

---

# The Climate Change and Energy Security Nexus

MARCUS DUBOIS KING  
JAY GULLEDGE

---

The study of the impacts of climate change on national and international security has grown as a research field, particularly in the last five years. Within this broad field, academic scholarship has concentrated primarily on whether climate change is, or may become, a driver of violent conflict. This relationship remains highly contested.<sup>1</sup> However, national security policy and many non-governmental organizations have identified climate change as a threat multiplier in conflict situations.<sup>2</sup> The U.S. Department of Defense and the United Kingdom's Ministry of Defense have incorporated these findings into strategic planning documents such as the *Quadrennial Defense Review* and the *Strategic Defence and Security Review*.<sup>3</sup>

In contrast to the climate-conflict nexus, our analysis found that academic scholarship on the climate change and energy security nexus is small and more disciplinarily focused. In fact, a search of social science literature found few sources, with a significant percentage of these works attributable to a single journal. Assuming that policymakers are more likely to rely on broader social science literature than technical or scientific journals, this

---

**Marcus King** is Associate Research Professor and Director of Research at the Elliott School of International Affairs. He has served in policy and research positions involving international energy and environmental issues at the Departments of Energy and Defense and the Center for Naval Analyses. He received a Master of Arts in Law and Diplomacy in 2000 and a PhD in 2008 from The Fletcher School of Law and Diplomacy. **Jay Gullede** is Director of the Environmental Sciences Division at Oak Ridge National Laboratory and a member of the ORNL Climate Change Science Institute. He is a non-resident Senior Fellow of the Center for a New American Security in Washington, DC, and previously directed the science program at the Pew Center on Global Climate Change and the Center for Climate and Energy Solutions in Arlington, Virginia.

---

leaves a limited foundation. This then begged the question: what are these sources? We identified a body of grey literature on the nexus of climate change

*In contrast to the climate-conflict nexus, our analysis found that academic scholarship on the climate change and energy security nexus is small and more disciplinarily focused.*

and energy security of a greater size than the body of peer-reviewed social science literature. We reviewed fifty-eight recent reports, issue briefs, and transcripts to better understand the nexus of climate change and energy security, as well as to gain insight about the questions policy-makers need answered by those undertaking the research.

In this article, we describe the nature of the sources reviewed, highlight possible climate change and energy security linkages found within those sources, identify emerging risks, and offer conclusions that can guide further research.

## THE NATURE OF THE SOURCES

Typically, “peer-reviewed” literature is based on original research by an academic scholar in a given field of study and published by an academic publisher in an archived serial journal. These publications are generally known to scholars in the relevant fields of study and have a commonly recognized and expected practice of peer review to determine whether a piece of work merits publication. We found that the number of sources on the nexus of climate change and energy security that met these criteria was small.<sup>4</sup> It is notable that six of these articles were published in the peer-reviewed journal *Energy Policy*.<sup>5</sup> This journal is highly unusual because it is oriented toward the policy community.<sup>6</sup> Further searches indicate that narrow and usually technical issues relevant to climate change and energy security are treated in highly specialized academic journals on energy fuels, engineering, meteorology, and atmospheric studies. Many of these sources can be obtained only on an expensive subscription-only basis.

An alternative form of publication, commonly called “grey literature,” is “information produced on all levels [by] government, academics, business, and industry in electronic and print formats not controlled by commercial publishing.”<sup>7</sup> The authors may not have conducted original research, but may be well informed or experienced on a topic.

Rather than advancing a particular academic field, this grey literature addresses topics that may be of greater interest to practitioners than

to academic scholars. Reports on the climate change and energy security nexus appear to fall into this category. This is not surprising given the role of practitioners in creating this literature. Governments directly fund many of the organizations from which we drew our sources, marking research agendas as subject to control or influence. Other sources were drawn from think tanks, often staffed by people who have government experience and the explicit mission of informing policy. Likewise, sources such as reports by international organizations provide analytical policy support capability to their member countries' governments.

Because the grey literature involves practitioners to a greater extent than academic literature, the two literatures may contain distinct sets of insights that arise from different methods of analysis and frames of reference. Grey literature has potential shortcomings including the lack of verification of facts and methodologies through a

*Although this lack of distance may cause biases and political slants, it also may provide insight into the questions that policymakers are asking.*

rigorous peer-review process, leaving more room for errors and a lack of critical distance from the policy process. Although this lack of distance may cause biases and political slants, it also may provide insight into the questions that policymakers are asking. For example, the formulation of climate change as a "threat multiplier" originated in the *National Security and the Threat of Climate Change* (2007) report from CNA Corporation, an American think tank, and has been cited in a great number of scholarly articles. This formulation has not only guided an entire literature on the climate change-conflict nexus and its implications for human security, but also formed a basis for national security planning.

This review considered grey literature consisting of fifty-eight English language reports, issue briefs, and panel transcripts primarily from think tanks and governmental organizations (Table 1):

TABLE 1: SOURCES BY CATEGORY:

NGOs/ Think Tanks	Government	Multilateral Agencies	Military/Security Organizations	Panels	Non peer- reviewed Journals
27	11	7	5	4	4

The large majority of these sources were written by American or Northern European authors. Research approaches ranged from interviews

to scenario-casting to sophisticated models, but were generally more qualitative than quantitative; thus they offered less assurance compared to peer-reviewed sources that any given source was not influenced by ideological predispositions. Hence, while grey literature must be vetted carefully for soundness and credibility, it may also offer unique insights that are lacking in the academic literature. The literature we reviewed was based on distinct parameters (Table 2).

TABLE 2: SOURCE SELECTION CRITERIA

Each source is recent, covering the time period from 2007 to 2012.
The organizations sponsoring or publishing the sources enjoy reputations for high research standards.
The organizations identify themselves as non-partisan.
The organizations have research experience with energy and/or climate change issues.
The sources are widely available and easy to acquire through electronic media.
The sources are accessible to readers from various backgrounds, including social and physical sciences and the humanities.

## DEFINING CLIMATE CHANGE AND ENERGY SECURITY

We adopt the Intergovernmental Panel on Climate Change's definition of climate change as a "change in the state of the climate that can be identified (e.g. by using statistical tests) by changes in the mean temperature and/or the variability of its properties and that persists for an extended period, typically decades or longer."<sup>8</sup> Additionally, climate change may be due to natural or manmade causes.<sup>9</sup>

Defining energy security is arguably more contextual, and certainly more central to our analysis. The literature offered a variety of what we consider to be partial definitions. At the microeconomic level, energy security is the ability of households and businesses to accommodate disruptions of supplies in energy markets.<sup>10</sup> A more comprehensive definition includes the availability of adequate, reliable, and affordable energy.<sup>11</sup>

We found that this definition is typical of the economics literature, which emphasizes energy supply over other elements of energy security.

Winzer uses case studies of three European countries to find that the definition of energy security that best serves clear policy goals is “energy supply continuity.”<sup>12</sup> For example, oil is the only fuel imported in significant quantities by the United States. The avoidance of oil supply disruptions and the resultant economic effects of price volatility are especially important to policymakers. Oil price shocks preceded almost every recession in the United States since World War II, as well as many worldwide recessions.<sup>13</sup>

Other organizations provide a more securitized definition. For example, the Center for a New American Security (CNAS) deemphasizes price and affordability altogether, defining energy security as maintaining energy supplies that are “geopolitically reliable, environmentally sustainable, and physically secure.”<sup>14</sup> Other organizations also include the physical protection of energy resources or infrastructure in their definitions.<sup>15</sup> Ladislav and Nakano build on the CNAS definition by also taking geopolitical, sustainability, and social acceptability factors into consideration.<sup>16</sup> This synthesized definition of energy security is new in the literature, but it is one that illuminates and is responsive to the choices policymakers must make.

#### ELEMENTS OF THE CLIMATE CHANGE AND ENERGY SECURITY NEXUS

The idea that climate change may act as a “threat multiplier” or a “conflict accelerant” originated in the grey literature.<sup>17</sup> According to the U.S. Department of Defense (DoD), climate change could affect environmental or resource problems that communities already face by intensifying grievances, overwhelming coping capacities, and possibly spurring population displacement in areas that lack resilience.<sup>18</sup> Indeed, many politically volatile areas are experiencing physical climate impacts—such as changes in temperature and precipitation—that can exacerbate extreme weather events or droughts.<sup>19</sup> Risks associated with climate change in the Middle East may exacerbate existing factors such as historical and current levels of internal conflict, competition for scarce resources, and income disparities within oil-producing nations.<sup>20</sup> Analysis of climate as a threat multiplier for conflict and instability is conducted in various ways by academia, intel-

*Analysis of climate as a threat multiplier for conflict and instability is conducted in various ways by academia, intelligence and defense organizations, and other research organizations, but the second order impacts on energy security are understudied.*

ligence and defense organizations, and other research organizations, but the second order impacts on energy security are understudied. Scenario analysis is one key approach used by defense organizations to do so.

Instability in developing nations can affect energy systems in a variety of ways as institutions become less functional. However, interruption of

*The literature indicates that climate change's potential to trigger conditions that may interrupt oil supplies is most likely to occur in Africa.*

energy supply is the threat in which policymakers and security organizations from more developed nations are most interested. The literature indicates that climate change's potential to trigger conditions that may interrupt oil supplies is most likely to occur in Africa. The DoD observes that many African states are critical to continued

U.S. success in securing strategic mineral and fuel resources; the impact of climate change could destabilize fragile states by overwhelming their political systems and eroding government legitimacy.<sup>21</sup> Inadequate governance and regime fragility will impede near-term responses to the impact of climate change, including water availability, food production, health, and local economic output.

In 2010, the United States relied on African sources for at least sixteen percent of its oil imports.<sup>22</sup> However, vast quantities of unconventional oil and gas discovered on U.S. soil will radically diminish the need to continue imports at the current level, changing the geopolitics of energy. Demand for oil is growing in rapidly developing Asian economies including China. Greater continued reliance on African oil, which reached a level of at least twenty-four percent in 2010, will make China more vulnerable to supply disruptions than the United States. China's oil consumption growth accounted for half of the world's oil consumption growth in 2011.<sup>23</sup>

Within Africa, Nigeria is a particularly troubling case study. Since the 1990s, rebel groups in southern Nigeria, where the majority of oil infrastructure is located, have reacted to political and income disparities by pirating oil, sabotaging oil equipment, and holding oil company employees hostage.<sup>24</sup> This insurgency may have no connection to climate change, but it demonstrates that energy systems can be attractive targets for attack when conflict ignites.

Climate impacts are starker in northern Nigeria, where 200 villages have been abandoned due to desertification. Resultant migration and unrelated population growth have added to existing stability.<sup>25</sup> Uprisings in 2010 and 2011, related to land disputes and accentuated by religious differ-

ences, resulted in over 1000 casualties.<sup>26</sup> A new militant Islamist group, Boko Haram, reportedly affiliated with al-Qaeda in the Islamic Magreb (AQIM), has increased the frequency and intensity of this violence.

Boko Haram claims to represent the grievances of northern Nigerians and seeks to overthrow the existing national government and establish an Islamic state. Boko Haram pursued its objectives by bombing the United Nations headquarters in Abuja in 2011. Since 2011, Boko Haram has staged almost weekly attacks, with militants planting bombs in public or in churches in Nigeria's northeast.<sup>27</sup> If the group further contributes to ongoing violence in the state or escalates attacks on northern Christians, the results could have serious implications for the country's unity.<sup>28</sup> Boko Haram's activity is not co-located with major energy infrastructure, but illustrates that social instability associated with climate stress in northern Nigeria may foment conflict and weaken the state's resilience and oil producing capability by forcing it to contend with multiple conflicts. Taken, together, the violence in the northern and southern regions of Nigeria substantially weakens the capacity of the Nigerian government to dedicate resources to priorities, such as development, and suggests that climate change has strong potential to amplify energy insecurity.

The ongoing conflict in Sudan's Darfur region, which possesses significant oil reserves, is also commonly regarded as hinging on competition for dwindling ecological resources stemming in part from the impact of climate change.<sup>29</sup> Busby et al. have studied North Africa using vulnerability indicators to determine the role that climate change might play in conflict, migration, and terrorism. Their study found the lack of a direct causal relationship between climate change and conflict, noting the situation was more complex.<sup>30</sup>

More recently, the military conflict between Sudan and South Sudan, which shares some common roots with the Darfur conflict, has led Sudan to interrupt the flow of oil from pipelines crossing the territory that South Sudan relies on to ship its oil to market.<sup>31</sup> The two countries also share oil fields. Again, the direct climate-conflict link is inconclusive, but this region remains a focal point for further analysis. However, areas of South Sudan are highly vulnerable to climate change impacts, such as extreme weather events. Heavy rainfall in 2009 not only displaced 40,000 people but also damaged roads and other infrastructure necessary to maintain oil flow.<sup>32</sup>

Other potential hot spots for supply disruptions are in areas adjacent to sensitive maritime chokepoints for oil transport, such as the Straits of Malacca. Indonesia, which is highly vulnerable to climate change, is susceptible to droughts and extreme storms.<sup>33</sup> The government's insufficient

response to natural disasters has eroded its authority in the province of Aceh, home to an active insurgency for several decades. If the central government continues to prove unable to respond to disasters, separatists might renew piracy in the Straits.<sup>34</sup> While tanker traffic could be diverted to the adjacent Lombok and Makassar Straits, thereby avoiding Indonesian territorial water altogether, a tanker heading from the Arabian Gulf to Japan would be forced to take a costly diversion around Australia. Komiss and Huntzinger estimated that a twenty percent disruption of traffic in the straits—generous estimate of the pirates' capabilities—would block five million barrels per day of 84 million, a world production level based on 2006 estimates. While no oil destined for the United States is transported through the Straits, much more significant quantities of Australian and Asia crude oil are, and the world price of oil could rise correspondingly.<sup>35</sup>

Somali pirates have occasionally intercepted oil tankers in the Arabian Sea. From 2008-2012, actual and attempted robberies against ships in this region outnumbered those in the Straits of Malacca by 447 to 9.<sup>36</sup> The total amount of oil seized has been small and it is generally returned to the world market

*While some of the conditions leading to Somali piracy against oil tankers appear to have environmental roots, the stage is set for larger scale disruption of oil supply in Sudan/South Sudan, either from severe climate events themselves or the resulting instability brought about by slower onset impacts like drought.*

after the shippers have paid ransom. However, this piracy is one of the best examples of climate change acting as an instability accelerant that in turn effects energy supply—climate change-induced drought is one of the several factors that created the conditions of conflict and government collapse in Somalia from which the pirates emerged.<sup>37</sup>

We have identified cases such as in southern Nigeria where energy supplies have been disrupted by social instability, and cases such as Indonesia where climate stressors have played a role in social instability. Yet the literature we reviewed has not identified a strong case where social instability

or conflict resulting directly from climate change has interrupted energy supply or destroyed energy infrastructure on a large scale. While some of the conditions leading to Somali piracy against oil tankers appear to have environmental roots, the stage is set for larger scale disruption of oil supply in Sudan/South Sudan, either from severe climate events themselves or the resulting instability brought about by slower onset impacts like drought.



## PHYSICAL IMPACTS OF CLIMATE CHANGE ON ENERGY SYSTEMS AND RESOURCES

The direct physical impacts of climate change, such as increased frequency and severity of storms, heat waves, and droughts are likely to impact energy security in a number of ways. Issues at the nexus of water and energy and power grid resilience have gained substantial and growing attention in the literature, indicating that policymakers are focusing on these issues. Previous reports on the physical impacts of climate change, such as the Intergovernmental Panel on Climate Change (IPCC) global climate assessments, have focused more on the impacts of climate change on natural systems and human health.

Even in developed countries, energy infrastructure is susceptible to disruption by weather conditions.<sup>38</sup> A blackout that crippled most of the U.S. northeast in 2003 occurred on a hot summer day when electricity demand was high and an overheated power line in a small Ohio town sagged and came into contact with a single tree. This normally unremarkable incident interacted with several other power system failures to create a major regional blackout that affected 50 million people in the U.S. and Canada and caused financial losses between \$4 and \$10 billion in the United States.<sup>39</sup> Increased frequency of extreme heat is likely to put greater stress on aging electrical grids.

In fact, an increase in extreme weather more generally could cause disruption. In the wake of Hurricane Katrina in 2005, many offshore oil platforms, onshore oil refineries, and other energy related facilities were completely or partially shut down for extended periods of time.<sup>40</sup> As storms are projected to become more intense with climate change, this could easily happen again—two-dozen nuclear power facilities and numerous refineries along the U.S. coasts are susceptible to storms.<sup>41</sup>

In the literature reviewed in this study, the strongest relationship between climate change and energy security was the water-energy nexus.

In many regions, climate change is likely to reduce precipitation, increase surface water evaporation, and decrease river flows. Therefore, maintaining

.....  
*In many regions, climate change is likely to reduce precipitation, increase surface water evaporation, and decrease river flows. Therefore, maintaining adequate water supply in the face of climate change is a major emerging issue for the energy industry.*  
 .....

adequate water supply in the face of climate change is a major emerging issue for the energy industry. All energy technologies require water at some stage, often in large quantities.<sup>42</sup> In fact, the energy sector accounts for eight percent of worldwide water withdrawals and is the fastest growing consumer of water in the United States.<sup>43</sup>

Water scarcity will diminish hydro-electrical generation capacity in nations turn towards this option to lower carbon emissions and diversify energy sources. China is the world's leading emitter of greenhouse gases.<sup>44</sup> To increase and diversify energy production, China generated approximately sixteen percent of its electricity from hydropower in 2009 and plans to double this capacity by 2020.<sup>45</sup> However, capacity has been declining due to recent droughts, and climate models predict reduced precipitation in some areas of China in the near future.<sup>46</sup> Declining hydropower capacity is likely to increase reliance on heavily polluting coal-fired power plants—China's cheapest alternative. Dwindling Himalayan glaciers that feed major river systems may also decrease the potential for hydroelectric generation in China, as well as for other nations in South and Southeast Asia.

Furthermore, other energy technologies rely on water. Nuclear reactors and fossil fuel electric generation plants use water for functions including cooling, steam generation, and waste disposal. Coal plant emissions can be mitigated by carbon capture and storage (CCS) technologies, but these modifications would more than double their water consumption.<sup>47</sup> Likewise, water scarcity is also a limiting factor in the liquid fuels sector where biofuels and synthetic fuels production is very water intensive.<sup>48</sup> Net withdrawal of water competes with other uses, including agriculture and human consumption.<sup>49</sup>

However, we found one example where the direct impacts of climate change actually increase access to energy resources. The melting of the Arctic ice sheet, accelerated by climate change, is expected to bring new oil supplies online and generate wealth, as the melting ice and allows seabed oil and gas to be exploited. This development will also have geopolitical consequences. Between 2008 and 2011, a spate of major policy announcements and actions focused on re-militarizing the region suggests the possibility of emerging interstate competition for control and access to the region's resources.<sup>50</sup>

### **CLIMATE CHANGE MITIGATION POLICY'S EFFECTS ON ENERGY SECURITY**

The clearest relationship and arguably most urgent issue we identified was the connection between climate mitigation policy and energy security. Long-range forecasting units of the U.S. and UK governments

have included this issue in their risk assessments. For example, the UK Ministry of Defence found that policies to mitigate climate change will have “a significant effect on the development of societal norms, the cost and usage of energy, land use, and economic development strategies by 2040.”<sup>51</sup> Climate policies may be compatible, or may work at cross-purposes, with energy security.

Policies designed to mitigate climate change and promote energy security can also be mutually reinforcing. Energy conservation is described as a “no regrets” strategy for enhancing energy security while reducing climate change—at least in developed nations. In many cases, policies that reduce demand for energy—especially oil—through technology innovation require greater energy efficiency that may also address both challenges.

One tension is that policies addressing each may require implementation on different timescales. Climate mitigation may phase in greenhouse gas emissions reductions over time because physical climate risks, such as sea level rise, evolve over decades and many of the solutions, including capital stock replacement, also require decades to implement. However, the risks associated with energy security affect national

economies on a daily basis. Climate policies can undermine energy security by limiting near term energy supply options. Consequently, Furman et al. suggest that greenhouse gas emissions reductions would be less disruptive to energy security if they were implemented only after key technological solutions—such as carbon capture and sequestration—become available for large-scale deployment.<sup>52</sup>

Some long-run solutions to climate change and energy security will require higher prices for gasoline, electricity, and home heating oil.<sup>53</sup> Carbon pricing is expected to increase the cost of fossil fuels, diminishing energy security for many consumers in the short-term, while stimulating the development of cleaner technologies in the long-term.<sup>54</sup> The key to cross-compatibility of climate and energy security is for efficiency measures to provide near-term cost reductions while maintaining or increasing

*Energy conservation is described as a “no regrets” strategy for enhancing energy security while reducing climate change—at least in developed nations. In many cases, policies that reduce demand for energy—especially oil—through technology innovation require greater energy efficiency that may also address both challenges.*

supply availability and reliability.<sup>55</sup> Whether consumption reductions can completely offset cost increases associated with more efficient technologies remains a point of contention in the grey literature.

Policies designed to increase energy security may have the perverse effect of accelerating greenhouse gas emissions. A desire to reduce reliance on foreign oil and take advantage of abundant coal reserves has led some countries to explore coal-to-liquid fuel conversion processes (CTL).

*Policies designed to increase energy security may have the perverse effect of accelerating greenhouse gas emissions.*

..... Emissions from these fuels exceed those of fuels obtained from crude oil by a factor of two.<sup>56</sup>

Regulatory uncertainty surrounding long-term climate policies, particularly in major greenhouse gas emitter nations, has also had an indirect negative impact

on energy security. In the United States, this uncertainty has caused power companies to delay capital investment decisions, such as building new natural gas, nuclear, or renewable generation facilities that would lower carbon emissions and diversify the fuel mix.<sup>57</sup> New coal-fired plants are also on hold, causing generation capacities to lag demand growth. Meanwhile, the economics of renewable and nuclear energy plant construction remains hazy.<sup>58</sup>

As an example, following the accident at the Japanese Fukushima plant, the German decision to shut down seven of its seventeen reactors and phase out nuclear energy by 2020 has implications for climate change mitigation policy and energy security. Several sources indicate that as a result of this policy, Germany produced more power through renewable energy than the nuclear sector in 2010 and 2011.<sup>59</sup> However, wind and solar power are relatively expensive and power supply is intermittent depending on changes in the weather. Therefore, German policymakers will be compelled to select another power source to supply the constant baseload power necessary for the electrical grid system to function until renewable energy becomes more economically feasible. Germany has essentially three energy choices to fulfil this goal: coal, natural gas, and imported nuclear power. Coal will substantially increase greenhouse gas emissions; natural gas supply and nuclear power are susceptible to monopolization by Russia and France respectively.

## EMERGING STRATEGIC POLICY RISKS

Policies encouraging the transition to a more secure, low-carbon energy supply are likely to entail emerging strategic and political risks that

must be considered in order to address energy security and human security, as well as to maintain policy flexibility. The grey literature identifies areas where policymakers have commissioned research analysing some of the following geopolitical risks.

World demand for nuclear energy may grow in response to climate mitigation policy, with the possibility that dual use technology could lead to weapons development. Every nation surrounding the volatile South China Sea that does not possess nuclear power—Vietnam, Malaysia, Indonesia, the Philippines, and Singapore—is considering acquiring nuclear energy.<sup>60</sup> Iran is actively developing nuclear technologies, insisting its program is purely for peaceful purposes, despite most world governments believing the contrary.<sup>61</sup> Furthermore, disposal of nuclear waste poses another consideration; while there is widespread scientific agreement on how nuclear waste disposal should be approached, the politics are complicated.<sup>62</sup>

*World demand for nuclear energy may grow in response to climate mitigation policy, with the possibility that dual use technology could lead to weapons development.*

Some clean energy technologies require large supplies of minerals or rare earth elements. Electric vehicles generally use lithium ion batteries. Worldwide lithium deposits are concentrated in the hands of a few countries. Advanced automotive technologies require significant quantities of other rare earth minerals; at least fifty percent are concentrated in China, which has exerted geopolitical leverage by threatening to cut off supplies swapping of one dependency (foreign oil) for another (foreign rare earth minerals), with significant implications for the geopolitical landscape.<sup>63</sup>

The United States has discovered vast natural gas reserves in shale deposits, and the exploitation of shale gas deposits is likely to expand to other countries within the coming decade.<sup>64</sup> A debate has emerged about the environmental consequences of the increasingly prevalent gas extraction technique called hydraulic fracturing. Howarth and others argue that this technique may release methane, one of the most potent greenhouse gases.<sup>65</sup> As the least carbon-intensive fossil fuel, natural gas is widely viewed as a bridge in the transition to lower carbon emissions. Policies that discourage the carbon-intensive fossil fuels, such as coal and oil, could encourage countries to import natural gas. Russia's threats to cut off gas supplies and the inadequate investment in infrastructure put European economies in a vulnerable position.<sup>66</sup>

Natural gas and biofuels, as well as electricity generated using renewable resources—for example, solar power, wind power, biomass—could be

used to power private vehicles and public transport systems. Policies that encourage the transition from petroleum-based transportation to alternatives could destabilize rentier oil states as their revenues decline, while transferring wealth to other suppliers, with major implications for strategic and geopolitical interests.<sup>67</sup> Biofuels reduce reliance on oil, boost farmers' incomes, and can decrease greenhouse gas emissions when best practices are applied. However, crops grown to produce biofuels could displace food crops, potentially affecting food prices and increasing food insecurity.

CONCLUSION

.....  
*From our perspective, climate change is the "actor" that may: 1) create second-order effects that exacerbate social instability and disrupt energy systems; 2) directly impact energy supply and/or systems; or 3) influence energy security through the effects of climate-related policies.*  
.....

We have found significant linkages between climate change and energy security. From our perspective, climate change is the "actor" that may: 1) create second-order effects that exacerbate social instability and disrupt energy systems; 2) directly impact energy supply and/or systems; or 3) influence energy security through the effects of climate-related policies. This heuristic frame may be helpful to those who are responsible for mitigation policy-making and management of critical energy infrastructure.

However, the grey literature we reviewed had modal characteristics that limited its utility. A research agenda that addresses the following gaps and

limitations would enhance understanding of the climate change-energy security nexus:

- **Currency of the science:** Most of the recent grey literature on climate change relies heavily on the 2007 IPCC assessment report. Scientific progress since 2006 is therefore generally neglected. This issue has been identified as a key gap for informing national security decision-makers about the risks and solutions to climate change.<sup>68</sup> Likewise, analysts that develop policy scenarios must be guided by awareness of the latest, and most likely scientific, advances in energy technologies. Stronger working partnerships between organizations that produce grey literature and scientific experts could help fill the gap.

- **Regional focus:** The majority of the literature we located and reviewed focuses on countries in the global North. The literature on climate impacts on developing countries largely emphasizes the impact of climate change in isolation from energy security. A research agenda focusing on human security is needed that includes greater emphasis on developing nations where climate impacts are expected to be especially severe, where the resilience of energy systems to withstand those impacts is expected to be low, and where many countries depend on energy exports for economic growth.
- **Level of Analysis:** The reviewed literature is focused primarily on the national level. Climate change and energy security are concepts that require evaluation on both wider (transboundary) and narrower (household) scales. Improved resolution of climate models is playing a vital role in this analysis. However, better coordination of social science and natural science sources is needed to integrate climate data with socioeconomic and political information.<sup>69</sup> Research methodologies, capabilities, and motivations vary widely among organizations that produce grey literature and the academy is needed to bring stringency and “state-of-the-science” techniques to filling research gaps. Although many grey literature sources dealt with various aspects of the climate change and energy security nexus, fewer than ten were explicitly related to this topic. This therefore suggests the need for more integrated assessments of the issue.
- **Negative Bias:** On balance, we find that existing literature demonstrates that the current and emerging impacts of climate change on energy security will be negative. These empirical findings may reflect a bias or gap in the literature. Further research could be devoted to analysis or case studies that explore the challenge of how the goals of energy security (as defined by security of supply) and climate mitigation can be achieved through policy intervention or measures or through advanced technologies.

The interdisciplinary approach taken by the grey literature is a key strength. Due to the complexity of the decisions policymakers must tackle, a literature that fully considers climate change and its consequences for energy security requires an interdisciplinary approach; yet interdisciplinary capacity remains limited in academia, with some notable exceptions.<sup>70</sup> Much of the grey literature is aimed at integrating disciplines in order to synthesize the information most tailored to inform public policy

decisions. Therefore, it is a useful resource for those conducting integrated climate change assessments, such as the IPCC reports. Also useful are tools employed outside of academia such as the synthesis of information from the deliberations of expert panels and scenario forecasting. Moreover, the grey literature, which is more directly responsive to policymakers needs, offers insight into their thinking, which can be a valuable tool in guiding academic research and revealing salient gaps in available scholarly analysis.<sup>71</sup> Finally, because the grey literature is more responsive to the practitioners' research agenda, the gaps we have identified indicate that policymakers are still largely unaware of some key implications of the climate change and energy security nexus. ■

## ENDNOTES

- 1 Jon Barnett and Neil W. Adger, "Climate Change, Human Security, and Violent Conflict," *Political Geography*, Vol. 26, [http://waterwiki.net/images/7/77/Climate\\_change\\_human\\_security\\_and\\_violent\\_conflict.pdf](http://waterwiki.net/images/7/77/Climate_change_human_security_and_violent_conflict.pdf), 639-655; N.P. Gleditsch, "Whither the Weather?: Climate Change and Conflict," *Journal of Peace Research*, Vol. 49, No. 1: 3-9.
- 2 *National Security and the Threat of Climate Change*, Center for Naval Analyses, (2007): <http://www.cna.org/reports/climate>; "Report to Congress: Energy for the Warfighter: Operational Energy Strategy," U.S. Department of Defense, (2011); *Global Trends to 2025: A Transformed World*, National Intelligence Council, (2008):[http://www.dni.gov/nic/PDF\\_2025/2025\\_Global\\_Trends\\_Final\\_Report.pdf](http://www.dni.gov/nic/PDF_2025/2025_Global_Trends_Final_Report.pdf).
- 3 *Quadrennial Defense Review*, U.S. Department of Defense, (2010); K. Harris, "Climate Change in UK Security Policy: Implications for Development Assistance," Working Paper 342, Overseas Development Institute, (January 2012).
- 4 A search on the Thomson Reuters Web of Knowledge academic search engine for sources in English using the terms "climate and energy security" in the title of peer-reviewed articles published from 2007-2012 yielded twenty results. The search time-frame was based on the publication of the latest IPCC Assessment on Global Climate Change that establishes the scientific baseline upon which further sociopolitical analysis is based.
- 5 A Boolean search of peer-reviewed scholarship in the PAIS database of political, social, and public policy issues using the search terms of "energy security" within ten words of "climate change" yielded thirty-nine results, seventeen of which were found in *Energy Policy*.
- 6 According to its website, it is "the authoritative journal addressing issues of energy supply, demand, and utilization that confront decision-makers, managers, consultants, politicians, planners, and researchers." See: *Energy Policy: The International Journal of the Political, Economic, Planning, Environmental and Social Aspects of Energy*, <http://www.journals.elsevier.com/energy-policy/>.
- 7 J. Schöpfel and D.J. Farace, "Grey Literature," in: Bates and M.N. Maack, eds, *Encyclopedia of Library and Information Sciences*, Third Edition, (London: CRC Press, 2010): 2029-2039.
- 8 "Summary for Policymakers," in S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller (eds.), *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 University



- Press: Cambridge, United Kingdom, 2007): <http://www.ipcc.ch/pdf/glossary/ar4-wg1.pdf>, 942.
- 9 Ibid.
  - 10 “Energy Security in the United States,” U.S. Congressional Budget Office, Washington, DC, (2012): <http://www.cbo.gov/sites/default/files/cbofiles/attachments/05-09-EnergySecurity.pdf>.
  - 11 Other organizations that have used the same or similar definitions include the International Energy Agency (IEA), the European Commission, and the U.S. Senate. See: B.C. Staley, S. Ladislaw, K. Zyla, J. Woodward, “Evaluating the Energy Security Implications of a Carbon-Constrained U.S. Economy,” World Resources Institute, Center for Strategic and International Studies, (January 2009).
  - 12 C. Winzer, “Conceptualizing Energy Security,” Electricity Policy Research Group, University of Cambridge, Cambridge, UK, (2011).
  - 13 J.D. Hamilton, “Oil and the Macroeconomy since World War II,” *Journal of Political Economy*, Vol. 91: 228–248.
  - 14 Sharon Burke and Christine Parthemore, *A Strategy for American Power: Energy Climate and National Security*, Center for a New American Security, (June 2008): [http://www.cnas.org/files/documents/publications/Burke\\_EnergyClimateNatlSecurity\\_June08.pdf](http://www.cnas.org/files/documents/publications/Burke_EnergyClimateNatlSecurity_June08.pdf).
  - 15 Food Crisis Response Report, UNCT (Haiti United Nations Country Team), (2008): [http://www.fao.org/newsroom/common/ecg/1000903/en/Food\\_crisis\\_report\\_Haiti\\_Jul\\_2008.pdf](http://www.fao.org/newsroom/common/ecg/1000903/en/Food_crisis_report_Haiti_Jul_2008.pdf); “Energy and Water Management Program,” U.S. Army (2012): <http://army.energy.hqda.pentagon.mil/>.
  - 16 S. Ladislaw and J. Nakano, “Leader or Laggard on the Path to a Secure, Low-Carbon Energy Future?” Center for Strategic and International Studies, (2008): [https://csis.org/files/publication/110923\\_Ladislaw\\_ChinaLeaderLaggard\\_Web.pdf](https://csis.org/files/publication/110923_Ladislaw_ChinaLeaderLaggard_Web.pdf).
  - 17 “National Security and the Threat of Climate Change,” Center for Naval Analyses, (April 2007): <http://www.cna.org/reports/climate>; “World in Transition, Climate Change as a National Security Threat,” WGBU (German Advisory Council on Climate Change), (2007): [http://www.wbgu.de/fileadmin/templates/dateien/veroeffentlichungen/hauptgutachten/jg2007/wbgu\\_jg2007\\_kurz\\_engl.pdf](http://www.wbgu.de/fileadmin/templates/dateien/veroeffentlichungen/hauptgutachten/jg2007/wbgu_jg2007_kurz_engl.pdf).
  - 18 “Trends and Implications of Climate Change for National and International Security,” U.S. Defense Science Board, (2011): <http://www.acq.osd.mil/dsb/reports/ADA552760.pdf>.
  - 19 “Summary for Policymakers,” IPCC, (2007.)
  - 20 “National Security and the Threat of Climate Change,” (April 2007).
  - 21 “Global Strategic Trends out 2040,” United Kingdom Ministry of Defence, (2010): [http://www.mod.uk/nr/rdonlyres/38651acb-d9a9-4494-98aa-1c86433bb673/0/gst4\\_update9\\_feb10.pdf](http://www.mod.uk/nr/rdonlyres/38651acb-d9a9-4494-98aa-1c86433bb673/0/gst4_update9_feb10.pdf).
  - 22 U.S. EIA, Department of Energy, [http://www.eia.gov/dnav/pet/pet\\_move\\_impacus\\_a2\\_nus\\_ep00\\_im0\\_mbbldpd\\_a.htm](http://www.eia.gov/dnav/pet/pet_move_impacus_a2_nus_ep00_im0_mbbldpd_a.htm).
  - 23 “China Country Analysis Brief,” USEIA (2013): <http://www.eia.gov/countries/country-data.cfm?fips=CH>.
  - 24 M. Werz and L. Conley, “Climate Change Migration and Conflict in Northwest Africa: Rising Dangers and Policy Options across the Arc of Tension,” Center for American Progress, (2012): [http://www.americanprogress.org/issues/2012/04/climate\\_migration\\_nwafrica.html](http://www.americanprogress.org/issues/2012/04/climate_migration_nwafrica.html).
  - 25 Ibid.
  - 26 Ibid.

- 27 A. Walker, "What is Boko Haram?" US Institute of Peace Special Report, (June 2012).
- 28 Ibid.
- 29 "National Security and the Threat of Climate Change," (April 2007); "World in Transition," (2007).
- 30 Joshua Busby, "Climate Change and National Security: An Agenda for Action," Council on Foreign Relations, (November 2007).
- 31 S. Mantshantsha, "South Sudan says it will build oil pipelines worth \$4 billion," *Bloomberg News*, June 7, 2012, <http://www.bloomberg.com/news/2012-06-07/south-sudan-says-it-will-build-oil-pipelines-worth-4-billion.html>.
- 32 Joshua Busby, "Climate Change and National Security," (November 2007).
- 33 "Summary for Policymakers," IPCC, (2007).
- 34 Joshua Busby, "Climate Change and National Security," (November 2007).
- 35 B. Komiss and R. Huntzinger, "The Economic Implications of Disruptions to Maritime Oil Checkpoints," CNA Corporation, (2011).
- 36 *Piracy and Armed Robbery Against Ships 2012 Annual Report*, ICC International Maritime Bureau, London, UK: (2013); "Energy Security and Climate Policy: Assessing Interactions," International Energy Agency (2007).
- 37 C. Webersik, *Climate and Security: A Gathering Storm of Global Challenges*, Praeger, e-book collection (EBSC host).
- 38 "National Security and the Threat of Climate Change," CNA (April 2007).
- 39 Ibid.
- 40 *Piracy and Armed Robbery Against Ships 2012 Annual Report*, ICC International Maritime Bureau, (2013); "Energy Security and Climate Policy," (2007).
- 41 *Global Trends to 2025: A Transformed World*, National Intelligence Council, (2008); "Summary for Policymakers," IPCC, (2007.)
- 42 "Summary for Policymakers," IPCC, (2007).
- 43 Nancy E. Brune, "Water-Energy-Security Nexus," Presentation delivered in Stockholm, Sweden, (August 2011): [http://www.worldwaterweek.org/documents/WWW\\_PDF/2011/Wednesday/T6/The-Water-Energy-Security-Nexus-Implication-for-Urban/The-security-implications-of-water-and-energy.pdf](http://www.worldwaterweek.org/documents/WWW_PDF/2011/Wednesday/T6/The-Water-Energy-Security-Nexus-Implication-for-Urban/The-security-implications-of-water-and-energy.pdf).
- 44 Global Greenhouse Gas Emissions Data, U.S. Environmental Protection Agency.
- 45 "Cooperation from Strength: the United States, China and the South China Sea," Center for New American Security, (2012): [http://www.cnas.org/files/documents/publications/CNAS\\_CooperationFromStrength\\_Cronin\\_1.pdf](http://www.cnas.org/files/documents/publications/CNAS_CooperationFromStrength_Cronin_1.pdf).
- 46 Ibid; "Summary for Policymakers," IPCC, (2007).
- 47 Photovoltaic (solar) and wind plants that produce a negligible amount of total world power are the only two generation technologies that do not require significant quantities of water for operation. See: Energy for Water and Water for Energy, Atlantic Council, (2011): <http://www.acus.org/publication/energy-water-and-water-energy>.
- 48 CNA Corporation, "Ensuring America's Freedom of Movement: A National Security Imperative to Reduce U.S. Oil Independence," (2011): <http://www.cna.org/EnsuringFreedomofMovement>.
- 49 D. Stover, "In Hot Water: The "Other Global Warming," Bulletin of the Atomic Scientists, (February 15, 2012): <http://www.thebulletin.org/web-edition/columnists/dawn-stover/hot-water-the-other-global-warming>.
- 50 R. Huebert, H. Exner-Pirot, A. Lajeunesse, and J. Gullede, "Climate Change and International Security: The Arctic as a Bellwether," Center for Climate and Energy Solutions, Arlington, Virginia (2012).
- 51 "Global Strategic Trends out 2040," (2010). The international community defines climate mitigation as the "stabilization of greenhouse gas concentrations at a level

- that would prevent dangerous anthropogenic interference with the climate system,” (United Nations Framework Convention on Climate Change, Article 2, 1992).
- 52 J. Furman et al, “An Economic Strategy to Address Climate Change and Promote Energy Security,” Brookings Institution, (2007): [http://www.brookings.edu/papers/2007/10/climatechange\\_furman.aspx](http://www.brookings.edu/papers/2007/10/climatechange_furman.aspx). This recommendation is at odds, however, with others such as Yohe who argue that significant greenhouse gas emissions reductions must begin immediately to achieve any long-term climate stabilization goal at the minimum cost. See: G. W. Yohe, “Addressing Climate Change through a Risk Management Lens,” in: J. Gullede, L. J. Richardson, L. Adkins, S. Seidel, eds, *Assessing the Benefits of Avoided Climate Change: Cost Benefit Analysis and Beyond*, Proceedings of the Workshop on Assessing the Benefits of Avoided Climate Change, March 16-17, 2009, Pew Center on Global Climate Change, Arlington, Virginia, <http://www.pewclimate.org/events/2009/benefitworkshop>.
- 53 J. Furman et al, (2007).
- 54 “Global Strategic Trends out 2040,” (2010).
- 55 Furman, J et al, (2007).
- 56 “Ensuring America’s Freedom of Movement,” (2011).
- 57 Charles P. Ferguson, “Nuclear Power’s Uncertain Future,” *The National Interest*, March 15, 2012.
- 58 For a review of a possible timeline for environmental regulations in the U.S. power utility sector, see: *World Resources Institute Fact Sheet*, [http://pdf.wri.org/factsheets/factsheet\\_response\\_to\\_eei\\_timeline.pdf](http://pdf.wri.org/factsheets/factsheet_response_to_eei_timeline.pdf).
- 59 M. Schneider, A. Froggatt, and S. Thomas, *Nuclear Power in a Post-Fukushima World*, Worldwatch Institute, <http://download.www.arte.tv/permanent/u1/tchernobyl/report2011.pdf>; and “Power Generation, Germany,” European Nuclear Society (2013): <http://www.euronuclear.org/info/encyclopedia/p/pow-gen-ger.htm>.
- 60 “Cooperation from Strength,” 2012.
- 61 A. Toukan, A. D. Cordesman, “Options in Dealing with Iran’s Nuclear Program,” Center for Strategic and International Studies, (2010): <http://csis.org/publication/options-dealing-iran%E2%80%99-nuclear-program>.
- 62 International Energy Outlook,” U.S. Energy Information Administration, U.S. Department of Energy, (2011): <http://www.eia.gov/forecasts/ieo/index.cfm>.
- 63 Burke and Parthemore, *A Strategy for American Power*.
- 64 “International Energy Outlook,” U.S. Energy Information Administration; “World Shale Gas Resources,” U.S. Department of Energy, (2011): <http://www.eia.gov/analysis/studies/worldshalegas/pdf/fullreport.pdf>.
- 65 R. W. Howarth, R. Santoro, and A. Ingraffea, “Venting and leakage of methane from shale gas development: Reply to Cathles et al,” *Climatic Change*, (2012).
- 66 Matthew Frank, et al., “Crossing the Natural Gas Bridge,” Center for Strategic and International Studies, (2009): <http://csis.org/publication/crossing-natural-gas-bridge>; *Global Trends to 2025: A Transformed World*, (2008).
- 67 CNA Corporation, “Ensuring America’s Freedom of Movement: A National Security Imperative to Reduce U.S. Oil Independence,” (2011): <http://www.cna.org/EnsuringFreedomofMovement>.
- 68 W. Rogers and J. Gullede, “Lost in Translation: Closing the Gap between Climate Science and National Security Policy,” Center for New American Security, (2010): <http://www.cnas.org/node/4391>.
- 69 Ibid.
- 70 Ibid.
- 71 For example, the formulation of climate change as a “threat multiplier” originated

from the CNA Military Advisory Board report, *National Security and the Threat of Climate Change* (2007) and has been cited in a great number of scholarly articles. It has also guided analysis on the climate change-conflict nexus and its implications for human security. A search on the Google Scholar search engine for “threat multiplier” yielded about 6,660 results.