

# Climate Change, Water and China's National Interest

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Outside analysts have long stressed that climate change threatens China's basic national interests. In recent months, the Chinese government has increasingly come to embrace a similar rationale, as a result moving towards aggressive efforts to limit the country's greenhouse gas emissions. In August 2009, China's cabinet, the Standing Committee of the State Council, announced that China would seek to control its greenhouse gas emissions even as it continues its economic development. Climate change, the Council affirmed, threatens China's development by increasing extreme weather events and exacerbating water shortages. As a result, China will set itself on a path towards low-carbon economic growth, stabilizing emissions within the next few decades.

This announcement, perhaps more clearly than any previous statement, illustrates the growing trend in China towards viewing climate change as a direct threat to the country's development objectives. It is clear that a number of factors, including economic interests and international political pressure, frame the Chinese government's position on climate change.<sup>1</sup> Nonetheless, given Beijing's attention at the highest levels to the strategic implications of climate change, it is vital to understand how climate change may affect the country's fundamental interests.

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At the heart of these challenges to China's future are changes in the quantity and distribution of water resources throughout the country and its neighbors. Droughts and flooding are expected to become more severe in many areas, and the melting of Himalayan glaciers is expected to lead to steep long-term declines in water availability in several areas of China and South Asia. Moreover, because of these changes, most major river systems are likely to experience an increased variability in water flow, making it harder for farmers and other users to predict water supply. Other interlinked processes, such as desertification in northern China and saltwater intrusion in low-lying coastal areas, pose further challenges to food production and ecosystems.

These changes in water availability have important implications for the Chinese government's objectives both at home and abroad. China already has contentious relations with its neighbors over many transboundary water resources, especially the Mekong River. As these resources shift and in many cases dwindle under climate change, China will have to become increasingly adept at dealing with transboundary water issues. Moreover, melting glaciers and shrinking snow packs portend severe water shortages in fragile border regions like northern Pakistan. Such specters are of great concern to Beijing as it pursues its policy of "peaceful rise."

Domestically, too, water resource changes threaten China's vision of stable and orderly economic development. Its restive western areas, including Xinjiang and Tibet, are expected to suffer most from declining water resources. Already poor and underdeveloped, these regions could experience rising inter-ethnic tension over the distribution of water or become a source of growing environmental out-migration as water-stressed inhabitants seek better opportunities elsewhere. Such migration has been documented in several parts of western China and identified by environmental security scholars as a key risk factor for environmentally-related conflict.

These implications indicate that climate change will bear increasingly on China's strategic ambitions and priorities, forcing the revision of some. Among the implications of climate change for China, three themes are particularly relevant for policy-making. First, climate change impacts are defined primarily by the uncertainty that they introduce; it is difficult to plan large-scale development objectives, for example, without being able to count on stable water resources. Second, it is clear that regional climate change impacts will be more acute in some places, like northwestern China, than in others. Third and finally, there will be a growing opportunity cost, in terms of financial, administrative and other resources, to adapting to climate change. For a developing country like China, this opportunity cost is of no small concern.

#### CLIMATE CHANGE IMPACTS IN CHINA AND ITS NEIGHBORS

The eastern portion of the Asian landmass faces particularly acute changes in water availability and distribution as a result of climate change. Many Asian nations are already under water stress, and the Asian continent has the lowest per-capita water allocation of any continent save Antarctica.<sup>2</sup>

*Water Resources and Dependency<sup>3</sup>*

<i>Country</i>	<i>Total Internal Renewable Water Resources (km<sup>3</sup>)</i>	<i>Total External Renewable Water Resources (km<sup>3</sup>)</i>	<i>Dependency Ratio (%)</i>
Afghanistan	55	10	15
Australia	492	0	0
Bangladesh	105	1,106	91
Cambodia	121	356	75
China	2,812	17	1
India	1,261	636	34
Indonesia	2,838	0	0
Iran	128	9	7
Japan	430	0	0
Kazakhstan	75	34	31
Kyrgyzstan	46	-26	0
Laos	190	143	43
Malaysia	580	0	0
Mongolia	45	0	0
Myanmar	881	165	16
Nepal	198	12	6
Pakistan	55	170	77
Philippines	479	0	0
South Korea	65	5	7
Sri Lanka	50	0	0
Thailand	210	200	49
United States	2,800	51	8
Uzbekistan	16	34	77
Vietnam	366	525	59

In northern China, the water use-to-availability ratio was three to four times the level in the south as of 2000.<sup>4</sup> In China and its immediate neighbourhood, climate change threatens to exacerbate this already tenuous water situation in several ways.

China’s National Climate Change Program asserts that “climate change has already caused changes [in] water resources distribution over China,” focusing particularly on an increase in “hydrological extreme events,” such as drought in the north and flooding in the south.<sup>5</sup> This assessment draws largely from Intergovernmental Panel on Climate Change (IPCC) data indicating an observed increase in precipitation in north and northeastern China, and a marked increase in the west (Chang Jiang delta region) and southeast.<sup>6</sup> Researchers stress that as a result of climate change precipitation is decreasing in eastern China’s agricultural areas, with drought-related agricultural losses increasing steadily since the mid-20<sup>th</sup> century.<sup>7</sup> Soil degradation as a result of climate change is further expected to increase the possibility of “disastrous drought and floods” in central, southwestern and northeastern China.<sup>8</sup>

A tendency toward more extreme climate events is also predicted for other regions surrounding China. A major study of the Indian Himalaya found that climate change will increase the variation of seasonal flows significantly.<sup>9</sup> In the Mekong river basin, Southeast Asia’s most important river system, maximum monthly water flows are expected to increase by 35 to 41 percent by mid-to late-century over 20<sup>th</sup> century levels, while the minimum monthly water flows are expected to decline by 17 to 24 percent.<sup>10</sup>

Such increased variation threatens to disrupt normal economic and agricultural activity in vulnerable regions, and, as the IPCC has noted, “there could be increased flooding risks [in the Mekong region] during the wet season and an increased possibility of water shortages in the dry season.”<sup>11</sup> In the case of the Mekong, this variability is enhanced by additional risks from sea level rise and resulting salt water intrusion, which pose a profound threat to agricultural production in the river’s delta region.<sup>12</sup>

Potentially even more serious, however, is a predicted long-term decline in water availability as Himalayan glaciers melt and snow packs are reduced in size. The IPCC estimates that a decrease in Himalayan glacier mass of about 25 percent is possible by 2050 as global temperatures rise.<sup>13</sup> This is significant, as glacial melt water accounts for some 70 percent of summer flow in the Ganges river system and 50 to 60 percent of the flow in other major Asian river systems.<sup>14</sup> One major study predicted that the flow of Himalayan melt-fed water systems will peak by 2050-2070, with annual mean flow declining thereafter by between one-fifth and one-third.<sup>15</sup> The consensus of modeling studies is that a significant portion of northwest China and northern India will be subject to declining water availability by the end of the century as seasonal water shortages arrive abruptly, “going from plenty to want in perhaps a few decades.”<sup>16</sup>

Nonetheless, there is likely to be substantial regional variability in these effects. Some river basins are likely to be particularly heavily impacted; the Tarim River for instance, Xinjiang’s most important river system, depends on glacial melt water for 40 percent of its mean annual flow.<sup>17</sup> Other areas of northwestern China are likely to be severely impacted by changes in water availability. As the IPCC has reported, “The duration of seasonal snow cover in [Chinese] alpine areas—namely the Tibet Plateau, Xinjiang and Inner Mongolia—is expected to shorten, leading to a decline in volume and resulting in severe spring droughts.” Changes of similar magnitude are predicted for major river systems elsewhere in China and Asia.

*Changes in flow of major East Asian rivers under climate change<sup>18</sup>*

<i>River system</i>	Chang Jiang	Huang He	Ganga/Brahmaputra	Mekong
<i>% change in annual mean rates of simulated discharge (D, 103 m<sup>3</sup> s<sup>-1</sup>)</i>	+28	+18	+49	-6

To summarize, water distribution patterns will become much more variable. Many areas of China are likely to have too much water when they don’t need it (i.e., flooding during the rainy season) and too little when they do (the dry summer months). Certain areas, such as north and northwestern China and the Mekong river system,

will be impacted more and by a greater combination of factors than others. This conclusion has important implications for both China’s national and regional security.

### HYDROPOLITICS IN CHINA’S NEIGHBORHOOD

It is clear that water-related climate impacts spill over China’s borders, which increases the importance of water issues in China’s foreign and regional security policies. This concern is reflected in the attitudes of China’s neighbors. In Pakistan, for instance, officials have suggested that changes in Himalayan melt water could devastate agriculture in this already fragile country.<sup>19</sup> A recent study from the Earth Policy Institute makes clear the heavy dependence of vast numbers of people on agriculture fed by glacial melt water.<sup>20</sup> (See Table 3 below.) An Asia Society report has similarly concluded that hydropolitics will be an increasingly potent force in Asian security.<sup>21</sup>

#### *Vulnerability of Major Asian River Systems to Changes in Glacial Melt Water<sup>22</sup>*

<i>River system</i>	<i>Population (million)</i>	<i>Basin area (thousand square kilometres)</i>	<i>Cropland (%)</i>	<i>Dependence on glacial melt water</i>
Tarim	8	1152	2	Very high
Indus	178	1082	30	Very high
Ganges	407	1016	72	High
Brahmaputra	118	651	29	High
Chang Jiang	368	1722	48	High
Yellow	147	945	30	High
Mekong	57	806	38	Moderate

Certain Asian river systems seem to be more contentious than others. A major study of water and conflict, for example, ranked the Ganges, Indus and Mekong rivers as at risk for conflict.<sup>23</sup> The Mekong River System presents particular challenges for China’s security. Relations between China and its downstream neighbors in the Mekong basin have long been fragile.<sup>24</sup> This situation is likely to be exacerbated by the construction of several dams in Chinese territory, which restrict flow to downstream nations. If, as climate models suggest, water flow to the Mekong becomes more variable under climate change, China’s “asymmetric” control of the river’s headwaters will become an issue of even greater concern to Southeast Asian nations.<sup>25</sup>

This power asymmetry is of special significance, since research on water and conflict suggests that a high density of dams is associated with conflictive behavior unless freshwater treaties are involved.<sup>26</sup> China has steadfastly refused to join such “hard law” regimes in the Mekong region.<sup>27</sup> Thus, it seems reasonable to assert that China will have to improve its cooperative frameworks and increase diplomacy if it is to avoid significant tension with Mekong nations as the flow of the river changes along with the climate.

There are some signs that China’s strategic studies community is beginning to come to grips with these realities. In recent years, Chinese analysts, mirroring their

Western colleagues, have articulated a broader conception of security. China's "New Security Concept," promulgated since the late 1990s, addresses environmental and social issues, and emphasizes cooperation and dialogue as a means of conducting foreign relations.<sup>28</sup> As a subset of this trend, China's strategic studies and international relations community has also devoted increasing attention to the potentially destabilizing impacts of climate change. For example, citing the broadening definition of security in the West, one prominent article advocates creating a special policy research group that focuses on the political and security dimensions of environmental change.<sup>29</sup>

Moreover, a series of Western studies, including a widely-read 2004 Department of Defense study, have prompted commentary within China over the possibility that climate-related resource shortages could lead to conflict or even war.<sup>30</sup> Some non-official commentators have more specifically identified water-related conflict as a growing threat between China and neighboring countries.<sup>31</sup> Other Chinese commentators have focused on the potential for water-related conflict to increase in politically unstable regions of the world, such as the Middle East.<sup>32</sup>

Water issues have, in parallel with this commentary, become more prominent in China's relations with some neighboring countries. China has in recent years concluded a number of agreements with countries like Russia and Kazakhstan regarding the demarcation and protection of transboundary rivers.<sup>33</sup> Furthermore, the Shanghai Cooperation Organization (SCO), initially promoted largely as a body for expanding security cooperation, has begun working on water issues. The SCO's 2004 meeting was devoted to water, and in 2005 the organization signed a compact with the Association of Southeast Asian Nations (ASEAN) to broaden cooperation on water resources.<sup>34</sup>

In contrast, however, the Chinese government has appeared hesitant to link climate change and security at a general level. For most officials, climate change simply does not rise to the level of national security.<sup>35</sup> Moreover, Beijing has strongly opposed United Nations efforts to link climate change and security through debating climate change issues in the Security Council. *China Daily*, the country's official English-language newspaper, editorialized that "The call for the international community to address climate change is sensible, but sensationalizing it as an issue of security is conspiratorial."<sup>36</sup> A separate *China Daily* report quoted China's deputy representative to the United Nations as saying, "Discussing climate change at the Security Council will not help countries in their efforts to mitigate its effects."<sup>37</sup>

One could read this general hesitancy several ways. China's long-standing support for the principle of noninterference in domestic affairs probably leads it to be suspicious of nontraditional security paradigms.<sup>38</sup> In addition, it is important to view the government's reluctance to link climate change and security in general within the context of Beijing's determination to avoid binding greenhouse gas emissions reductions.<sup>39</sup> Nonetheless, there is substantial evidence to suggest a shift of thinking at the domestic level, prompted in large part by the social challenges posed by a changing climate.

## INTERNAL UPHEAVAL: HOW LARGE A THREAT?

If at the international level Chinese officials take a dim view of linking climate change and security, domestically they appear to take very seriously the consequences of water-related climate change impacts. Premier Wen Jiabao, for instance, was quoted in 1998 as saying, “The survival of the Chinese nation is threatened by the country’s shortage of water.”<sup>40</sup> Lin Erda, a prominent member of China’s Agricultural Sciences Institute, has similarly called attention to the threat posed by retreating glaciers, saying that these and other effects of climate change “directly threaten China’s food security.”<sup>41</sup> The recent winter drought of 2008-2009 also indicated the government’s concern for water issues, with state media reporting in its wake that “Agriculture is a top government priority... [In early 2009 the] State Council and the Central Committee of the Communist Party issued their first joint document of the year, which reiterated that the development of agriculture and rural areas in 2009 was of special significance.”<sup>42</sup>

Such attention reflects in large part several distinct implications of climate change. Several of China’s most strategically important regions are predicted to suffer significant water resource shortages as a result of climate change. Some 23 percent of China’s population lives in western regions where glacial melt water provides the principal dry season water source,<sup>43</sup> and as glaciers melt, water will become increasingly scarce. One study attributes climate change for causing a decrease in stream flow during the summer months. This decrease in water availability is inducing desertification, which, exacerbated by population growth, has imposed serious socio-economic costs on an already poor area.<sup>44</sup> Such impacts are particularly significant since these western regions are not only impoverished but also the most restive in China, being home to ethnic minorities who have long mounted challenges to Beijing’s rule.<sup>45</sup>

Changes in water availability in China’s northwest can pose security challenges in two primary ways. First, competition over scarce resources can exacerbate existing tensions between China’s majority Han ethnic group and minority groups such as Tibetans and Uyghurs.<sup>46</sup> As the Asia Society report concluded, “One could certainly foresee the potential for conflict as urbanization and industry begin to deplete already scarce water supplies, particularly if certain Han-run businesses are perceived to be receiving favorable treatment in water resource allotment.”<sup>47</sup> One Chinese scholar has similarly noted the danger environmental change poses for the success of the country’s much-touted Western Development Strategy (*Xibu da kaifa*), saying “The environment of the West itself is the foundation of the Western Development Strategy.”<sup>48</sup>

Second, water scarcity could increase the number of “environmental refugees” from the northwest, potentially inflaming ethnic tensions as they seek opportunity elsewhere in China. Sociological studies have found that an increasing number of farmers in Gansu province are abandoning their lands as a result of “the rapid dete-

rioration of [their] water environment.”<sup>49</sup> Similar phenomena have been described in Tibet, where a variety of challenges are inducing higher rates of out-migration of ethnic Tibetans.<sup>50</sup>

The danger posed by such environmental refugees is that they may be deprived of the means to sustain livelihoods in their new homes. Research has indicated that gradual environmental deterioration affects the very poor disproportionately; al-

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*Scarce resources may exacerbate tensions with minority ethnic groups.*

ready bereft of resources, they have little capacity to re-establish themselves elsewhere.<sup>51</sup> Arable land is scarce in China, and environmental refugees, pulled away from their livelihoods and kinship networks, often face great difficulty setting up new livelihoods when forced to resettle.<sup>52</sup> Research by environmental security scholars has further indicated that this dislocation can cause significant social stability issues. In particular, as a result of environmental scarcity, “people migrate in large numbers to regions where resources seem more plentiful, only to fight with the people already there. Or they migrate to urban slums, where unemployed young men can be primed to join criminal gangs or radical political groups.”<sup>53</sup>

Additionally, climate-related water shortages pose challenges to China's food security. The north China winter drought of 2008-2009, which China's National Meteorology Centre classified as an “extreme weather event” attributable to climate change,<sup>54</sup> illustrates these security implications. This drought was the worst in 30 years and affected China's principal wheat-growing areas, damaging several hundred thousand acres of farmland.<sup>55</sup> Reports indicated that about 40 percent of China's winter wheat crop would be affected,<sup>56</sup> and that the drought was expected to decrease the wheat harvest, one of China's most important, by 5 percent nationally and by 20 percent in some areas, such as Henan province.<sup>57</sup> The scale of such effects has led many commentators to warn that climate-related drought in north China could threaten the country's food security.<sup>58</sup> Political factors dictate that food security is an especially sensitive issue in China, as the government is anxious to insulate the large population of rural poor from food price shocks.<sup>59</sup>

While it is unclear whether climate change will actually threaten China's total domestic food supply,<sup>60</sup> the government cannot afford to ignore extreme weather events, which increase pressure on the country's military and paramilitary institutions to develop disaster management and assistance capabilities. The drought provides an illustration of the increased need for such operations. The paramilitary People's Armed Police (PAP) mobilized some 2,400 troops over eight provinces. Additionally, assets from the People's Liberation Army and Air Force were called into service.<sup>61</sup> With the predicted increase in extreme weather events, China's military will be compelled to incorporate these domestic disaster response and assistance capabilities more closely into its operational planning strategies. Interestingly, this does not seem to have yet happened; China's recent law governing the PAP makes only brief mention of disaster relief activities, focusing instead on the force's internal security role.<sup>62</sup>



In addition to posing challenges to the country's military, adaptation to water-related climate impacts will impose serious economic costs upon China. Xinjiang Province, for example, is building 59 reservoirs to collect melt water from the Himalaya's shrinking glaciers in attempt to address concerns about long-term water availability. The ten-year project is expected to cost RMB 200 million annually for at least the next three years,<sup>63</sup> a considerable sum for one of China's poorest areas. A large-scale study also sheds light on the costs of adaptation to water distribution changes in China. After compiling water storage costs and modeling changing flow under various climate change scenarios, the study indicated that water storage costs vary widely by region; the cost of capturing 120 billion cubic meters of water are US\$4.5 billion in the southern Xi Jiang river area and less than \$2 billion in the central Chang Jiang. Most noticeably, it will become increasingly difficult and expensive to enhance water storage capacity (reservoirs, catchments, etc.) in water-stressed areas like north China, simply because water shortages will be so severe.<sup>64</sup>

The security implications of water-related climate impacts can be fundamentally characterized by the uncertainty they introduce with respect to overall water availability, food security and social stability. As one commentator has noted, climate change is an "engine of destabilization."<sup>65</sup> This characterization seems particularly appropriate with respect to China. Water-related climate impacts will be severe in several areas within China, with the result that China's military, governmental institutions and national resources will be increasingly burdened by climate change and water issues. As a result, the government has been compelled to devote more attention to these issues, a trend which is only likely to accelerate.

Concern for resource security issues does appear to drive Chinese policy-making to at least some extent. In mid-2008, state media reported that "With food and water security becoming great concerns around the world, China will take measures to ensure agricultural water use and promote its plan to increase food production," including raising the price of water.<sup>66</sup> China further appears to take the issue of water availability in the Himalayans seriously, flying several cloud-seeding sorties a month to increase rainfall and water availability on the Tibet-Qinghai Plateau.<sup>67</sup> Perhaps the clearest statement of the government's linkage of water and security issues, however, is the National Framework for Medium to Long-Term Food Security, released in 2008, which emphasizes water-saving agriculture and conversation.<sup>68</sup>

Chinese discourse on climate, water and security is clouded. There remains a general reticence to link climate change issues and security; however, with regard to specific issues, government officials have been quite clear about the threats posed by climate change impacts. At the domestic level, official voices have expressed particular concern over inequities in water resource distribution, as well as potential implications for food security. The net result is that it is reasonable to assume China's foreign and security policy framework has not been broadened to include climate-related impacts. Given the manifold strategic challenges these impacts will pose for China, this is of some concern.

## STRATEGIES FOR CLIMATE, WATER AND SECURITY

Despite the uncertainties inherent in assessments of the future, it's safe to say that water-related climate change impacts will increasingly bear on China's security, foreign relations and political discourse. Both Chinese and foreign policy-makers will be compelled to deal with several key issues. First among these is uncertainty. The climate system is incredibly complex, making precise scientific assessment of climate change impacts, particularly on water, extremely difficult. As a result of this fundamental uncertainty, the security implications of such change center on grave but general threats to stability, including large-scale migration, decreasing agricultural water availability and increased risk of catastrophic flooding.


A second issue relates to acute regional impacts. It is clear that specific regions, such as the Mekong River, parts of the Indian Himalaya and northwest China, will be more severely impacted by changes in hydrology under climate change. In most such cases, these ecological impacts will be exacerbated by social, economic and political factors; in the Mekong, water management is hampered by transboundary political disputes, while in northwest China ethnic tensions and poverty enhance the threat of climate-hydrological changes. Thus, the political-security implications of such changes are likely to be centered on several specific "hot spot" regions.

The third and final major issue is that water-related climate change impacts will strain the capacity of Chinese institutions and policy frameworks. This is particularly evident with respect to the military's natural disaster response capabilities and transboundary water management policy, as well as with domestic agricultural, emergency management and water management policies. The Chinese government, perhaps with the increased aid of international and civil society actors, will be pressed to improve its conceptual, planning and implementation capacities in each of these policy areas. China will be forced to devote large economic resources to adaptation, including the construction of flood defenses, reservoirs and water distribution systems, if it is to escape the worst water-related climate change impacts. At a time when China's development priorities demand investment in so many areas, this increasing burden is almost certain to increase political tensions between provinces and governmental institutions.

Nonetheless, these issues in fact point a way forward for improving international cooperation on climate change. First, water-related security issues present a particularly good opportunity to broaden and deepen bilateral and regional cooperation on climate change. Acute institutional vulnerabilities, such as increased strain on emergency management and disaster response capabilities in China, present opportunities for international technical assistance and cooperation. A recent Council on Foreign Relations (CFR) paper, for example, recommends that the US military integrate climate-related extreme weather response into its regional command structure,<sup>69</sup> by building dialogue between such commands, their Chinese and other Asian counterparts could dramatically improve the efficacy of international disaster response efforts.

Moreover, adaptation assistance under the new climate regime can be focused to address strategic concerns such as food security. The US Agency for International Development (USAID) has launched a program in cooperation with the Gates Foundation to develop new rice varieties capable of surviving various climate change-related stresses. The \$35 million project will focus on enabling farmers in South Asia to obtain higher rice yields even in the face of climate change, with fewer inputs of fertilizer and irrigated water. Similar models could be explored, possibly with a greater degree of co-financing, in China.<sup>70</sup>

Finally, climate change cooperation should be seen not only as an ecological imperative, but also as a strategic one. As the Council on Foreign Relations has noted, international climate negotiations have a clear national security dimension, inasmuch as the international community has an interest in integrating nations like China and India into a “rules-based global order” through participation in climate negotiations.<sup>71</sup> This interest is heightened when the security ramifications of climate change are considered. Particularly when applied to the kinds of hot spot regions likely to become flashpoints in a changing climate, the strategic approach can help to guide policy-makers towards adopting long-term, systemic approaches to addressing climate change.

Given the severity of climate change for both China and the world at large, it's welcome news that Beijing increasingly sees reducing its own emissions as a matter of national interest. But getting a better idea of what's at stake can provide valuable insights to guide the progress of global climate cooperation. Framing climate change as a strategic security issue helps to parse its manifold repercussions, which stretch from instability in China's borderlands to pressures on local government coffers. It also provides added perspective on how large climate change will loom in the future of both China and the world, unless aggressive steps are taken to prevent it. 

## NOTES

- <sup>1</sup> See, for example, Elizabeth Economy, "Decoupling China in the Climate Change Debate," Sept. 22, 2009, <[http://www.cfr.org/publication/20247/decoupling\\_china\\_in\\_the\\_climate\\_debate.html?breadcrumb=%2Fbios%2F21%2FElizabeth\\_c\\_economy%3Fgroupby%3D3%26amp%253Bhide%3D1%26amp%253Bid%3D21%26filter%3D2009](http://www.cfr.org/publication/20247/decoupling_china_in_the_climate_debate.html?breadcrumb=%2Fbios%2F21%2FElizabeth_c_economy%3Fgroupby%3D3%26amp%253Bhide%3D1%26amp%253Bid%3D21%26filter%3D2009)>.
- <sup>2</sup> *Asia's Next Challenge: securing the region's water future* (New York: Asia Society, 2009), p. 9.
- <sup>3</sup> *Asia's Next Challenge: securing the region's water future* (New York: Asia Society, 2009), p. 44.
- <sup>4</sup> Zmarak Shalizi, *Addressing China's Growing Water Shortages and Associated Social and Environmental Consequences*, April 18, 2009, p. 8, <[http://www-wds.worldbank.org/external/default/WDSContentServer/IW3P/IB/2006/04/18/000016406\\_20060418155242/Rendered/PDF/wps3895.pdf](http://www-wds.worldbank.org/external/default/WDSContentServer/IW3P/IB/2006/04/18/000016406_20060418155242/Rendered/PDF/wps3895.pdf)>.
- <sup>5</sup> *China's National Climate Change Program* (Beijing: National Development and Reform Commission, 2007), p. 22.
- <sup>6</sup> B.C. Bates, Z.W. Kundzewicz, S. Wu and J.P. Palutikof, *Climate Change and Water*. Technical Paper of the Intergovernmental Panel on Climate Change (Geneva: IPCC Secretariat, 2008), pp. 85-6.
- <sup>7</sup> Yang Jianping, Ding Yongjian, Chen Rensheng, & Liu Lianyou, "Fluctuations of the Semi-Arid Zone in China, and Consequences for Society," *Climactic Change* (2005), p. 184.
- <sup>8</sup> Fulu Tao, Masayuki Yokozawa, Yousay Hayashi, & Erda Lin, "A perspective on water resources in China: interactions between climate change and soil degradation," *Climactic Change* (2005), p. 169.
- <sup>9</sup> Pratap Singh, Manohar Arora, & N.K. Goel, "Effect of climate change on runoff of a glacierized Himalayan basin," *Hydrological Processes* (2006), p. 1991.
- <sup>10</sup> Bates, Kundzewicz, Wu & Palutikof (2008), p. 87.
- <sup>11</sup> *Ibid.*
- <sup>12</sup> Reiner Wassmann, Nguyen Xuan Hien, Chu Thai Hoanh, & To Phuc Tuong, "Sea level rise affecting the Vietnamese Mekong Delta: water elevation in the flood season and implications for rice production," *Climactic Change* (2004), p. 89.
- <sup>13</sup> *The Regional Impacts of Climate Change: An Assessment of Vulnerability*. Intergovernmental Panel on Climate Change (1997), p. 14.
- <sup>14</sup> T. Barnett, J. Adam, & D. Lettenmaier, "Potential impacts of a warming climate on water availability in snow-dominated regions," *Nature* (2005), p. 306.
- <sup>15</sup> H. Gwyn Rees & David Collins, "Regional differences in response of flow in glacier-fed Himalayan rivers to climactic warming," *Hydrological Processes*, (2006) pp. 2167-2168.
- <sup>16</sup> T. Barnett, J. Adam, & D. Lettenmaier, "Potential impacts of a warming climate on water availability in snow-dominated regions," *Nature* (2005), pp. 304-306.
- <sup>17</sup> Liu Yongbo & Chen Yaning, "Impact of population growth and land-use change on water resources and ecosystems of the arid Tarim River basin in western China," *International Journal of Sustainable Development and World Ecology* (2006), p. 298.
- <sup>18</sup> Adapted from S. Manabe, R. Wetherald, P. Milly, T. Delworth, & R. Stouffer, "Century-Scale Change in Water Availability: CO<sub>2</sub>-Quadrupling Experiment," *Climactic Change* (2004), p. 65.
- <sup>19</sup> Sandip Das, "Glacier melting to hit Pakistan's agriculture," *Financial Express*, March 5, 2008, <<http://www.financialexpress.com/printer/news/280876/>>.
- <sup>20</sup> Lester Brown, "Melting mountain glaciers will shrink grain harvests in China and India,"

Earth Policy Institute, <[http://www.earthpolicy.org/Updates/2008/Update71\\_data.htm](http://www.earthpolicy.org/Updates/2008/Update71_data.htm)>.

<sup>21</sup> Asia's Next Challenge: securing the region's water future (New York: Asia Society, 2009), p. 13.

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