

# Environmental Change, Strategic Foresight, and Impacts on Military Power

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## *Redefining the Environment for Scenario Planning*

After 20 years, a clear definition of environmental security has yet to be adopted at critical policy levels. Since 1989, researchers have argued that security cannot be understood well without taking environmental factors into account, and that future environmental changes will create new security risks and potential for conflict. The surge in interest during the post-Cold War 1990s was more a reaction to specific historical events than actual security, as environmental issues had long been intertwined with security risks and military operations. Environmental factors have always been crucial, but planners have often assumed the consistency of environmental conditions without question. The environment was always perceived as something external and constant, and while environmental damage may result from military preparations and operations, strategic interests were hardly threatened.

The last few years have witnessed a new form of environmental security discussion in which global changes present unique risks to stability and operations and new methods are being developed to assess these risks. The military community can play a key role in such strategic scenario planning, and in developing early warning systems for energy and environmental insecurity.<sup>1</sup> Rather than take a simplistic view of environmental and conflictual dynamics, military planners are qualified to assess complex and uncertain risks, but, in so doing, they are required to engage with a larger community of researchers and scientists. This article will define the nature of environmental

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risks as understood by scientific data, illustrate how environmental changes pose risks to both operations and strategic interests, and recommend how to integrate environmental risks with strategic scenario planning.

Environmental security is presently understood based on definitions from the 1990s, where emphasis was often placed on resource scarcity leading to violent conflicts in developing countries. Environmental security is still largely based on “realist” theories of political science, which posit that states are the primary actors and units of analysis in the international world, and violence is a primary expression of power. The basic argument is that increasingly scarce resources cause competition and conflict and will ultimately result in violence between or, perhaps, within states. These arguments were led by Thomas Homer-Dixon and were popularized in 1994 by Robert Kaplan in an influential article predicting chaos and violence in Africa.<sup>2</sup>

Kaplan’s mistake, and that of most environmental security researchers in the 1990s, was in conceiving environmental change and degradation as merely local issues in less developed regions. Local populations tended to be blamed for resource scarcity and violence in their own regions, an overly simplistic characterization that failed to encapsulate the complexity of both historical violence and environmental dynamics, including global trade patterns.<sup>3</sup> Researchers in the 1990s failed to substantiate claims of a resource scarcity-conflict link. Although environmental factors could be key factors in conflict, the conflicts themselves could never be reduced to a single, rational cause like deforestation. The scarcity-conflict theories also tended to overstate the direct link between environment and violent conflict, while ignoring crucial, intermediary relationships.<sup>4</sup> When applied to less developed regions, areas of existing violence, therefore, gained more attention than areas that may be more vulnerable to environmental changes, even if the violence had little to do with environmental factors.<sup>5</sup>

The resurgence of interest in environmental security risks, particularly climate change impacts on the military, was most visibly illustrated in a Center for Naval Analysis (CNA) 2007 report, *National Security and the Threat of Climate Change*, signed by 12 former 3- and 4-star US military officers.<sup>6</sup> In 2008, Thomas Fingar testified to Congress that environmental changes were a serious national security concern, a view echoed by other officials such as General Richard Engle and Senators John Kerry and John Warner.<sup>7</sup> By 2010, the Department of Defense had included energy and environmental change issues in its *Quadrennial Defense Review* (QDR); yet, there remained some confusion over what “environmental security” meant and how to measure it.<sup>8</sup> At the same time, the expertise for effective foresight and warning lay across various international agencies, with little

concerted effort to build foresight capacity.<sup>9</sup> The following portions of this article communicate some of the crucial lessons already learned from the security community on environmental issues, and what more is needed to provide adequate early warning of security risks, beginning with applications for scenario planning.

### ***The Scenario Process***

Scenario planning, or advanced long-term contingency planning, was codified after World War II by experts closely associated with the RAND Corporation, a think tank that had roots in the US Army Air Forces. Scenarios were used as a way of systematically wargaming future events, in an attempt to identify vulnerabilities in defense systems and doctrines well in advance of any conflict. The background assumptions (appropriately referred to as the “environment”) for scenarios tended to be static, allowing situational changes without complicating the picture too much.<sup>10</sup> Yet by the 1970s, certain strategists and futurists argued that environmental conditions could, themselves, change.<sup>11</sup> Should this happen while planning remained locked in earlier assumptions, the planning could create new vulnerabilities to the changing conditions.<sup>12</sup> Pierre Wack, who led the now-famous scenario planning group at Shell Oil in the 1970s, pointed out that global changes in oil demand and supply were entirely possible in the future. Rather than continue to invest in new infrastructure, Wack argued that Shell executives should take actions to allow the company to adapt in the event supplies fall; he worked with the company to explore how the future might be significantly different from the past. Once the OPEC-led oil embargo hit in 1973, Shell was one of the few companies able to navigate the crisis successfully.<sup>13</sup>

The scenarios at Shell Oil required new scenario methods and ways of thinking; similar efforts have already been made to adjust security foresight methods for changing natural environments. The US Department of Energy’s (DOE) Global Energy and Environment Strategic Ecosystem (Global EESE) program developed a multilayered scenario process to provide early warning of energy and environmentally-related instability. The associated risk assessments required scalability of global environmental data from regional to global security issues. The architecture was also designed to be modestly funded, leveraging outside expertise rather than relying entirely on in-house experts. The system developed at DOE was meant to provide early warning of potential instabilities at home and abroad, identifying key uncertainties and areas where more monitoring would be needed in order to avoid strategic surprises. This required identifying key

vulnerabilities in energy and environmental systems by translating scientific data into security risks.

### ***Vulnerability and Risk***

Translating the scientific data concerning potential, abrupt environmental changes and security impacts can result in a rather complex risk assessment. It is not enough simply to claim that changing environmental conditions will increase existing security concerns (a common interpretation of the term “threat multiplier”), rather such an assessment may create new security risks where none existed before. Vulnerability is a characteristic of a system in which change results in disproportionate impacts or dislocations, and where the system (political, ecological, or economic) is unable to adapt to the changes. While some vulnerabilities are obvious, many are only exposed after significant damage has already been done. Regions are unique geographically, socially, politically, and economically. Past research on disasters has revealed and defined key components of a vulnerable system.<sup>14</sup>

The first component of vulnerability is the basic risk of exposure; natural events occur more often in some places than others. Less visible is the component of resilience, or how well a system or society can recover following a major event. Resilient systems are those with resources and backups to use in case certain parts of the system fail. In technical terms, these are scale-free networks where random removal of any node does not threaten stability of the whole. Expressed in terms of a society, resilience consists of available resources to rebuild and, even more importantly, healthy relationships between people in the society so that rebuilding efforts are equitable. Vulnerable systems may also exhibit sensitivity, or the distance from which a system is moved or reconfigured during a given event. Sensitive ecosystems, for example, are those that are damaged more easily by a smaller rise in temperature. Finally, there is the component of fragility, or the amount of stress a system can endure before it ceases to act as the same society, ecosystem, or economy. The system may fall to a lower level of stability, where its essential character has changed permanently. Taken together, these measures of vulnerability can be mapped to indicate where potential environmental changes will have the greatest impact on stability.<sup>15</sup> Following are examples that illustrate how this process can take advantage of uncertainty rather than attempting to avoid it, beginning with research that describes how global environmental systems are far more vulnerable to change than was previously believed.

The reason for the resurgence of interest in environmental security is not merely one of media or public perception. Scientific research on climate

change has accelerated greatly since the 1990s, and data now includes mounting evidence that environmental systems are far more sensitive and chaotic than had previously been understood. Earlier Intergovernmental Panel on Climate Change (IPCC) reports were replete with linear graphs showing gradual but modest rises in atmospheric temperatures well into the twenty-first century, with relatively little summary discussion of significant changes in other environmental systems.<sup>16</sup> According to these earlier assessments, climate change was a mild, long-term concern and had little place in security discussions. By the release of the *IPCC Fourth Assessment Report: Climate Change 2007 (AR4)*, this had changed. The data used in AR4 was only as recent as 2002 or 2003; and the IPCC typically publishes fairly conservative predictions.<sup>17</sup> IPCC's worse-case scenarios for emissions of greenhouse gases and physical changes, such as Arctic summer sea ice or Greenland ice sheet melt, were surpassed soon after publication.<sup>18</sup>

Despite IPCC scenarios' proliferation of knowledge and conservatism, environmental and climate security assessments have invariably drawn their climate data from the AR4 summaries. In an attempt to reduce scientific uncertainty as much as possible, this reliance led to several potentially misleading assumptions or blinkered views of environmental change. Analyses have, therefore, made dubious assumptions that suggest environmental change is not a pressing issue for the military services and reactive policies are the options available. A number of these fallacies are worth dispelling.

- Climate changes are not limited to increasing air temperature; the atmosphere only contains a minor percentage of the total energy absorbed by the sun.

- Changes will not be gradual or fairly "smooth" (i.e., equal around the world). Even a small change in air or water temperature can have an enormous impact on systems.

- A climate model projection average result is not a prediction. Risk is a function of variability; we cannot understand security challenges simply by projecting the present into the future.

- Environmental vulnerabilities exist in developing and industrial countries. A focus primarily on other regions can lead to unpleasant surprises at home.

The emphasis on air temperature in climate change is not only understandable in terms of everyday experience but also historic biases in climate research that, while necessary at the time, now partly obscure the true nature of climate systems. The most reliable climate change records came from air temperature trapped in Arctic ice in Greenland and Antarctica. Since their discovery, researchers of greenhouse gas climate change have focused on air

temperature. The greenhouse effect, however, is a process of trapping energy, only part of which can be stored in the atmosphere.<sup>19</sup> Thus, climate changes may refer not only to air temperature but also environmental changes such as drought, floods, storms, shifting ecosystems, or changing ocean currents. These environmental changes are also closely interrelated, and significant impacts may result from multiple, marginal changes, rather than extreme shifts in a particular system.<sup>20</sup>

When considering pressures that impact critical vulnerabilities, there is a tendency to focus on “most likely” outcomes, believing that risk is only composed of impact multiplied by probability. In the case of energy and environmental security, however, discussions of probabilities are often linked to either past environmental conditions or median projections of potential changes. Past conditions are poor predictors of future events, especially when what scientists refer to as boundary conditions, or the rules of the game, have changed. Climate scientists who input more data into models may find the variability in their results increases as the model is refined, increasing uncertainty. In other words, rather than saying global sea levels may rise between 190 and 590 millimeters by 2100, we now find it may rise between 1 and 5 meters, an order of magnitude difference and a much greater absolute variance.<sup>21</sup> This uncertainty is a component of risk.<sup>22</sup> Rather than concentrating on known events and risks, planners need to be aware of when environmental conditions may adversely affect operational and strategic security.

### ***Stability Operations and Infrastructure***

Effective planning requires consideration of not only where instability may exist but also how environmental changes may impact security operations, domestic resources, and infrastructure. Existing stability operations can be affected in the short- and long-term. In the short-term, military operations can have severe environmental consequences on the very areas authorities are trying to protect. Water or air pollution from garbage disposal, for example, can pose risks to local populations and create new environmental risks for deployed troops. To protect deployed forces, medical intelligence needs to consider existing and evolving environmental conditions, which may require rapid environmental assessment techniques presently being developed.<sup>22</sup> Even simple environmental risks, however, can create enormous problems for logistical planning. If adequate drinking water is not available, bottled water has to be trucked or flown in at enormous cost, or reconstruction teams are required to invest large amounts of money to rebuild infrastructure. In Iraq and Afghanistan, the US Army spends nearly one-third of in-theater

costs just on transporting water, raising the cost of water to between \$15 and \$30 a gallon.<sup>24</sup> Knowledge of environmental conditions is key to reducing troop exposure to risks and prioritizing resources.

More problematic are the uses of environment as a weapon in conflict. Directly targeting environmental resources is a common tactic during

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conflicts. It is a measure that decreases an opponent's ability to sustain or rebuild capabilities following a conflict. This resilience targeting is illegal under the auspices of international law but remains extremely common in violent conflicts.<sup>25</sup> Destruction of livestock, deliberate pollution of water, laying of landmines in agricultural lands, and damaging green infrastructure (e.g., water purification plants and sewage treatment facilities) reduce food security and greatly increase environmental hazards through reduced resilience and increased exposure.<sup>26</sup> Insurgencies in operational areas are often closely related to environmental conditions. Destruction of basic environmental goods such as fresh water, energy, and sewers can serve to delegitimize authorities. According to a US Army study in the Sadr City section of Baghdad, insurgency support was highest where potable water and working sewers were unavailable much of the time.<sup>27</sup> Not coincidentally, insurgents targeted water and energy infrastructure as a way to undercut support for the Iraqi government and allied forces. This same infrastructure had decayed due to a combination of damage from military actions in 1991 and 2003 and under-investment during intervening years. This increased, postconflict vulnerability of areas later occupied by Coalition Forces. Had such knowledge been effectively communicated and integrated into post-conflict planning, stabilization of certain areas may have been more rapidly and effectively achieved.<sup>28</sup>

Environmental changes can also shift where operations are likely to occur, regardless of political stability. Changes in the Arctic provide the most visible example of environmental shifts to large-scale operational security and responsibilities. Maritime vessels were long unable to operate in the Arctic, save for icebreakers and nuclear submarines; the rapid retreat of Arctic sea ice now has allowed summer operations through the Northwest Passage. The operation of commercial vessels in this region raises not only territorial issues of sovereignty and resource rights but also practical demands upon forces to patrol and police such waters. Highly sensitive Arctic ecosystems and insufficient resources to patrol such a vast and climatologically difficult region increase vulnerabilities to both commercial and

environmental disasters.<sup>29</sup> Similar budget pressures for Arctic patrols are also being felt in Canada, Norway, Russia, and Denmark.<sup>30</sup>

Less visible, perhaps, are environmental changes that directly impact the operations of military facilities and infrastructure. A number of US airbases lie close to sea level. Any rise in sea levels or increase in the severity of tropical storms might inundate and damage these facilities. Those airbases nearest waterways may possibly be exposed to higher levels or incidences of flooding in the future. The Pacific island of Diego Garcia is a crucial forward base for operations in Asia and the Middle East. Yet, it lies only a few feet above sea level. So too are many bases and facilities along the US East and Gulf Coasts, such as Patrick Air Force Base.<sup>31</sup> Even marginal rises in sea levels combined with storm surges and coastal erosion can put areas several meters above normal sea level at risk. This may result in periodic or sustained flooding in areas that never planned for such events and overwhelm the facilities' adaptive capacities. Emergency planning for the New York metropolitan region needs to now include reasonable probabilities of a Category III hurricane traveling west up Long Island Sound, an event that could create storm surges of up to 10 meters (over 30 feet), inundating lower Manhattan and the Newark Liberty International, John F. Kennedy International, and LaGuardia airports.<sup>32</sup> Such a storm's ripple effects would be felt economically by disrupting transportation and energy infrastructures, undoubtedly requiring a diversion of military resources.<sup>33</sup>

Even inland bases are vulnerable to climate changes, particularly in the form of extreme heat events, which can limit large aircraft operations, or a base's inability to directly impact the energy and water for operations. Public utilities are often responsible for providing water and energy to nearby military installations, yet long-range forecasts of environmental conditions may not be communicated adequately or integrated into the facilities' strategic planning. The military installations around Colorado Springs, Colorado, for example, are substantially expanding, requiring greater investments from federal sources (e.g., the Bureau of Reclamation) in an effort to provide the city adequate water supplies to support the influx of military personnel and their dependents.<sup>34</sup> Without resilient water supply systems, military bases and facilities would be left vulnerable to droughts.

It is more cost effective to identify and address such risks well in advance. Shifting environmental conditions raise questions concerning what sort of equipment and training is needed, where facilities should be placed or drawn down given emergent risks, and which commands should take responsibility for these decisions. The changes in environmental risks need to be considered in the larger, global context of stability. Rather than

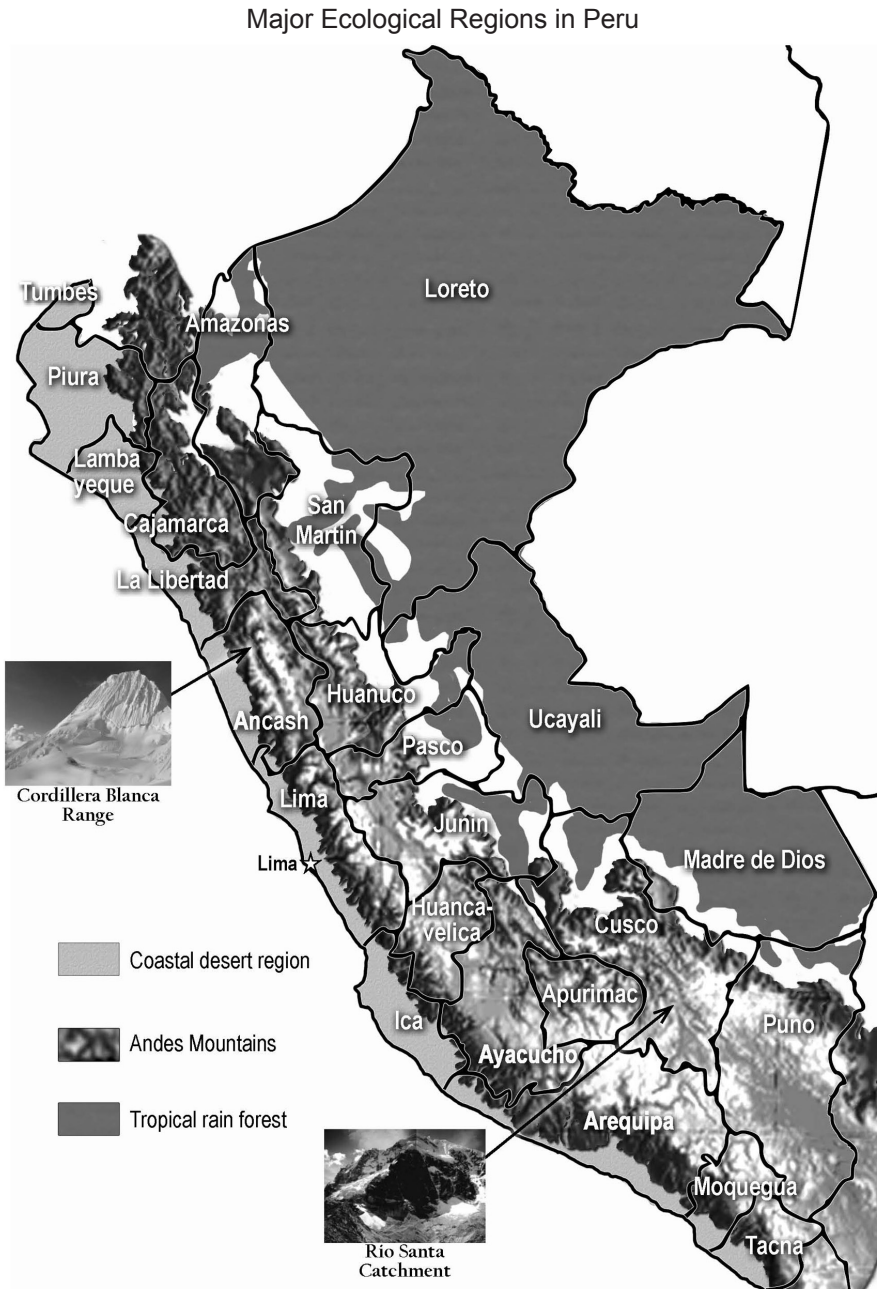


waiting for conflicts or disasters to occur and then reacting, it is far better to identify those regions where environmental changes will impact existing tensions or create new and unique challenges that are not yet recognized in security planning. A perfect example is outlined below where, in equatorial South America, looming environmental change will create new risks and security challenges in a region that was previously thought to be relatively stable.

### ***Horizon Scanning for Instability***

The country of Peru (see map of Peru) provides one of the most compelling examples of a looming yet largely unrecognized environmental instability. This South American nation has experienced periodic insurgency over the years but has been viewed as relatively stable and, therefore, received far less attention from the security community than some of its neighbors (e.g., Columbia). Yet Peru's dependence on glacier-fed water makes it highly vulnerable to climate change, in much the same way as Ecuador, Bolivia, Chile, and Brazil. Covering an area of 1.3 million km<sup>2</sup>, Peru's location between the Andes Mountains and South America's west coast encompasses three major ecological regions: the coastal desert region west of the Andes, the tropical rain forest east of the Andes, and the cordilleras within the Andes. All are interlinked in the climate and hydrological cycle, where the existence of equatorial glaciers provides crucial reservoirs for precipitation.<sup>35</sup> The Peruvian Andes contain 70 percent of the world's equatorial glaciers, formations that are rapidly melting and predicted to nearly disappear in the next 20 years.<sup>36</sup>

Peru relies on glacier-fed water for 80 percent of its water use, including agricultural, municipal, industrial, and energy. The 8 million inhabitants of Lima are almost entirely dependent on glacier water, while 2 million of those inhabitants have no reliable access to municipal utilities at all. Overall, 70 percent of Peru's population lives in the coastal desert region that contains only 2 percent of Peru's water sources.<sup>37</sup> While some agricultural communities rely on rainwater for crops, a large number rely entirely on runoff from the Cordillera Blanca Mountain Range into the Rio Santa catchment area. Some modeling efforts demonstrate that many lower-altitude glaciers will completely disappear in the cordillera within the next 10 to 20 years, while others maintain that glaciers below 18,045 feet will completely disappear by 2015.<sup>38</sup> Although the equatorial regions have experienced fewer temperature changes than the polar areas, even marginal shifts in ocean and air temperatures have greatly accelerated glacial melt. Western Latin America also experiences greater variability due to the El Niño-Southern Oscillation



(ENSO) phenomenon, a warming/cooling cycle that creates more frequent and sudden heat transfers as ocean temperatures rise.<sup>39</sup>

Given a fairly high-confidence environmental change, security scenarios are required to address what happens when the water disappears. Water loss affects the vulnerability of multiple, interconnected systems and

is a basic requirement of stability for ecological, agricultural, energy, and municipal systems.<sup>40</sup> Security scenarios need to address how these systems may attempt to adapt, rather than assuming wholesale descent into conflict and violence. Given underlying environmental change in this particular scenario, one must ask:

- How much will agriculture be affected, and how dependent are Peru and its neighbors on this agricultural output for consumption and export?
- If water cannot be replaced in communities, where will people go? Will migration be local or long-distance, and what are the secondary effects on destination communities?
- How will energy production be affected and can substitutes be found?
- Will inability to provide water, energy, or food affect government legitimacy?
- What will the effect be on existing insurgency movements?<sup>41</sup>
- How will water loss affect ecosystems, particularly rain forests east of the Andes?

In the simplest terms, Peru's total water budget (which includes food and energy) will be affected. Although one can assume that security implications will arise, the impacted systems are too complex for simplistic assumptions of scarcity and conflict. As communities and states attempt to adapt to new conditions, potential conditions need to match with potential behaviors and resultant reactions. Vulnerabilities and adaptive strategies will be region-specific, and the identification of critical vulnerabilities and potential intervention points is key to effective strategic planning.

### ***Geopolitics and Response***

Other countries are already planning for such environmental change. Long-term planning regarding geostrategic shifts are evidenced in Chinese foreign policy as it applies to Africa and the small South Pacific island states, including securing mineral and resource rights. Development aid programs to other nations have assisted China in planning for climate and other environmental changes, often well in advance of other nations. China has been singularly successful in anticipating geopolitical shifts. As an example, China has reportedly been working on contracting "Atlantis rights" for minerals and other resources within the Exclusive Economic Zones (EEZs) of several small island states. This means that if and when such states disappear as sea levels rise, the rights revert to China. This could potentially result in Chinese resource domination of large areas of the Pacific—a scenario that is only possible because of looming climate

change. Advanced planning will pay large dividends to Chinese foreign policy.<sup>42</sup> The earlier examples of buying and leasing land for food security also have the possibility of reshaping economic and political relations as environmental conditions evolve, leaving some areas much more vulnerable and potentially overwhelming those that are either not prepared or lack adequate resources to counter such effects.

In July 2010, the DOD signed a memorandum of understanding with the US Department of Energy (DOE) to strengthen cooperation in areas of research and technology for energy efficiency and grid security. The DOD has taken a number of steps to increase energy security and efficiency, but as with earlier DOE warnings, the focus needs to be broader than technology investments.<sup>43</sup> Absent adequate foresight and planning, determining which technology investments are worthwhile can be difficult. What one should focus on is investment planning. The pace of scientific research and environmental change is such that one cannot wait for security risks to become obvious or scientific data to percolate from researchers through the IPCC to the media and then to policymakers. Without adequate and timely information related to potential risks and resource allocation, policy will likely be reactive, and planning will only assess risks according to historical experience and conditions.

Scenario planning can suffer from experiential biases, where well-established knowledge of past events guides how we perceive the future. What do we not understand yet and what possible limitations exist? Where are we exploring for evidence of risks? And are there potential risks that we either do not understand well or to which we are blind, possibly because we are focused elsewhere? Humanitarian crises related to environmental change are often ignored until it is too late for effective intervention by security forces. Proper use of planning scenarios requires identifying key intervention points in advance of violence or instability. This is necessary to either mitigate such instability or develop reaction capabilities. As the United States and other military powers advance where future natural disasters, population displacements, and instability might arise, they can take appropriate measures to mitigate such events in advance. The most effective and least costly military operations are ones that never take place.

Policy-makers may wish to acknowledge the complexity of environmental and energy effects on security but, in recognizing, these potential impacts, invest in early warning capabilities that emphasize data sharing between scientists and other risk assessors. Such visions have been articulated in defense planning for the US Quadrennial Defense Review and NATO's Strategic Concept and could rapidly be put into practice given

tools already available. Due to past practices and bureaucratic stovepipes, implementation is limited more by initiative and imagination than actual resources. Evidence of climate and its environmental impact will become more obvious in coming years, but what those changes mean in terms of international and domestic security requires a greater number of skilled and effective translators. The past is unlikely to be our future.

#### NOTES

1. John T. Ackerman, "Climate Change, National Security, and the Quadrennial Defense Review: Avoiding the Perfect Storm," *Strategic Studies Quarterly* (Spring 2008): 56-96.
2. Thomas Homer-Dixon, "On the Threshold: Environmental Changes as Causes of Acute Conflict," *International Security* 16 (1991): 76-116. Thomas Homer-Dixon, "Environmental Scarcities and Violent Conflict: Evidence from Cases," *International Security* 19, no.1 (1994): 5-40. Robert Kaplan, "The Coming Anarchy," *The Atlantic Monthly* (February 1994):44-76.
3. Simon Dalby, "Security and Environmental Linkages Revisited," in *Globalization and Environmental Challenges: Reconceptualising Security in the 21st Century, Hexagon Series on Human and Environmental Security and Peace*, vol. 3, eds. Hans Günter Brauch, et al. (Berlin: Springer-Verlag, 2006): 165-171. Nils Peter Gleditsch, "Armed Conflict and the Environment: A Critique of the Literature," *Journal of Peace Research* 35, no. 3 (1998): 381-400.
4. Wenche Hauge and Tanja Ellingsen, "Beyond Environmental Scarcity: Causal Pathways to Conflict," *Journal of Peace Research* 35, no.3 (1998): 299-317.
5. Ken Conca and Geoffrey D. Dabelko, *Environmental Peacemaking*, (Washington and Baltimore: Woodrow Wilson Center Press and Johns Hopkins University Press, 2002). Betsy Hartmann, "Population, Environment and Security: A New Trinity," *Environment and Urbanization* 10, no. 2 (October 1998): 113-128.
6. Center for Naval Analysis (CNA), National Security and the Threat of Climate Change, 2007, <http://securityandclimate.cna.org/report/> (accessed August 10, 2010).
7. Thomasingar, "National Intelligence Assessment on the National Security Implications of Global Climate Change to 2030," Deputy Director of National Intelligence for Analysis and Chairman of the National Intelligence Council, 25 June 2008, [http://www.dni.gov/testimonies/20080625\\_testimony.pdf](http://www.dni.gov/testimonies/20080625_testimony.pdf) (accessed August 7, 2010).
8. US Department of Defense. *Quadrennial Defense Review Report, 2010*. [http://www.defense.gov/qdr/images/QDR\\_as\\_of\\_12Feb10\\_1000.pdf](http://www.defense.gov/qdr/images/QDR_as_of_12Feb10_1000.pdf). See also Lauren Morello, "Defense Experts Press for Probabilistic Risk Assessment of Climate Change," *Scientific American*, 24 June 2010, <http://www.scientificamerican.com/article.cfm?id=defense-experts-press-for-probabilistic-risk-assessment-of-climate-change> (accessed August 1, 2010).
9. US Department of Energy. "The Energy and Environment Strategic Foresight Laboratory Final Report," Energy and Environmental Security Directorate, US DOE. June 2009 <http://www.globaleese.org/> (accessed July 26, 2010). Behind the scenes, in 2007 the US Department of Energy (DOE) established its Energy and Environmental Security Directorate, charged with tackling the full complexity of these security issues and their risks, and with developing a strategic foresight capability on energy and environmental security. The project was disbanded in March 2010.
10. Fred Kaplan. *The Wizards of Armageddon* (Stanford: Stanford University Press, 1991), 33-50.
11. Harvey A. DeWeerd , "A Contextual Approach to Scenario Construction," RAND document P-5084, 1973, <http://www.rand.org/pubs/papers/2008/P5084.pdf> (accessed May 15, 2010).
12. Pierre Wack, "Scenarios: Shooting the Rapids," *Harvard Business Review* 63, no. 6 (1985): 139-150.
13. Peter Schwartz, *Art of the Long View* (New York: Doubleday, 1991).

14. Ben Wisner et al., *At Risk: Natural Hazards, People's Vulnerability and Disasters* (London: Routledge, 2005). Hans-Martin Füssel, "Vulnerability: A generally applicable conceptual framework for climate change research," *Global Environmental Change* 17 (2007): 155-167.
15. Chad Briggs, Lucy Anderson, and Moneeza Walji, "Environmental health risks and vulnerability in post-conflict regions," *Conflict, Medicine & Survival* 25, no.2 (2009): 119-130.
16. Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge, UK: Cambridge University Press, 2001).
17. Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge, UK: Cambridge University Press, 2007).
18. Derek S. Arndt, Molly O. Baringer, and Michael R. Johnson, eds., "State of the Climate in 2009," *Bulletin of the American Meteorological Society* 91, no.6 (2010): S1-S224.
19. R. Knutti, et al, "A Review of Uncertainties in Global Temperature Projections over the Twenty-First Century," *Journal of Climate* 21, (2008): 2651-2663.
20. Ibid, 107-131.
21. James Hansen, "Scientific reticence and sea level rise," *Environmental Research Letters* 2 (April-June 2007) 024002, doi:10.1088/1748-9326/2/2/024002.
22. Stanley Sienkiewicz, "Observations on the Impact of Uncertainty in Strategic Analysis," *World Politics* 32, no. 1 (Oct. 1979): 90-110. As an analogy, during the Cold War US security planners tended to assume greater range and accuracy of Soviet ballistic missiles than may have been the case, even though this acknowledged greater uncertainty in terms of where targets may exist and thus complicated planning. Likewise today, antiterrorism policies assume the need for precaution on less than complete information of potential attacks, to the extent of randomly screening people based merely on their potential to cause harm. When knowledge is incomplete, focusing on only those areas that are well understood will inevitably result in surprises, but there are admitted differences in political acceptability of respective security policies.
23. Birgitta Liljedahl et al., "Environmental Impact Assessment in Peacekeeping Missions." *FOI Sweden report for UNEP*. January 2010. <http://www.foi.se/upload/projects/Africa/424-Liljedahl-Environmental-Impact-Assessment-in-peace.pdf> (accessed August 11, 2010).
24. American Physiological Society, "Army Study Improves Ability To Predict Drinking Water Needs," *ScienceDaily*, 11 July 2009. <http://www.sciencedaily.com/releases/2009/07/090708073849.htm>. Leo Shane, "Scientists looking for ways to pull troops' water out of the desert air," *Stars and Stripes*, 26 Nov 2006. <http://www.stripes.com/news/scientists-looking-for-ways-to-pull-troops-water-out-of-the-desert-air-1.57328> (accessed July 28, 2010).
25. Briggs, et al., "Environmental health risks and vulnerability in post-conflict regions," 129.
26. S. Lantze and A. Raven-Roberts, "Violence and complex humanitarian emergencies: implications for livelihoods models," *Disasters* 30, no.4 (2006): 383-401.
27. Timothy E. Hill. *Reducing an Insurgency's Foothold: Using Army Sustainability Concepts as a Tool of Security Cooperation for AFRICOM*. (Carlisle, PA: US Army War College, 2008).
28. Robert Jervis, "Reports, politics, and intelligence failures: The case of Iraq," *Journal of Strategic Studies* 29, no. 1 (February 2006): 3-52. Steven Metz, "Insurgency and counterinsurgency in Iraq," *The Washington Quarterly* 27, no. 1 (Winter 2003): 25-36. Ward Thomas, "Victory by Duress: Civilian Infrastructure as a Target in Air Campaigns," *Security Studies* 15, no. 1 (April 2006): 1-33.
29. US Coast Guard, *Report to Congress: U.S. Coast Guard Polar Operations, 2008*. [http://www.uscg.mil/hq/cg5/cg513/docs/FY08\\_OMNIBUS\\_Polar\\_Ops\\_Report.pdf](http://www.uscg.mil/hq/cg5/cg513/docs/FY08_OMNIBUS_Polar_Ops_Report.pdf)
30. Scott G. Borgerson, "Arctic Meltdown - The Economic and Security Implications of Global Warming," *Foreign Affairs* 87, no. 2 (March/April 2008): 63.
31. Cleo Paskal, "How Climate Change Is Pushing the Boundaries of Security and Foreign Policy," *Chatham House Briefing Paper*, June 2007.

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32. Mark J. Koetse and Piet Rietveld, "The impact of climate change and weather on transport: An overview of empirical findings," *Transportation Research Part D: Transport and Environment* 14, no. 3 (May 2009): 205-221, DOI: 10.1016.
33. BBC. Medvedev sacks officers over Russia fire failures. 4 August 2010. <http://www.bbc.co.uk/news/world-europe-10871997> (accessed August 4, 2010). The August 2010 fires in Russia are a grim reminder than even 'normal' events can have enormous impacts if they overwhelm normal response.
34. City of Colorado Springs. 2008. Letter from Mayor Lionel Rivera to the US Bureau of Reclamation (re Southern Delivery System). 6 June 2008. [http://www.sdswater.org/docs/newsroom/in\\_the\\_news/MayorDEISltr.PDF](http://www.sdswater.org/docs/newsroom/in_the_news/MayorDEISltr.PDF). See also Donald F. Fournier and Eileen T. Westervelt, *Energy Trends and Their Implications for U.S. Army Installations*, Sept 2005. <http://handle.dtic.mil/100.2/ADA440265> (accessed August 11, 2010).
35. Jennifer Gonzalez, "Abrupt Climate Change Scenarios and Security Foresight: Climate Change & Water in Peru." *US Department of Energy Background Study*, 2010.
36. Mathias Vuille, et al, "Climate change and tropical Andean glaciers: Past, present and future," *Earth-Science Reviews* 89 (2008): 79-96. Rocío Urrutia and Mathias Vuille, "Climate change projections for the tropical Andes using a regional climate model: Temperature and precipitation simulations for the end of the 21st century," *Journal of Geophysical Research* 114, no. D02108 (January 2009): 1-15. Edward Spang, *Alpine Lakes and Glaciers in Peru: Managing Sources of Water & Destruction*, Tufts Institute of the Environment Research, June 2, 2006.
37. Gonzalez, "Abrupt Climate Change Scenarios and Security Foresight: Climate Change & Water in Peru."
38. Raymond S. Bradley, et al, "Threats to Water Supplies in the Tropical Andes," *Science* 312 (June 2006): 1755-1756.
39. Gonzalez, "Abrupt Climate Change Scenarios and Security Foresight: Climate Change & Water in Peru."
40. Kelley Lubovich, "The Coming Crisis: Water Insecurity in Peru." *FESS Issue Brief, Foundation for Environmental Security and Sustainability, USAID*, 2007.
41. Gavin David White, "Displacement, decentralisation and reparation in post-conflict Peru." *Protracted Displacement FMR33* (September 2009): 44-46.
42. Cleo Paskal, *Global Warring: How Environmental, Economic, and Political Crises Will Redraw the World Map* (London: Palgrave Macmillan, 2009): 182-190.
43. US Department of Energy. "Memorandum of Understanding Between U.S. Department of Energy And U.S. Department of Defense Concerning Cooperation in a Strategic Partnership to Enhance Energy Security," July 22, 2010. <http://www.energy.gov/news/documents/Enhance-Energy-Security-MOU.pdf> (accessed July 23, 2010).