Climate security, risk assessment and military planning

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The effort to tie together environment and security is not a new endeavour. The Epic of Gilgamesh spoke of floods, possibly referring to actual changes in the Euphrates and Tigris rivers, resulting in clashes over water access and land use. Stories from the Third Punic War (albeit of disputed veracity) spoke of the Romans sowing the fields of Carthaginians with salt in order to prevent the communities from rebuilding. Environmental factors have been crucial in warfare throughout history, from storms warding off the Spanish Armada in Elizabethan times to the decimation of European troops by disease during the Crusades. Later colonial powers, recognizing that the conquest of land overseas required also the conquest of nature, established schools of tropical hygiene and medicine to provide adaptation strategies for new environmental conditions.

Since the mid-2000s, a wide range of reports and research articles have discussed the emergence of climate change as a security issue, including in 2010 the UK Ministry of Defence Green Paper and the US Department of Defense Quadrennial Defense Review (QDR).[1] Describing climate change as a 'threat multiplier', militaries have argued that shifting conditions can heighten tensions as food, energy and related systems are strained. Other narratives have been more direct in their claims of a link between climate and security, arguing that resource scarcity will lead to violent conflict, either through direct competition or as a result of migrants prompted by climate change crossing international borders. Popular media and policy journals have carried both claims and counter-claims to the climate security arguments, while a sizeable number of academic researchers have attempted to model empirical evidence to the concept. Yet despite the common use of the term 'climate security', there remains uncertainty over what the concept really means, and disputes over whether climate change is a legitimate security concern. Use of the term 'climate change' in policy documents does not mean that associated risk assessments have been mainstreamed into military planning.

This article describes why climate change is a significant security risk, and how military planners can integrate new science and concepts into operations and

* The views expressed by the author are his own, and do not reflect official policies of the US Air Force or Department of Defense.

1 UK Ministry of Defence, *Adaptability and partnership: issues for the Strategic Defence Review* (London: MOD, Feb. 2010); US Department of Defense, *Quadrennial Defense Review 2010* (Washington DC: DOD, 2010).

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strategy, with a focus on energy and environmental security (EES) 'net assessment' risk approaches. It will address the military's interest in climate change as a security risk, examine why accurate prediction of climate change impacts will be difficult, and explain why it is possible and indeed necessary to plan for adaptable responses to new environmental conditions. As environmental changes accelerate and become more acute, the ability to integrate such shifts into mainstream security planning takes on new urgency. In order for these concepts to be successfully integrated, we must understand the nuanced security implications of environmental change, and the challenges in translating science into policy.

A changing climate

The urgency of current climate change discussions stands in marked contrast to the tone set in earlier decades, reflecting both mounting scientific data on environmental hazards, and at least a perception that increasingly severe weather is linked to such changes. From the 2003 heatwave in Europe to Hurricanes Katrina, Wilma and Rita in the United States in 2005, and the floods in Pakistan and wildfires in Russia of 2010, environmental impacts are increasingly visible. Environmental security research in the 1990s was generally dismissive of climate change as an important factor, following predictions by the Intergovernmental Panel on Climate Change (IPCC) that global warming would amount to marginal changes in air temperature by the end of the twenty-first century.[2] The environmental security focus at the time was much more on local resource scarcity.[3]

By the time of the IPCC's Fourth Assessment in 2007, scientific data strongly indicated that the climate system was more sensitive to changes than had previously been thought, and empirical observations were recording changes that often outpaced even worst-case scenarios of climate models. The accelerating melt of Arctic Sea ice and Greenland ice sheets was particularly striking, by 2007 far exceeding predictions.[4] Climate change has accelerated at just the same time that international political responses have largely stalled. Environmental security problems were no longer merely local, but had been effectively globalized in scope.

The surprising discrepancy between predictions and measurements in observable climate change was at least partly due to attention being overly narrow in scope. As most weather observations, both official and personal, are made in terms of air temperature, so official discussions also centred on global warming of that air (including the United Nations negotiations to limit warming to 2 degrees Celsius). In climatology, this focus derived largely from the availability of reliable air temperature records in the Greenland ice sheet, which tended to divert focus

[2] IPCC, *IPCC second assessment: climate change 1995* (London: Cambridge University Press, 1995).

[3] Hans Günter Brauch, 'Securitizing global environmental change', in Hans Günter Brauch, John Grin, Navnita Chadha Behera, Patricia Kameri-Mbote, Czeslaw Mesjasz, Úrsula Oswald Spring and Heinz Krummenacher, eds, *Facing global environmental change* (London: Springer, 2009), p. 73.

[4] Hans-Martin Füssel, 'An updated assessment of the risks from climate change based on research published since the IPCC Fourth Assessment Report', *Climatic Change* 97: 3–4, 2009, pp. 469–82, DOI: 10.1007/s10584-009-9648-5.

from other avenues of climate change and its manifestations in different latitudes.[5] The attention to air temperature by the public and governments ignored the basic fact that 93.4 per cent of solar radiation is absorbed by the oceans, and that many changes would be felt in terms of precipitation shifts.[6] Changes to air temperature were often secondary in terms of importance for impacts on ecosystems and infrastructure. Subsequent work on climate records indicated abrupt change events, such as monsoon failures, at various times during the Holocene (for example, 3,200, 4,200 and 5,200 years before the present).[7] Particularly with shifting climate boundary conditions, such events could happen again.

Scientists also increasingly argued that environmental changes are more likely to be abrupt rather than gradual, reflecting knowledge of complex adaptive systems and historical records from palaeo-climatological records. Once tipping points in certain systems are reached, a phase shift occurs that could fundamentally alter regional or global climate conditions. Abrupt changes in global and local temperatures are common in the palaeo-climatological record, their discovery countering long-standing assumptions that climate changed only gradually, over millions of years. Abrupt changes are very likely occurring now, such as accelerated melting of Andean glaciers, but the forcing events (e.g. geologically sudden increases in greenhouse gases) differ significantly from those conditions found in the historical record.[8] It is therefore extremely difficult to predict where and when changes will occur, as scientific studies are by necessity dependent upon palaeo-records that do not match existing conditions, or models that must make judgements on the sensitivity, dynamics and starting environments of the current climate system.[9]

Climate change uncertainty is compounded by uncertainty in related systems. Geophysical shifts trigger changes in related ecosystems and socio-economic systems, to which humans then react. Abrupt changes in related systems can be triggered by relatively small changes in climate. Failures in one system can create cascading effects in other systems, with feedback effects that can either dampen or accelerate changes.[10]

For example, it is well established that tropical storms require a sea surface temperature of greater than 26 degrees Celsius to grow and increase in strength.[11] A modest increase in sea surface temperature can greatly expand the reach of tropical storms, particularly in combination with oscillation events such as El Niño. The appearance of even mild tropical storms in regions and urban areas not

5 Personal communication with Dr Richard Alley, Penn State University, 5 July 2009.

6 Martin Wild and Beate Liepert, 'The Earth radiation balance as driver of the global hydrological cycle', *Environmental Research Letters* 5, 025203, 2010, DOI:10.1088/1748-9326/5/2/025203.

7 Richard B. Alley and Anna Maria Ágústsdóttir, 'The 8k event: cause and consequences of a major Holocene abrupt climate change', *Quaternary Science Reviews* 24: 10–11, May 2005, pp. 1123–49.

8 Lonnie G. Thompson, Ellen Mosley-Thompson, Henry Brecher, Mary Davis, Blanca León, Don Les, Ping-Nan Lin, Tracy Mashiotta and Keith Mountain, 'Abrupt tropical climate change: past and present', *Proceedings of the National Academy of Sciences* 103: 28, 11 July 2006, pp. 10536–43.

9 In technical terms, we must take knowledge of current climate boundary systems of the Holocene but link them to events that may not have been witnessed since the Pliocene or earlier.

10 Leonardo Dueñas-Osorio and Srivishnu Mohan Vemuru, 'Cascading failures in complex infrastructure systems', *Structural Safety* 31: 2, March 2009, pp. 157–67.

11 P. J. Webster, G. J. Holland, J. A. Curry and H.-R. Chang, 'Changes in tropical cyclone number, duration, and intensity in a warming environment', *Science* 309, 2005, pp. 1844–6.

accustomed to such precipitation can result in enormous damage and disruption.[12] Likewise, combinations of changes to ocean temperatures and land use can disrupt the usually predictable rains of the summer monsoons in regions such as India. Even mild increases in variability of monsoon rains can result in alternating floods (as in Pakistan in 2010) and drought (as in India in 2009).[13]

In addition, environmental systems often exhibit feedback and multiplier effects, where a smaller change in one area leads to a cascade of impacts with much greater shifts elsewhere. The Russian heatwave of 2010 sparked a series of events whose impact is often not well appreciated. In addition to the thousands who died in Russia as a result of heat and wildfires, the Russian military lost 200 aircraft at a naval air station near Kolomna and nearly suffered damage to a nuclear facility in Sarov.[14] In addition to these visible events, a critical vulnerability with global security implications concerned food production. The loss of crops from the heatwave prompted an embargo on the export of Russian grain, much of which was destined for ports in the Middle East and North Africa. In Egypt, for example, the sudden loss of major food imports could not be made good from other sources, as world markets were already tight and US grains could not be imported for fears of invasive ragweed pollen.[15] The heatwave in Russia therefore led to a major price spike in grains and breads in the Middle East and North Africa, which is said to have been a contributing factor to Arab Spring revolts, as national governments unable to provide for their citizens lost legitimacy.[16]

Such potential environmentally induced tipping points, where environmental changes trigger sudden social impacts, have been documented: the role for environmental intelligence is to help map out cascading impacts and potential future scenarios in order to plan appropriate responses.[17] Impacts are often asymmetrical, depending upon specific geographic, socio-economic, cultural, ecological and infrastructural vulnerabilities. These factors, combined with the current political situation of a given region, help to determine whether and how systems can adapt to environmental changes, and whether these changes might precipitate a larger security concern. The security impacts of climate change are almost always indirect, but may be significant enough to warrant serious consideration.

[12] Kevin E. Trenberth, 'Framing the way to relate climate extremes to climate change', *Climatic Change*, 2012, DOI: 10.1007/s10584-012-0441-5.

[13] Timothy M. Lenton, Hermann Held, Elmar Kriegler, Jim W. Hall, Wolfgang Lucht, Stefan Rahmstorf and Hans Joachim Schellnhuber, 'Tipping elements in the Earth's climate system', *Proceedings of the National Academy of Sciences* 105: 6, 12 Feb. 2008, pp. 1786–93; Anders Levermann, Jacob Schewe, Vladimir Petoukhov and Hermann Held, 'Basic mechanism for abrupt monsoon transitions', *Proceedings of the National Academy of Sciences* 106: 49, 8 Dec. 2009, pp. 20572–7.

[14] 'Forest fires destroy Moscow military base', *Defense News*, 3 Aug. 2010, http://www.defensenews.com/article/20100803/DEFSECT02/8030306/Forest-Fires-Destroy-Moscow-Military-Base, accessed 31 July 2012.

[15] '2011 food price spikes helped trigger Arab Spring, researchers say', Voice of America, 13 Dec. 2011, http://www.voanews.com/content/article-2011-food-price-spikes-helped-trigger-arab-spring-135576278/149523.html; see also http://www.hpj.com/archives/2010/aug10/aug16/0816Russianwheatstory_2pixj.cfm, both accessed 31 July 2012.

[16] Sarah Johnstone and Jeffrey Mazo, 'Global warming and the Arab Spring', *Survival* 53: 2, April–May 2011, pp. 11–17.

[17] T. M. Lenton, V. N. Livina, V. Dakos, E. H. van Nes and M. Scheffer, 'Early warning of climate tipping points from critical slowing down: comparing methods to improve robustness', *Philosophical Transactions of the Royal Society A* 370: 1962, 13 March 2012, pp. 1185–204.

Given these risks, a small number of researchers (beginning with Jon Barnett in 2003) began asking systematic questions about the ways in which climate change could affect security. These researchers hypothesized that changes in climate could create indirect security risks, from migration pressures to loss of state capacity.[18] Over the ensuing decade the climate security community has grown enormously. Interest in climate-related risks on the part of the military, particularly the US Department of Defense, shifted the focus of the climate security debate and highlighted its importance. The military involvement was somewhat ironic, in that the US military's interest in earlier environmental security debates had generally been limited to regulatory compliance issues, and trying to minimize environmental impacts from operations.[19] The same person responsible for the development of environmental compliance at the Pentagon in the 1990s, Sherri Goodman, then led a redefinition of climate security and the military's role in addressing it.

The security community and climate change

One of the most significant influences on the climate security debate came in 2007, with the publication of the CNA Corporation's report on climate security. CNA has been a central, independent actor in defence science and research in the US, and this report was signed by CNA's Military Advisory Board, coordinated by Sherri Goodman and consisting of twelve retired three- and four-star officers, all asserting that climate change posed a real threat to national security strategies and military operations.[20] Though earlier works (such as the 2003 Schwartz and Randall 'abrupt climate change' report) had been discussed prior to 2007, the CNA report introduced concepts of why military thinking mattered to climate change discussions.[21] The CNA was not alone in Washington DC in this new preoccupation: between 2007 and 2009 climate intelligence and security programmes were established in the Central Intelligence Agency (CIA), the US Department of Energy (DOE), the US Navy, and other think-tanks such as the Center for New American Security (CNAS).[22]

From a strictly military standpoint, climate change is an important factor in security planning, but largely as a supportive element in understanding strategy and operations. Like public health policies, the successful application of risk assessment and response often means a decrease in visibility for the problem being addressed. The more successful public health policies become, the less salient the health risks appear. While the symptoms of climate change may well remain

18 Jon Barnett, 'Security and climate change', *Global Environmental Change* 13: 1, April 2003, pp. 7–17.

19 Many in the military are also well aware that the US Department of Defense is one of the single largest greenhouse gas emitters on earth.

20 CNA, *National security and the threat of climate change* (Alexandria, VA: CNA Corporation, 2007).

21 Peter Schwartz and Doug Randall, *An abrupt climate change scenario and its implications for United States national security*, Global Business Network report (San Francisco, 2003), http:/climate.org/PDF/clim_change_scenario.pdf, accessed 31 July 2012.

22 Charles Mead and Annie Snider, 'Why the CIA is spying on a changing climate', *McClatchy News*, 10 Jan. 2011, http://www.mcclatchydc.com/2011/01/10/106406/why-the-cia-is-spying-on-a-changing.html, accessed 31 July 2012.

evident even with robust mitigation policies in place, the aim of many climate security policies will be to adapt to changing conditions and bolster the resilience of communities at risk. It is when such policies fail that security impacts will be felt most strongly. The concern is not in direct links between climate and violent conflict, but in the ability of climate change to disrupt those systems that underlie stability and human security more generally. When a region becomes sufficiently destabilized that military intervention is deemed necessary, there are often few military options available to address the problems. The US experience in Somalia in the 1990s, and reconstruction efforts in Iraq and Afghanistan since 2002, have been sober reminders of how difficult systems are to repair once they are broken. From a purely practical viewpoint, one way to preserve resources is to exercise adequate foresight and coordination in preventing such engagements and continuing to focus on traditional military threats.[23]

The military and intelligence approach to climate security, starting with the 2007 CNA report, is therefore not a 'green' view of the world. On the contrary, the security view is that climate change represents a disruptive force that has the potential to make operations more costly and time-intensive, and to require further deployments as part of humanitarian assistance and disaster response (HA/DR) operations. Even when the probabilities are unknown, the risks to strategic interests and operational goals are often significant enough to be included in planning. Uncertain climate change contingencies are addressed now precisely in order to avoid having to deal with the consequences of such risks later. To quote General Gordon Sullivan, 'If you wait until you have 100 percent certainty, something bad is going to happen on the battlefield.'[24]

The need to act under conditions of uncertainty is common in risk policy, and with climate change is heightened by the non-linear nature of many changes.[25] Most climate discussions and many scientific models are based upon historical experience and temperature-related trends. As stated previously, although historical approaches make psychological sense from a public risk assessment perspective, scientific understandings of environmental systems suggest that changes are more likely to be abrupt than gradual. The general focus is therefore more on the extremes (variation) than on the averages.

As abrupt changes and surprises do not lend themselves well to estimations of 'most likely' probabilities (otherwise they would not be surprising), climate security assessments often therefore also focus more on what is possible than on what is probable. Military planning does take into account probable risks, but very often contingency planning is also made for events that are of unknown probability, yet entail severe consequences. The priorities in military training and education are to reduce surprise when possible, and to prepare appropriate responses for when novel conditions and situations are encountered. In either case the emphasis is on

[23] Chad Briggs, 'Environmental change, strategic foresight, and impacts on military power', *Parameters* 40: 3, 2010, pp. 1–15.
[24] CNA, *National security and the threat of climate change*, p. 10.
[25] Robert Gibson, 'Respecting ignorance and uncertainty', in Erik Lykke, ed., *Achieving environmental goals* (London: Belhaven, 1992), pp. 158–78.

responding to uncertainty, rather than on waiting for uncertainty to disappear. This in part explains the divergence that sometimes arises between military interests in climate security, in which planning can proceed without full information, and academic studies, which exhibit strong preferences for predictive modelling capabilities. The goal of strong prediction, however, overly narrows the scope of security assessments, and increases the risk of strategic and operational surprises. As the intelligence communities have a long history of failing to predict historic events (for example, Pearl Harbor, the fall of the Berlin Wall, 9/11), alternative assessment approaches are necessary.

General prediction vs specific assessment

If strong predictions are impractical, then alternative methods of vulnerability assessment and risk scenarios may come into play. From a practical standpoint, adequate risk foresight means taking a broad view of security while at the same time being specific about potential impacts and vulnerabilities. Yet not all approaches to the subject agree, and often mismatches exist between approaches taken by the academic communities and the needs of planners and policy-makers.

Many political pronouncements on climate security take a general approach that 'things will get worse' while relying on general assumptions about climate change and competition over scarce resources. These attempts to elevate climate change into 'high politics' are easily criticized by those who deny that climate change is a security issue and argue that vague definitions and lack of empirical data risk overselling the concept.[26] Likewise, there can be disagreement between those who take human security approaches to climate change and impacts on public health and livelihoods and those who posit that environmental factors can only be understood in the context of 'hard' security and national interests.[27] Those who take human security approaches may have difficulty in explaining to their compatriots at home why the suffering of others in far-off places should matter to them.

Other political science approaches to climate security have attempted to address the problem of lack of evidence by using large-scale data sets on violent conflict, matching historical events to records of temperature and precipitation. Not surprisingly, the overall conclusion of such studies has been that there exist only weak links between specific changes in climate and incidences of conflict. Even when statistically significant correlations were found, for example between violence and changes to rainfall, the mechanisms for such links were unknown.[28] Some analyses of climate security take an essentially deductive approach of using specific factors to predict general changes, such as stating that changes in air temperature increase the risk of conflict. Although researchers assume that the

[26] Stephen Walt, 'National security heats up?', *Foreign Policy*, 10 Aug. 2009, http://walt.foreignpolicy.com/posts/2009/08/10/national_security_heats_up, accessed 31 July 2012.

[27] See Mark J. Lacy, *Security and climate change: International Relations and the limits of realism* (New York: Routledge, 2005), pp. 72–99.

[28] Cullen S. Hendrix and Idean Salehyan, 'Climate change, rainfall, and social conflict in Africa', *Journal of Peace Research* 49: 1, Jan. 2012, pp. 35–50.

link is indirect, without contextual details it is difficult to understand security and risk pathways.[29] Similar conclusions were already being drawn in the 1990s in response to the dominant resource scarcity–conflict models, and in narrowing the scope from 'environment' to 'climate' it is not surprising that no new conclusions were reached.[30] More important is the consideration that such approaches do not answer the 'so what?' concerns of the military and policy-makers. If, on average, heavier rains are followed by an increased probability of violence, does that actually mean anything to either policy-makers or combatant commanders?

The challenge for researchers is how to explain in digestible terms what are in reality complex, overlapping and geographically unique systems. The risk is in assuming that climate change impacts are 'smooth', meaning that environmental changes in one place are meaningful in and of themselves, and can also be transposed onto other geographies. Too often 'environmental change' is simplified to mean averaged global warming of atmospheric temperature, rather than combinations of geophysical, ecological and hydrological changes. Arguments that climate change will 'make things worse' or 'lead to conflict' are far less compelling than assessments of cascading risks that develop assessments of critical vulnerabilities and geographically specific impacts.

Scenario risk assessments and vulnerability

An alternative approach is to use risk assessments within a framework approach, rather than as predictive models. Risk assessments use different standards of evidence, carry very different expectations for outcomes, and when done properly are explicit in their associated psychological and value assumptions. As has been argued elsewhere, it is more useful to approach climate issues via risk assessment rather than predictive formulas.[31] Practical risk assessments use combinations of factors to describe possible, specific impacts, ones that reflect geographically and culturally specific vulnerabilities. Scenario planning, risk assessment and vulnerability assessment are often considered separate processes, but programmes at the US DOE and US Air Force have attempted to structure these approaches into an integrated process that helps to translate scientific data into risk assessments for security purposes.[32]

Risk assessments are tools for decision-making for future conditions, and in the environmental realm are related to environmental impact assessments or public health assessments. Applied to environmental, health and energy fields, risk assessments prioritize potential actions by assessing potential impacts and associated costs and benefits. These assessments are not merely calculations of potential impact multiplied by probability. Risk also functions according to uncertainty,

[29] Nils Petter Gleditsch, 'Whither the weather? Climate change and conflict', *Journal of Peace Research* 49: 1, Jan. 2012, pp. 3–9.

[30] Nils Petter Gleditsch, 'Armed conflict and the environment: a critique of the literature', *Journal of Peace Research* 35: 3, May 1998, pp. 381–400.

[31] Nick Mabey, Jay Gulledge, Bernard Finel and Katherine Silverthorne, *Degrees of risk* (London: E3G, 2011).

[32] Chad Briggs and Tracy Walstrom Briggs, *Air University Minerva Initiative 2010–2011: energy and environmental security* (Maxwell Air Force Base, AL: Air University Press, 2011).

where greater uncertainty surrounding a potential action translates into greater risk.[33] As known probabilities and known impacts are easier to calculate, uncertainty over either measure increases the perceived risks.

In flight training such risk scenario planning is standard, and pilots are required to practise for situations that are unlikely ever to happen. It is often the case that disasters occur from unlikely combinations of completely normal and commonplace problems. No individual event or risk may be notable or unusual, but a problem may touch upon a critical node in the system, or combine with one or more others in an improbable way to create a unique risk.[34] The uncertainty of these combinations is enough to trigger precautionary actions and to make it important not to assume that minor problems have minor consequences. In risk assessments, this is characterized as preferring false positives (type I errors).[35] A climate example came with Hurricane Irene in the United States in 2011. Although it was a relatively weak tropical storm by the time it reached New England, a series of normal meteorological events (e.g. heavy rains) preceding it combined to create a situation where the storm became one of the most expensive disasters in US history, with costs reaching US$15.6 billion.[36]

Vulnerability assessments are similar to risk assessments, but extend the analysis by focusing on the ability of a system to withstand or respond to impacts. Public health assessments often refer to vulnerabilities in populations, and the concept is used frequently in both disaster and post-conflict assessments. Definitions of vulnerability in respect of disaster examine exposure to specific risks, the resilience of communities (however defined) in responding to the risk, and the sensitivity of affected populations to the associated risk.[37] Some studies also measure fragility, which is the tendency of a system to revert to a lower level of stability if the disaster pressure is great enough.[38]

Assessments can provide important baseline data for expected risks, particularly if trends are linear. The US Navy's Task Force Climate assesses, for example, the potential impacts on infrastructure of sea-level rise, as well as the impacts on force readiness of changes in the Arctic sea ice. Both identify specific pathways and use trends to project likely impacts and vulnerable areas.[39] Detailed vulnerability assessments generally require extensive, contextual knowledge of the affected system, whether it is a community, an energy infrastructure or an ecosystem. In many cases general pressures and averaged resilience tell only part of the story, and focus on these risks obscuring critical vulnerabilities or critical nodes.

33 John Lemons, Kristin Shrader-Frechette and Carl Cranor, 'The precautionary principle: scientific uncertainty and Type I and Type II errors', *Foundations of Science* 2: 2, 1997, pp. 207–36, DOI: 10.1023/A:1009611419680.

34 Robert Besco, 'Aircraft accidents aren't: part two', *Accident Prevention* 48: 1, 1991, http://aviationsafetywiki.org/solutions/levelbust/ResPool/FS_AxAt2.pdf, accessed 31 July 2012. See also Charles Perrow, *Normal accidents* (New York: Basic Books, 1984).

35 Kristin Shrader-Frechette, 'Methodological rules for four classes of scientific uncertainty', in John Lemons, ed., *Scientific uncertainty and environmental problem solving* (London: Blackwell Scientific, 1996), pp. 12–39.

36 Lixion A. Avila and John Cangialosi, 'Tropical cyclone report: Hurricane Irene', US National Hurricane Center, 14 Dec. 2011, http://www.nhc.noaa.gov/data/tcr/AL092011_Irene.pdf, accessed 31 July 2012.

37 B. Wisner, P. Blaikie, T. Cannon and I. Davis, *At risk* (London: Routledge, 2005).

38 Chad Briggs, Lucy Anderson and Moneeza Walji, 'Environmental health risks and vulnerability in post-conflict regions', *Medicine, Conflict and Survival* 25: 2, 2009, pp. 122–33.

39 US Navy, *Climate change roadmap* (Washington DC: US Naval Observatory, 2010).

Critical vulnerabilities are parts of a system that are disproportionately affected by risks, such as how the elderly are most at risk in extreme heat events. Critical nodes represent those parts of the system that, should they fail, render the rest of the system inoperable.[40] For example, in the 2011 Tohoku earthquake in Japan, coastal populations were critically vulnerable to the resulting tsunami, while the backup diesel generators at the Fukushima Daiichi plant were critical nodes in the nuclear power system. Once the generators were overwhelmed by the tsunami, this sparked a cascade of events that disabled not only the Fukushima plant, but the entire nuclear industry in Japan.[41]

As vulnerabilities vary widely even within specific geographical locations, case-studies must often suffice as the basis for discussing global impacts. As in ecology, stating that global climate change will affect *x* number of species may be less useful than finding examples of where keystone species are affected by specific change pathways, and then describing cascading effects on the ecosystem. Determining such critical species relies upon systems analysis and a detailed understanding of how components of a network interact. Whether the system at issue is a computer network, an ecosystem, an energy infrastructure or a society, lack of 'terrain' knowledge can result in unfortunate surprises when critical components fail and backup systems are not in place. In security terms, surprises can be disproportionately damaging, and can result in paralysis of response.[42]

Identification of 'wild cards' that impact on critical nodes and trigger cascading impacts generally relies upon development of risk scenarios. Scenario analyses are often associated with business planning, or with the use of climate models to create descriptions of future environmental conditions. There are, however, more security-orientated versions that combine risk assessment with systems analysis, and so differ from either the trend-line tradition of the Hudson/RAND approach or the more narrative style of Royal Dutch Shell. This environmental 'net assessment' approach uses the basic approach of military net assessment in evaluating the relative capabilities of environmental systems and affected populations to respond to particular scenarios. Such an approach does not merely include 'worst-case' scenarios, but covers unique combinations of factors (often moderate) that act as starting conditions for analysis of cascading impacts and responses.[43]

[40] Albert-László Barabási, 'The architecture of complexity', *IEEE Control Systems* 27: 4, 2007, pp. 33–42. Barabási uses the term 'hubs', while 'critical nodes' is a military term. In some literatures, 'critical dependencies' is also used. See Swedish Civil Contingencies Agency, *If one goes down, do all go down?* (Karlstad, Sweden: Swedish Civil Contingencies Agency MSB, 2009); also Bo Ebenmana and Tomas Jonsson, 'Using community viability analysis to identify fragile systems and keystone species', *Trends in Ecology and Evolution* 20: 10, Oct. 2005, pp. 568–75.

[41] Sara B. Pritchard, 'An envirotechnical disaster: nature, technology, and politics at Fukushima', *Environmental History* 17: 2, 2012, DOI: 10.1093/envhis/ems021.

[42] Ephraim Kam, *Surprise attack* (Cambridge, MA: Harvard University Press, 1998), pp. 8–9.

[43] The approach uses *n*-dimensional modelling for starting conditions to ensure maximal variability, and allows traceability of assumptions. See Chad Briggs and Henrik Carlsen, 'Environmental and climate security: improving scenario methodologies for science and risk assessment', American Geophysical Union Research abstract, Dec. 2010, http://adsabs.harvard.edu/abs/2010AGUFMNH12A..05B. Impacts and responses are also used in wargames, and the US Air Force and US Navy now use environmental layers in their games.

The challenges of climate security assessment

Such risk and vulnerability questions must address the challenges of scale and virtual distances. The challenges of scale are extremely difficult to overcome, and represent a fundamental mismatch between global processes like climate change and the local level at which all impacts will ultimately be felt. Climate scientists grapple with different methods to downscale models to regional grids, often losing crucial dynamics in the process.[44] From a methodological perspective, viewing climate impacts in terms of averaged conditions over averaged regions gives little insight into actual risks. If analyses are scaled to cover large geographical regions, specific vulnerabilities and politically or culturally unique responses are lost with averaged conditions. Contrary to common perceptions, environmental changes are not smooth, linear processes represented by averages and direct impacts.

For example, an increase in average air temperature of 2 degrees Celsius may not appear to be a significant change, as air temperatures tend to shift much more than that during any 24-hour period. The averaged increase, however, may shift the 'long tail' probabilities of more frequent storms, extreme heat events or worsened droughts, each with its own impacts on related systems.[45] The annual temperature deviation for Europe in 2003 (based on historical records) was about 1 degree Celsius above average, yet the summer heatwave that year far exceeded previous records and resulted in the deaths of 70,000 Europeans.[46] The variation and specific locations within that average, and the range of impacts on vulnerable populations, were crucial to understanding the 2003 heatwave. Likewise, average precipitation for Australia between 2000 and 2010 did not diverge acutely from the historical mean, but patterns of precipitation did change during that time, with extended droughts in the agricultural region of the Murray–Darling Basin concurrent with heavier rains in the north.[47]

If the apparent solution to scaling is to focus much more on local events and responses, the challenge of virtual distance comes into play. Virtual distance is the reminder that separation in geographical space does not insulate a system from impacts elsewhere. Environmental systems are often linked globally, not just through greenhouse gas emissions but through contaminants, species loss and physical events such as tsunamis. International political economy critiques of environmental security have also long established that energy and resource trades can have profound impacts and causal links that are not immediately obvious.[48] Ecological footprints can extend far from consumers, and the import and export

44 Roger Pielke and Robert Wilby, 'Regional climate downscaling: what's the point?', *Eos* 93: 5, 31 Jan. 2012, pp. 52–3.

45 See C. B. Field, V. Barros, T. F. Stocker, D. Qin, D. J. Dokken, K. L. Ebi, M. D. Mastrandrea, K. J. Mach, G.-K. Plattner, S. K. Allen, M. Tignor and P. M. Midgley, eds, *Managing the risks of extreme events and disasters to advance climate change adaptation* (Cambridge: Cambridge University Press for IPCC, 2012).

46 European Environment Agency, 'Annual temperature deviation in Europe in 2003', http://www.eea.europa.eu/data-and-maps/figures/annual-temperature-deviation-in-europe-in-2003, accessed 31 July 2012.

47 CSIRO, 'State of the climate 2010', http://www.csiro.au/Outcomes/Climate/Understanding/State-of-the-Climate-2010/Rainfall.aspx, accessed 31 July 2012.

48 Jeroen C. J. M van den Bergh and Harmen Verbruggen, 'Spatial sustainability, trade and indicators: an evaluation of the "ecological footprint"', *Ecological Economics* 29: 1, April 1999, pp. 61–72.

of sustainability is common. Consumer tastes in North America affect deforestation rates in Indonesia, and computer recycling programmes in the UK can result in water pollution in Ghana. The 2011 Japanese tsunami has perhaps been the most powerful example, as events in one location (Fukushima Daiichi) had immediate impacts on energy markets and policies across Eurasia, and tertiary impacts that are still being felt globally. The key to climate change lies not in average changes, but in the increased variability of systems, cascading impacts, and the risk of tipping points being reached.

Starting points: the water–energy nexus

Given this focus on extreme complexity, uncertainty and connectivity, it is often difficult to know where to start. One suggestion is to begin analyses in one of the most basic of relationships, and one that is often central to discussions of environmental, food, and climate security: the energy–water nexus. Understanding some of the basic interdependencies in this relationship can help in describing cascading effects and security relevance.

A crucial point for climate security is that changes do not happen in isolation. While in certain cases climate changes pose direct operational challenges to the military (as, for example, in the US Navy Task Force Climate's concern over opening of the Arctic ice), most often climate changes are considered within the larger context of EES. As stated earlier, the experience of the 2005 US hurricanes (Katrina, Wilma and Rita) provided impetus for security planners to consider the impacts of natural forces more broadly. A primary security consideration, beyond the physical security of those trapped by rising floodwaters in New Orleans, lay in the impacts of the storms on coastal energy infrastructure, with many large refineries and ports shut down for much of the autumn of 2005.[49] This led the Office of Intelligence and Counterintelligence at DOE to establish its Energy and Environmental Security Directorate (then IN40), charged with examining potential 'shocks' to energy security from emerging environmental risks.[50] Likewise, the 2007 CNA report was followed by a series of energy security assessments, and CNAS's 'Natural Security' programme included energy; in addition, the programme head, Sharon Burke, became Assistant Secretary of Defense for Operational Energy Programs.[51]

Although energy security and environmental security approaches had been separate (if not antagonistic) in earlier years, their melding since the experience of Hurricane Katrina has not been coincidental. EES risk assessments by the US Departments of Defense and Energy have begun to focus on the close connection between water and energy, and how an understanding of this dynamic

[49] Cleo Paskal, *The vulnerability of energy infrastructure to environmental change*, Chatham House briefing paper, 2009, http://www.chathamhouse.org/sites/default/files/public/Research/Energy,%20Environment%20and%20Development/bp0409energy.pdf, accessed 31 July 2012.

[50] Mead and Snider, 'Why the CIA is spying on a changing climate'.

[51] http://www.defense.gov/bios/biographydetail.aspx?biographyid=259, accessed 31 July 2012.

helps to uncover critical vulnerabilities and critical nodes in various regions.[52] All modes of energy production, with the exception of wind and photovoltaic solar, require large amounts of water for extraction, processing, generation and recycling. By some estimates, well over half of all water use in Europe and North America is dedicated to energy production. A water-cooled generator can easily require 40 cubic metres of water every second, or 2.4 million litres per minute.[53] Water scarcity, either from drought or from overconsumption, threatens energy production in many parts of the world, whether attributed to the Hoover Dam in the United States or thermal coal plants in India. Likewise, water scarcity limits the ability to extract domestic sources of energy, for example shale gas deposits in China. Floods can threaten power generation facilities (e.g. the Fort Calhoun nuclear power plant in Nebraska); overheated coolant water can force the shutdown of facilities (e.g. when 17 French nuclear power plants shut down in 2003).[54]

Conversely, energy is also required for water use, whether for irrigation of agriculture (in some Indian states, 70 per cent of electricity is used for groundwater pumps), wastewater treatment, desalination or other processes.[55] Without careful planning, energy–water systems can develop interdependencies and feedback loops: the need for more water in a region can require greater production of energy, which in turns requires greater use of water, and so on. Energy–water vulnerabilities—which have been documented in countries including Kyrgyzstan, China and the United States—leave related systems such as economic stability or food security at risk from outside shocks or environmental changes.[56]

The risk inherent in the energy–water nexus highlights the shortcomings of traditional views that 'the vulnerable are poor', which in fact are often misplaced: advanced economies are at times more at risk from the effects of climate change than less developed ones. Risks to infrastructure, food production, transport, energy production and other sectors may exist irrespective of a country's wealth. Should environmental changes disable a critical node in such systems, the cascading impacts can be both rapid and widespread. It is also understandable—an important point in understanding long-term strategy—that those countries where acute water shortages have an impact on energy supplies (e.g. China) may take action to reduce such risks, with implications for security elsewhere. If, for example,

[52] It should be noted that food security falls easily into this water–energy nexus.

[53] This is a measure of water abstraction, not consumption, and includes water used for hydroelectric generation. See Dana Larson, Cheryl Lee, Stacy Tellinghuisen and Arturo Keller, 'California's energy–water nexus: water use in electricity generation', *Southwest Hydrology*, Sept.–Oct. 2007, pp. 20–30, http://www.swhydro.arizona.edu/archive/V6_N5/feature3.pdf, accessed 31 July 2012.

[54] Paskal, *The vulnerability of energy infrastructure to environmental change*.

[55] Interview with Upmanu Lall, 4 June 2010, Circle of Blue, http://www.circleofblue.org/waternews/2010/world/qa-upmanu-lall-gives-insight-to-indias-nexus-of-energy-food-and-water/, accessed 31 July 2012.

[56] Reuters, 'Nuclear, coal power face climate change risk-study', 4 June 2012, http://www.reuters.com/article/2012/06/04/climate-water-energy-idUSL3E8H41SO20120604, accessed 31 July 2012; Keith Schneider, 'Double choke point: demand for energy tests water supply and economic stability in China and the U.S.', Circle of Blue, 22 June 2011, http://www.circleofblue.org/waternews/2011/world/choke-point-china-us-comparison/, accessed 31 July 2012; Adam Albion, 'Winter of discontent: electricity supply problems in Central Asia', *Jane's Intelligence Review* 20: 12, Dec. 2008, pp. 54–5.

China were to dam or divert the Yarlung–Tsangpo River (which becomes the Brahmaputra at the Indian border, and then flows to Bangladesh) to provide the water and energy China needs, such risk mitigation may well be viewed as a security threat by the downstream countries of India and Bangladesh.[57]

Planning without predicting

By recognizing that critical tipping points and emerging trends are best addressed in advance, risks associated with disasters and complex emergencies may be lessened or mitigated. The US military, the State Department and the US Agency for International Development have acknowledged this need for greater security foresight in both the 2010 Quadrennial Defense Review (QDR) and the 2010 Quadrennial Diplomacy and Development Review (QDDR). The QDDR conceded that the US government has too often been reactive when addressing shifting conditions, and has not responded to emerging crises in a coordinated fashion.[58] Yet the US military deploys units to respond to HA/DR situations several times every year, and these demands are only expected to increase in the future.[59] In two of the larger 2011 operations, the US military deployed 24,000 troops in response to the tsunami in Japan (Operation Tomodachi) and dispatched the Third Marine Expeditionary Unit to Thailand in response to extensive flooding around Bangkok.[60]

To develop the capability of identifying early warning signals for climate-related risks, natural scientists and engineers must work with social scientists, planners and stakeholders on the ground to assess the critical vulnerabilities of systems and how best to respond. Such an interdisciplinary, comprehensive approach assesses multiple disaster/risk layers, and includes pre-planning coordination for mitigation and response. This approach recognizes that the interactions between the geophysical, ecological and built systems that evolve in disasters spark cascades across multiple, complex systems, and that the disabling of critical nodes in such systems (e.g. backup diesel generators at the Fukushima Daiichi plant) can cause a phase shift in system stability.

The Asia–Pacific Center for Security Studies (APCSS) and Multinational Planning Augmentation Team (MPAT), both of which operate under the US Pacific Command (PACOM), help facilitate education and planning for natural disasters and humanitarian risks. The model they use is one of cooperative exercises, with civilian and military leaders from the Asia–Pacific region working together on

57 Namrata Goswami, 'China ups the ante in Arunachal Pradesh', Institute for Defence Studies and Analyses, 17 Jan. 2012, http://www.idsa.in/idsacomments/ChinaupstheanteinArunachalPradesh_NamrataGoswami _170112, accessed 31 July 2012; Jonathan Watts, 'Chinese engineers propose world's biggest hydro-electric project in Tibet', *Guardian*, 24 May 2010, http://www.guardian.co.uk/environment/2010/may/24/chinese-hydroengineers-propose-tibet-dam, accessed 31 July 2012.

58 US Department of State, *Quadrennial Diplomacy and Development Review* (Washington DC: GPO, 2010), p. 123.

59 W. G. Ernst, 'The increasing severity of circumpacific natural disasters', *International Geology Review* 43: 5, 2001, pp. 380–90; United Nations, *Asia–Pacific disaster report 2010* (Bangkok: United Nations Economic and Social Commission for Asia and the Pacific, 2010), pp. 2–5.

60 MSNBC, 'US Marines arrive to assess Thailand's "worst" ever flood', 15 Oct. 2011, http://www.msnbc.msn.com/id/44912792/ns/weather/t/us-marines-arrive-assess-thailands-worst-ever-flood/#.T9TB_MXxTwo, accessed 31 July 2012.

emerging risks. MPAT, which has conducted Tempest Express and Cobra Gold exercises since 1996, provides an unclassified forum within which host countries can conduct response scenarios, in cooperation not only with other countries, but also with international aid agencies, the United Nations and the Red Cross/ Red Crescent. Crucially, US involvement in such planning is very modest, with an emphasis on capacity-building and other countries leading the exercises.[61] As with all military-style training, the purpose is not to predict and replicate a specific situation, but rather to enable teamwork among groups in advance, facilitating the informal development of common terms of reference, standard operating procedures and, above all, trust.[62] Even if future conditions little resemble what was discussed during Tempest Express, those in the community know whom to contact for information and response. In contrast to traditional security planning, establishing such networks requires greater reciprocal use of unclassified information and emerging scientific data.

Disasters and climate risks can serve as positive spaces for partnership building and advance agreements. If these activities are expanded to include larger risk assessment activities (beyond simply response), capabilities analyses can also be improved.[63] As mentioned previously, part of net assessment is evaluating what capabilities one possesses to respond to a risk/threat. If cooperation and trust can be established among affected parties, then these capabilities include allies and partners, allowing division of responsibilities and possibly bolstering some capabilities. This would enable, for example, regional militaries to understand who has capabilities to respond immediately to disasters and who would be available to carry out initial assessments, and to set out frameworks for turning over responsibilities to civilian agencies and NGOs for humanitarian responsibilities beyond the initial response. Since sending in US Marines to respond to humanitarian crises is highly political both to Americans and to those people on whose beaches they appear, understanding and planning for dual capabilities in regions may provide multiple benefits.[64] Locally led responses and solutions are generally preferred to relying on Americans.

Advance assessment can also help identify critical uncertainties in our knowledge of environmental change and of its relationship to energy and other systems, and what research or monitoring would best address the problem in any particular case. Many climate risks will appear not as acute disasters, but rather as triggering mechanisms for slow-onset threats and pressures. Communities that can help identify key vulnerabilities and critical nodes in advance, especially if this is done in an open, multinational and multidisciplinary fashion, are also the communities that can begin work in advance to reduce risks and avoid imposing undue costs on others. As with the MPAT tradition of coordinating ideas and then letting

61 MPAT's success in maintaining a low profile means that many people in the Pentagon and US disaster community know of the exercises, but do not know that MPAT even exists.

62 See https://community.apan.org/mpat/default.aspx, accessed 31 July 2012.

63 Models for giving communities early warning of environmental risks have existed since at least 2000. See e.g. http://www.pdc.org/ or more recently http://www.ahacentre.org/, accessed 1 Aug. 2012.

64 Avoiding sending in military units for climate-related issues also helps to inhibit over-securitization of climate issues, a frequent concern for both the military and their critics.

others lead, the military role in climate security is ideally to provide tools and approaches so that others can ensure that climate security does not emerge as a primary military concern.

Selection of the appropriate response to possible future conditions, whether defined as mitigation or adaptation, is still highly political and must involve value choices and priorities. The hope is that with improved appreciation of how to approach uncertainties in climate-related environmental changes, adaptive capacities and critical vulnerabilities can be identified in advance, even if specific conditions and disasters continue to elude prediction. In contrast to traditional security assessments that focused on likely responses of adversaries, with climate change a key uncertainty remains as to what our own responses might or can be. Determining this requires not only deeper understanding of complex environmental changes, but appreciation of our own capacities and weaknesses, and what we most value trying to protect. The future will not be like the past, and such risk discussions need to be conducted well in advance.