions. But defense facilities on American soil are not self-powered. They depend on the U.S. electric grid for their electricity leaving them vulnerable to the same outage risks as everyday residential and commercial buildings. Installations located overseas similarly depend on the commercial grid of their host nation.

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Some of these facilities, however, do not enjoy the luxury of grid connectivity. Forward operating bases located in hostile and/or remote regions use diesel powered generators to meet their electricity needs. In addition to generators, diesel also powers the *entirety* of army tactical vehicles on the battlefield – a conscious decision made to optimize fuel supplies during combat operations. It also necessitates constant refueling trips by ground resupply convoys in the theater of operations. This represents a point of vulnerability; as the Army's Operational Energy Policy report notes, since 2009 more than 3,000 service members and contractors had been killed or wounded defending these convoys in Afghanistan and Iraq.[7] Reliance on liquid fuel is therefore more than a constraint

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Secretary of Defense James Mattis refers to the military's dependence on liquid-petroleum based fuels as "The Tether of Fuel," because it restricts freedom of movement for our military.[8] Forward deployed forces and remote, generator-powered installations subsequently become the end of a long "logistics tail" which ties assets all the way back to their port of entry. Logistics areas located along this tail are vulnerable to physical attack, as are their distribution networks. Reducing our reliance on a fuel source that logisticians must transport across the battlefield increases combat capabilities, lowers costs, and saves lives.

The U.S. military acknowledges this weakness, and is taking steps to improve its energy resilience through renewable energy. In accordance with the DoD mandate enshrined in Title 10 USC §2911 (a product of the *Energy Independence and Security Act of 2007* and the *National Defense Authorization Act of 2010*), at least 25% of any DoD facility energy consumption must come from renewable energy sources by 2025. The military has also requisitioned the deployment of three gigawatts (GW) of renewable energy to power military facilities before the 2025 deadline. The Navy's Great Green Fleet, a carrier strike group which runs on biofuel blends and the latest energy conservation technologies, is another indication of the DoD's growing dedication to fuel diversification and energy resilience. And for good reason.

Renewable Energy: Inherently Secure

Renewable energy resources are those which replenish rapidly through natural processes. Solar photovoltaic (PV) and wind power are among the most prevalent of these renewable fuels. When considering the primary threats to energy (and more specifically electricity) supply, it is clear that these sources of generation offer a number of advantages over conventional liquid petroleum fuels.

Energy supply threats fall into two broad categories: man-made (price spikes, supply route closure, embargo, cyber-attack, physical attack, human error) and natural (severe weather events including floods, earthquakes, hurricanes, blizzards, tsunamis, solar flares). The inherent characteristics[9] of renewables make them resilience boosters wherever they are deployed. The U.S. electric grid, foreign-based military installations, and forward operating bases all stand to benefit from the security advantages that renewable resources provide. These include, but are not limited to:

> Renewable energy sources are not dependent on global marketplaces subject to volatile price spikes, or unexpected changes to fuel availability. This insulates end-users from perhaps the most prolific threat to America's energy security.

Zero-cost inexhaustible fuel. Renewable electricity relies on free and self-replenishing sources of fuel, such as sunlight, wind, geothermal heat, and the kinetic force of flowing water. While these fuel sources do suffer from intermittency and variability issues, output is steady over annual periods, and advanced modeling can accurately predict their availability. When paired with adequate storage technology, the intermittency issue is mitigated significantly.

Autonomy from global markets. Renewable energy sources are not dependent on global marketplaces subject

to volatile price spikes, or unexpected changes to fuel availability. This insulates end-users from perhaps the most prolific threat to America's energy security.

Microgrids: decentralized power generation. Large centralized power facilities present an important national security vulnerability. Not only are they costly and laborious to construct, the failure of one centralized power station could have cascading effects across concurrent grids. Renewable energy, by contrast, can be economically deployed in much smaller self-sustaining units known as "microgrids" – local energy grids with their own control capability. Powered by self-replenishing natural sources, they are able to function independent of the larger energy network in times of emergency (a feature known as "islandability"). Rooftop solar, for example, can be installed on military bases, homes and commercial buildings where it is either consumed or fed back into the grid. Utility-scale wind and solar can be economically built in electrical capacities, varying from one megawatt (MW) to over a gigawatt (GW).

Rapid Deployment. Renewable energy can be built and deployed far more quickly than traditional fossil fuel generation. From initial siting and analysis to electricity production, large utility-scale\wind or solar farms (over 250 MW) are typically constructed and brought online within one to three years. Smaller-scale 500 -kilowatt (kW) rooftop solar project can be completed in a matter of months. Coal, gas, and nuclear generation, on the other hand, usually take many years to construct, sometimes more than a decade. And generators, while mobile, are only as good as their fuel reserves (and highly inefficient to boot).

Point of Use availability. Localized renewable energy resources such as rooftop solar or small wind turbines (under 1 MW) allow for end-use demand to be met directly on site without need for transmission lines or resupply convoys. The general abundance of wind and sunlight across the globe means that there is almost always a potential to harvest these resources "on site." The Middle East and Africa (in particular Libya, Niger, Nigeria, Uganda, Mali, Somalia) are areas where the U.S. military is operationally active, and do not lack for sunlight or wind.

A Necessary Transition

For the foreseeable future, hydrocarbons will continue to dominate America's energy profile. Fossil fuels are cheap, abundant, and inextricably linked to the economy and our way of life. The U.S. armed forces, too, are locked into petroleum-based products for decades to come, since most military equipment runs on fossil fuels. Until we can gain access to a reliable, proven, and plentiful supply of alternative energy that can provide tactical vehicles with power on demand, reliance on fossil fuels like diesel will persist. We are still decades removed from battery powered tanks or solar powered fighter aircraft.

But for both operational efficiency and practical use, the military should continue investing in alternative energy technologies. Free and infinite fuel, insulation from market shocks, short supply lines, rapid deployment capability, and the potential for grid decentralization make renewables an attractive supplement to fossil fuels – particularly for base electrification.

Hydrocarbons, while a tremendous and abundant resource, cannot by themselves guarantee the energy security of the United States. Alternative fuels must soon become a conventional aspect of U.S. energy policy. Our national security depends on it. ■

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How Israel Can Help Alleviate the Global Water Crisis

Avi Jorisch

As people everywhere turn on their taps, most are not aware that by 2025, at least half the globe's population of 7.6 billion is expected to be living in water-stressed areas.[1] And according to the World Health Organization, as of 2017, over two billion people in the world lack access to safe drinking water.[2]

What is the reason for this looming water crisis? According to the World Resources Institute, a global non-profit that focuses on sustainable development, the crisis is the result of seven problems: climate change and its effects on a region's aridity, water demand, depleted groundwater, water waste, poor water infrastructure, lack of healthy ecosystems, and the price of water for investors and the general public.[3]

But there is one country that has solved its own water problem and has expertise to share with others. That country is Israel, and it is today what is perhaps the world's only water superpower.

The Road to Hydrological Independence

Israel is no longer reliant on the weather or its neighbors for its water needs. It achieved this by combining all available technologies to save as much water as possible. While the country is 60 percent desert, in 2013 it announced it had achieved water independence through smart planning and innovative thinking: desalinizing sea water, reusing treated sewage for agriculture, creating software that warns authorities about leaks, implementing drip irrigation techniques, and accounting for every drop of water. Some of the techniques Israel uses today were developed at home; others abroad.

Desalination: In 2018, Israel's fifth desalinization plant went online.[4] Collectively, the country's desalinization plants provide about 600 million cubic meters of water annually, which represents approximately 55 percent of Israel's domestic water supply. Experts expect that desalination plants will provide 70 percent of Israel's drinking water by 2050.[5] Much of the credit for the plants goes to IDE Technologies, an Israeli desalinization company established in 1965, which has built 400 plants in 40 countries over the last four decades. This technology was originally developed in the United States by Sidney Loeb in the early 1960s and perfected after Loeb moved to Israel in 1967.

Waste Water Recycling: Israel purifies almost 90 percent of its waste water and uses it in irrigation — four times more than any other country.[6] Spain, which ranks second in the world, recycles only about 20 percent, while the United States recycles less than 10 percent. In other words, human waste is now potentially extraordinarily valuable. Israel's recycled waste water is predominantly used for agricultural irrigation. Approximately 10 percent is used for environmental purposes, such as increasing river flow volume and fire suppression, and only five percent is discharged into the ocean. The emerging field of reclaimed water has created vast new business and economic opportunities for Israel. For example, Aqwise, which is active in over 20 countries, has become a global leader in the field, with over 150 installations around the world.

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> The entire Middle East is headed towards massive water shortages, which in some places will likely lead to disasters of biblical proportions.

Drip Irrigation: In the mid-1960's, Israel's Netafim invented the world's first modern drip irrigator, which helps farmers, cooperatives and governments conserve more water. Netafim is a global powerhouse, with more than 30 percent of the global drip-irrigation market, and sells its products in more than 110 countries. Irrigation is crucial to the global food supply: only 18 percent of the world's farmland is irrigated, and that yields 40 percent of the global food supply.[7] It is estimated that less than four percent of the world's irrigated land is equipped with drip irrigation, so clearly this revolution has a long way to go.

Big Data: In 2008, Amir Peleg created Takadu, a robust platform that marries big data and the cloud to monitor water networks to prevent leaks. Takadu gives cities, municipalities and countries the ability to check water infrastructure and detect leaks and burst pipes, saving millions of gallons of water. This groundbreaking technology is now being adopted by major cities around the world.

Dual-flush toilet: This toilet has two buttons or handles to flush different amounts of water, cutting water usage in half. Originally proposed in 1976 by American industrial designer Victor Papanek, the dual-flush toilet has since become almost universally adopted in Australia, New Zealand, Singapore and Israel.

Pricing: Perhaps above all, the secret of Israel's success in becoming a water superpower is directly tied to charging users the real cost of water and mandating that authorities spend 100 percent of all water and sewage fees on water-related infrastructure maintenance.

An Expanding Challenge

Global policymakers are beginning to wake up to the reality that Israel isn't the only country to have faced a water challenge. The entire Middle East is headed towards massive water shortages, which in some places will likely lead to disasters of biblical proportions. The United Nations predicts that by 2025, Egypt will approach a state of "absolute water crisis."[8] Jordan is also set to run out of potable water in the coming decades. Iranian government officials predict that in less than 25 years, over half the population of Iran will need to be relocated and become effectively water refugees.[9] In Iraq, engineers are warning that the Mosul Dam could collapse at any minute, killing 1.5 million people. The picture looks especially bleak.

Many will be surprised to learn that this trend holds true for the United States as well. Experts predict that

> According to the U.S. Government Accountability Office, over the next 10 years, 40 out of 50 states will have at least one region with a water shortage because of a lack of fresh water in lakes, rivers, reservoirs and aquifers. Over the course of the next four years, at least a third of U.S. households will lack potable water.

by 2022, 42 million Americans will be unable to pay their water bills, as the cost of water increases because of poor infrastructure and an expectation that this resource will be free — or at least, heavily subsidized.[10] In fact, according to the U.S. Government Accountability Office, over the next 10 years, 40 out of 50 states will have at least one region with a water shortage because of a lack of fresh water in lakes, rivers, reservoirs and aquifers. Over the course of the next four years, at least a third of U.S. households will lack potable water.[11]

Americans are also generally unaware that most of their water utility companies either lose money or just break even. Between government subsidies and household water bills, water providers collect just enough revenue to conduct their business and handle ongoing infrastructure

Updating aging infrastructure will cost over $1 trillion over the next 25 years, and that water prices will increase to four times their current levels over the next few decades.

projects. But this reality is changing fast. According to Elizabeth Mack, assistant professor at Michigan State University and author of a recent, forward-thinking study on water,[12] utility companies are now spending approximately 80 percent of their revenue to maintain infrastructure that was built primarily in the 1930s and 1940s. Mack believes that updating aging infrastructure will cost over $1 trillion over the next 25 years, and that water prices will increase to four times their current levels over the next few decades.

U.S. policymakers are already looking to Israel to help solve their domestic problems. In 2012, the Environmental Protection Agency signed a memorandum of understanding with Israel's Ministry of Environmental Protection to cooperate on a number of challenges, including water. Two years later, California signed a memorandum of understanding with Israel to help fight drought. Israel's IDE has now designed and built the Western Hemisphere's largest desalinization plant in Carlsbad, California, a facility capable of producing 54 million gallons of freshwater daily. That same year, Chicago signed a water research agreement with Ben Gurion University to develop solutions for improving water quality in surface and below-surface water, ground water, streams, ponds and lakes. Massachusetts is another state that has embraced Israeli water technology, and hundreds of Israeli water technology startups are domiciled there.

U.S. lawmakers are not the only ones taking note. According to water experts, Israel's water technology is being used in over 150 countries (including some that have no formal ties with the Jewish state). For example, IDE has built the largest desalinization plants in China and India. "Water is one of the biggest challenges humanity is facing," says Oded Distel, director of the Israel NewTech program at the Ministry of Economy and Industry. "Israel's holistic approach can serve as a model to overcome the global water crisis."

Future Horizons

By 2050, the world's population will balloon to roughly 9 billion. The result will likely be a surge in demand for food. In addition, in 15 years, experts say, half of the world's inhabitants could be living in areas where there isn't enough safe water to drink. Both these things mean that the world will need to grow more food with less water. To meet this need, humanity will have to find innovative ways to use existing land and water resources, which are already under heavy stress. "Water isn't just water," says Seth M. Siegel, water expert and author of *Let There Be Water*. "In the case of Israel, it's also an inspiring example of how vision and leadership can change a nation and transform the world."

Israel has figured out a way to leverage technology to improve the lives of billions of people. If the world can put current politics aside and turn over a new leaf, it will certainly look to Israel and its innovators to help effectively address this emerging challenge.■

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Food as a Terrorist Weapon

Chloe Thompson

While food security is often considered primarily a humanitarian issue, access to food is an important part of the complex web of factors that influences national security. Food insecurity places significant stress on communities. Widespread hunger can lead to immediate problems, such as food riots, and more long-term concerns, such as chronic undernourishment of whole populations. Food scarcity can also significantly exacerbate pre-existing tensions within and between states, especially ones involving intra-communal violence.

Food security issues are also prime for exploitation by militant groups, which can take advantage of both scarcity and international assistance for their own gain. By offering nourishment to potential members, these extremist actors can entice people whose families might otherwise starve to their cause. By stealing or blocking humanitarian aid, these groups can enrich themselves – and do so at the expense of the wellbeing of others. Furthermore, militant groups can often win support from local communities by providing nourishment.

Boko Haram provides a telling case in point. Over the past decade, Nigeria's premier Islamist group has significantly worsened the food security situation in that country, while simultaneously taking advantage of the resulting privation for its own gain.

Fertile Soil

In 2017, Nigeria witnessed one of the worst food crises in the world, comparable only to the situations in Somalia, South Sudan and Yemen.[1] Boko Haram has been the primary cause of this crisis, although other factors (such as stagnant economic growth and changes in local climate) have contributed as well. Over the past ten years, the Islamist group has brutally attacked countless small villages throughout northeastern Nigeria, stealing supplies and kidnapping civilians.[2] In response, nearly two million people have fled the region, seeking shelter in the nearby countries of Cameroon, Chad, and Niger.[3] And because the northeast of Nigeria is that country's most productive agricultural area, food production has ground to a virtual halt. Small-scale farmers have abandoned their farms in fear, while herders have taken their remaining animals and fled.[4]

The resulting drop in agricultural production, in turn, has generated food shortages and a sharp rise in the cost of foodstuffs. To compound the issue, many people now fear going to markets and other public gathering places, as Boko Haram often sends suicide bombers into these areas to kill civilians. Consequently, both people left in the northeast and Internally Displaced Persons (IDPs) throughout the nation are heavily reliant on food aid to survive. Even with international support, however, food aid cannot replace a functioning economy and working agriculture. The consequences are dire: the United Nations now ranks Nigeria as one of the world's most significant food crisis spots, with over three million Nigerians facing acute food insecurity in the country's north.[5]

Yet, despite the fact that Boko Haram has been a significant cause of the food crisis in Nigeria, widespread food insecurity has provided the group with a useful line of propaganda. Pervasive corruption and regional tensions have led to widespread distrust of government among the country's population[6] – a crisis of confidence that the group has deftly exploited for its own ends. Moreover, the country's food crisis and economic stress serve as useful recruitment tools, allowing Boko Haram to offer financial incentives to those who join its ranks.[7] And while determining why people join militant groups remains notoriously difficult, a recent study of Nigerian civilians drew a direct correlation between financial factors and extremism in that country.[8]

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A Hostile Environment

The current food crisis plaguing Nigeria remains an unintended side effect of Boko Haram's reign of terror. Indeed, many of the group's own fighters have been caught up in the crisis. In 2016, dozens of malnourished Boko Haram fighters surrendered to the Nigerian military.[9] Their defection was the result of the fact that group had so thoroughly destroyed local infrastructure and food systems that it could no longer support all of its fighters adequately.

> Food insecurity has been the natural result of the collapse of social systems and infrastructure associated with [Boko Haram's] long-running insurgency against the Nigerian state. This state of affairs is part of what makes food security so vital to national security.

Boko Haram, then, did not intentionally cause this crisis, given that it harms the organization itself. Food insecurity, however, has been the natural result of the collapse of social systems and infrastructure associated with the group's long-running insurgency against the Nigerian state. This state of affairs is part of what makes food security so vital to national security. Food systems are rarely the intended target of militancy, but they are a frequent casualty, and their disruption causes significant problems throughout any region.

Despite all this, Boko Haram remains a significant threat to Nigerian security. One of its core advantage is the enormity of the territory in which it operates.[10] Borno State—a major hub for the organization—covers over 22,000 square miles. And while Boko Haram does not control all of this territory, nor is it even active throughout its total expanse, its ability to carry out operations there constitutes a daunting challenge to government forces.

Furthermore, Boko Haram has in recent years pledged allegiance to the Islamic State terrorist group. While this new connection is complex—the fealty pledge and resulting power struggle split Boko Haram into two factions, Boko Haram and Islamic State West Africa Province (ISWAP)—it has also opened the group to greater interaction with the wider *jihadist* world, including through the Islamic State's formidable communication networks.

Looking Ahead

Addressing the challenge of food insecurity in Nigeria is daunting, in light of this complex strategic environment. Compounding the problem is the issue is endemic corruption within the Nigerian government. In 2017, the Nigerian government admitted that as much as half of the food aid meant for Boko Haram victims had been "diverted" – a turn of phrase that experts have suggested is a euphemism for theft on a grand scale.[11] Because eight-and-a-half million people in the country's northeast are in serious need of aid,[12] such corruption undermines confidence in the national government and significantly curtails the international community's ability to render assistance.

> Boko Haram victims had been "diverted" – a turn of phrase that experts have suggested is a euphemism for theft on a grand scale. Because eight-and-a-half million people in the country's northeast are in serious need of aid, such corruption undermines confidence in the national government and significantly curtails the international community's ability to render assistance.

At its core, food insecurity is caused by a complex web of factors. In response, the World Food Programme offers two kinds of food relief: food aid and food assistance. Food aid involves the direct delivery of rations to hungry people, while food assistance usually involves cash transfers (to be used by the recipients for nourishment).[13] The former approach can create dependency, if it is not coupled with investments in more stable local infrastructure. The latter, by contrast, empowers local populations to make their own decisions about what to eat and how to spend money in their communities.

Northeastern Nigeria may not currently be ready for such investments, however. While Boko Haram and ISWAP remain active, there is a limit to how effective any forward-thinking assistance can be. Preventing the civilian population from starving to death is the more important and immediate task. But the international community will need to refocus northeastern Nigeria when the conflict with Boko Haram and ISWAP eventually begins to die down – and it will need to make serious investments in local economies and agricultural systems that have been profoundly damaged in this conflict. Only in this way will Nigeria move beyond its current cycle of hunger and extremism. ■

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Significant Security Threats from Climate Change on the Horizon

Francesco Femia and Caitlin E. Werrell

On October 8, 2018, representatives of the world's governments met in South Korea to approve the final text of a special report from the Intergovernmental Panel on Climate Change (IPCC). That study examines the differences between the impacts of a further rise of global temperatures of between 1.5°Celsius/2.7° Fahrenheit to 2° Celsius/3.4° Fahrenheit above pre-industrial levels. The backdrop for the report is a world that has warmed by 1°C/1.8°F in the last 115 years, and is already contending with significant climate-driven security challenges. These security risks will be amplified significantly by the rise in world temperatures projected in the report.

Implications for Security

Although the report does not explicitly focus on the security dimension of climate change, this latest assessment is important for understanding how changes in the environment will shape existing threats – and for mapping the security dimensions of the steps that governments may take to limit climate change. Below are six of the study's main takeaways, from a national security and defense perspective.

1. We are already facing security challenges driven by climate change, and the 1.5°C and 2°C worlds will magnify those risks significantly. Climate change-exacerbated droughts, sea level rise and extreme storms are already contributing to instability and conflict in key regions, and impacting the readiness of U.S. military forces. The IPCC report is based on the premise that while the international community has largely been focused on keeping temperature increases below 2°C/3.4°F, long defined as the climate "guard rail" to avoid runaway climate change, even lower warming scenarios are likely to have significant implications.

2. Unstable regions will face even greater challenges under these scenarios, and we have already seen that these local risks have global security implications. The report found that "regions at disproportionately higher risk include Arctic ecosystems, dryland regions, small-island developing states, and least developed countries," and that within these locations, impacts would be felt most by "disadvantaged and vulnerable populations, some indigenous peoples, and local communities dependent on agricultural or coastal livelihoods." As the Carbon Brief summarizes:

> Increases in hot extremes are projected to be largest in central and eastern North America, central and southern Europe, the Mediterranean region, western and central Asia, and southern Africa. Holding warming to 1.5C rather than 2C will see around 420 million fewer people being frequently exposed to extreme heatwaves... High and low extremes in rainfall are also expected to become more frequent... in the Mediterranean region and southern Africa, for example, "increases in drought frequency and magnitude are substantially larger at 2C than at 1.5C.

Politically volatile and strategically-significant regions such as the Middle East and North Africa are projected to experience major decreases in winter precipitation and heat levels that may in some cases render vast swathes of land no longer habitable, and increase the likelihood of conflict. A 2016 study of global data sets concluded that climate change is already increasing the likelihood of conflict in "ethnically fractionalized" countries, so these projections are especially worrying. In a demonstration

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of how climate change is already affecting the security environment, the UN Security Council last year issued a resolution on conflict prevention in the Lake Chad Basin that addressed climate change drivers. A similar resolution on Somalia passed this year.

As climate impacts increase in severity, it is likely that security institutions, including militaries, will see climate-related crises on their agendas and in their mission sets more frequently. Further, though certain regions are more vulnerable than others, local vulnerabilities can have global implications. This "globalization of hazards" has already been playing out, with climate-exacerbated droughts and wildfires in Russia and China contributing to dramatic increases in the price of wheat in Egypt in 2010, broadening political unrest. The report warns that such dynamics are likely to increase in frequency and severity. This will have important and difficult-to-predict security consequences in both the 1.5°C and 2.0°C scenarios.

3. Sea level rise will be a major security problem for both populations and militaries. Sea level rise is already having impacts on coastal communities and military installations around the globe through increased flooding, storm surges and sea water intrusion. The report conservatively estimates that, if the global temperature rises to 2°C, sea levels would rise by another 25-40%, potentially affecting 10 million more people than at 1.5°C. More worrying still is the plausible catastrophic scenario of multi-meter sea level rise due to marine ice sheet instability in Antarctica and/or *irreversible* loss of the Greenland ice sheet. These instabilities, the report notes, "could be triggered around 1.5°C to 2°C of global warming."

The report also found that sea level will continue to rise well beyond 2100 even if warming is limited to the 1.5°C/2.7°F degrees. Under both scenarios, the security risks are clear – including risks to militaries and key strategic assets located at or near coastlines, potentially existential risks to low-lying island states that will likely lead to regional security disruptions, and threats to the world's growing coastal megacities – critical urban spaces whose fragility could drive mass displacement and conflict. The 2018 U.S. *National Climate Assessment* affirms many of these findings. Regarding military installations in Hawai'i. and U.S.-affiliated Pacific islands, for example, it highlights significant sea level rise pressures on seats for key military commands on low-lying islands, as well as forces "stationed and deployed throughout the region providing strategic defense capabilities to the United States."

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4. Arctic melt will create a new and uncertain security environment, including for great powers. The report found that warming is two to three times higher in the Arctic than the global average. Even today, at 1.0°C temperature, trade routes are beginning to open up. The IPCC concludes that the probability of a sea-ice-free Arctic Ocean during the summer is one out of every 100 years at 1.5°C/2.7°F, versus one out of every 10 years at 2°C/3.4°F. However, it does not take an ice-free Arctic to have significant implications for great powers and other Arctic states that are competing for influence by expanding trade routes, exploiting seabed resources and

"What happens in the Arctic doesn't stay in the Arctic." While the Arctic may see the most dramatic physical changes on the globe, those changes will have a significant impact on the rest of the planet, from changing weather patterns to sea level rise, which will have knock-on effects across the entire geostrategic landscape.

widening their military presence. China, for example, has already asserted itself as a "near-Arctic nation," and both China and Russia have positioned themselves to exploit the geopolitical advantages of the new ocean.

This rapidly-changing domain creates a geopolitical uncertainty that could be very dangerous if not appropriately managed. Further, as retired Rear Admiral David Titley and Katarzyna Zysk have noted, "what happens in the Arctic doesn't stay in the Arctic." While the Arctic may see the most dramatic physical changes on the globe, those changes will have a significant impact on the rest of the planet, from changing weather patterns to sea level rise, which will have knock-on effects across the entire geostrategic landscape.

5. Risks to food, water and health security will likely increase state fragility and conflict risk in strategically-significant regions. The report notes that the difference between 1.5°C/2.7°F and 2°C/3.6°F for food and water security for hundreds of millions of people is at stake. It states: "vulnerability to decreases in water and food availability is reduced at 1.5°C versus 2°C, whilst at 2°C these are expected to be exacerbated, especially in regions such as the African Sahel, the Mediterranean, central Europe, the Amazon, and western and southern Africa."

In some regions, this could contribute to an increasing "weaponization of water" as non-state and state actors take advantage of scarce water resources to increase their leverage over adversaries. Furthermore, the report states: "For global warming from 1.5°C to 2°C, risks across energy, food, and water sectors could overlap spatially and temporally, creating new and exacerbating current hazards, exposures, and vulnerabilities that could affect increasing numbers of people and regions." These scenarios are what are sometimes referred to as "cascading disasters," and will play out across a number of sectors whose vulnerabilities can drive major security problems.

Agriculture and livestock: The report found that there would be much greater net reductions in yields of maize, rice, wheat and potentially other crops as well as reductions in nutritional quality of crops in sub-Saharan Africa, Southeast Asia, and Central and South America if warming rises to 2°C/3.4°F. The food availability outlook is also measurably worse in a 2°C/3.4°F scenario in the Sahel, southern Africa, the Mediterranean, central Europe, and the Amazon. Changes in feed quality, spread of diseases and water availability will also adversely affect livestock. As noted previously, this can also have significant security implications in regions that are heavily dependent on the global food market, or where populations depend heavily on grazing livestock, such as in the Middle East and North Africa.

Fisheries: The report found that warming at the 1.5°C/2.7°F level will shift the ranges of fish into higher latitudes, lead to potentially irreversible damages to ecosystems, reduce fishery and aquaculture productivity, increase ocean acidification, and contribute to coral reef decline by a further 70-90%. These dynamics can interact with important geopolitical environments in ways that can exacerbate tensions within and between nations. Indeed, this is already occurring, to a degree, in places like the South China Sea, wherein a warming ocean is helping to drive fish stocks northward into internationally contested waters, thus raising tensions between China, its neighbors and the United States. More of this, particularly in a 2°C/3.4°F scenario, could exacerbate those tensions further and increase the risk of conflict.

Health: The report also found that increased warming will have negative consequences on human health. Both risks from heat-related morbidity and mortality and risks from some vector-borne diseases like malaria and dengue fever, which can increase and shift geographical ranges are lower at the 1.5°C/2.7°F level than at 2°C/3.4°F. Of particular concern are urban heat islands that amplify the impacts of heatwaves in cities. These health risks can also scale up into significant security challenges, including for military forces and aid personnel that operate in environments where infectious diseases are spreading - particularly as the geographic range of many disease vectors is expanding in a warming world.

"Large-scale reforestation, afforestation, and significant increases in the amount of land used for growing biofuels are all potential options for keeping the globe below 1.5°C/2.7°F temperature – but which could also increase food insecurity and tensions around land use.

6. Keeping the world below a temperature rise of 2°C may drive the deployment of geoengineering solutions for which there is currently no international governance, and which could pose security risks if not adequately managed. Some of the technologies and measures the IPCC says may be necessary to limit climate change could also be challenging in security terms, in the absence of effective governance. For example, large-scale reforestation, afforestation, and significant increases in the amount of land used for growing biofuels are all potential options for keeping the globe below 1.5°C/2.7°F temperature – but which could also increase food insecurity and tensions around land use. Geoengineering is a new field, and there remains an incomplete understanding of its consequences, no coherent means of tracking its use by state and non-state actors, and no established international norms for governing that use (or abuse).

A Responsibility to Prevent and Prepare

This report is the latest from a group that has been mapping climate change risks since 1988. In broad strokes, however, these risks should not be a surprise to anyone. We have been warned about them by scientists, as well as security and military professionals, for many decades. While inaction to date has limited the scope of opportunities available at this time, we still have a better understanding of how these security risks are and will be in the future than we did in the past. This knowledge and the technological capability for foresight provides an important responsibility to prepare for and reduce the threats. The IPCC report reinforces three such responsibilities, from a security perspective:

1. A responsibility to prevent a future where the security implications of climate change become potentially too difficult to adequately manage.
2. A responsibility to prepare for unavoidable changes in the security landscape driven both by temperature increases that have already occurred and those that most certainly will.
3. A responsibility to do the above in a security-sensitive manner: i.e., to ensure that mitigation and adaptation actions (including geoengineering) improve or do no harm to the security environment, rather than deteriorate it, through the development and enforcement of appropriate governance mechanisms.

In practical terms, these responsibilities translate into one overarching recommendation: we must prevent a difficult-to-manage security future of a 2.0°C/ 3.4°F world and robustly prepare for the likely unavoidable 1.5°C/ 2.7°F world, and do both in a way that improves international security. ■

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