Jun 18th, 9:45 AM - 10:30 AM

Climate change, water, and China's security : implications for global cooperation on climate change

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Abstract

This paper links the issues of climate change, water, and China's security, arguing that the water-related impacts of climate change post significant strategic challenges for China and Asia, with consequent implications for China's participation and engagement in global climate change cooperation efforts. Specifically, water-related climate impacts will strain the capacity of many key public institutions, and imperil the government's strategic development objectives. Recognizing these imperatives points the way toward a strategic dialogue with China on climate change. This paper first discusses scientific assessments of predicted hydrological changes in China and neighboring countries under climate change, progressing to a security analysis of the challenges these changes pose, and finally discusses how Chinese policymakers and commentators view climate change and water as geopolitical issues. This paper concludes by examining implications for global climate cooperation.

Introduction: Linking Climate Change, Water, and China's Security

As the world approaches the international climate negotiations at Copenhagen in December 2009, the two imperatives of promoting economic development and protecting the global atmospheric commons seem increasingly to stand at odds. Even as scientific assessments of the impacts of climate change grow more urgent, large developing nations like China and India continue to prioritize their own economic goals. Given the difficulties in resolving this impasse, it is helpful to think broadly about all dimensions of the climate change problem, social, political, economic and ecological.

This paper seeks a role in this debate by examining the strategic-security implications for China of a changing climate, with specific reference to water issues. It does so chiefly with an eye towards evaluating the contribution that such a perspective can make to shaping China's participation in global cooperation on climate change. Most commentators agree that China will play a crucial role in finalizing a post-2012 climate agreement; from this perspective, there is clear value to seeking a security imperative in its approach to international cooperation on climate change. As international relations scholar Katherine Morton has pointed out, the value in "securitizing" the climate issue is that "In situations where there is a growing international consensus that a problem exists, but limited consensus on the most effective and fair method of dealing with it, a preventive security approach encourages action on the basis of a pragmatic calculation that prevention is better than cure" (Morton, 2008, p. 54).[2]

The argument presented here is that water-related impacts of climate change imperil many of China's strategic development objectives, presenting an opportunity for foreign countries to engage the country in a strategic dialogue on climate cooperation. This paper first presents a scientific assessment of water-related climate change impacts, both in China and its neighboring countries. Next, it discusses strategic and security implications for China's foreign relations, domestic issues like food security, and also internal stability. The final section of the paper discusses discourse on climate change, water, and security topics within China, pursuing an understanding of how such discourse could help frame the

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[2] Morton also appropriately notes the objections of some who argue that securitizing environmental issues distracts from ecological, moral, and other imperatives to protect the environment. This paper does not specifically consider such objections here, instead choosing to qualify its conclusions and recommendations with these objections in mind.

country's participation in an international, strategic dialogue on climate change issues. This multifaceted approach, spanning the physical and social sciences, frames the Conclusions section, which identifies cross-cutting issues related to water, climate change, and China's security and also discusses implications for global climate cooperation.

This integration of climate change, water, and Chinese security issues is timely for several reasons. First, many of the most severe likely impacts of climate change in China and Asia generally are water-related, such as a predicted long-term decline in water runoff from the Himalayan region (Intergovernmental Panel on Climate Change, 1997, p. 15). Second, there is growing recognition of the linkages between water availability, conflict, and security issues in Asia. As a recent Asia Society report notes, "more than one billion people in Asia alone are projected to experience negative impacts on water resources as a result of climate change…Over time, these effects will have a profound impact on security throughout the region" (Asia Society, 2009, p. 7). Finally, climate change is becoming an important issue in China's relations with the rest of the world, as indicated by the recent visit of US Secretary of State Hillary Clinton to Beijing (Landler, 2009). Despite this confluence of factors, few commentators have focused specifically on the implications for China's security of water-related climate impacts. It is thus high time to do so.

Before delving into this discussion, the linkages between climate change, water, and security require further articulation. Recent decades have witnessed the gradual broadening of the concept of security from its traditional political and military foundations. In an influential 1989 article, former US government official Jessica Mathews called for a redefinition of national security to "include resource, environmental and demographic issues" (Mathews, 1989, p. 162). Subsequent research and scholarship has given prominence to the field of environmental security, which in one articulation "is central to national security, comprising the dynamics and interconnections among the natural resource base, the social fabric of the state, and the economic engine for local and regional stability" (Institute for Environmental Security, 2004).

Several strands of environmental security and related discourse are of relevance to this paper. First is a growing body of scholarship that has identified clear, though context-specific linkages between resources scarcity, environmental change, and conflict, particularly at the sub-national level (Homer-Dixon, Environmental Scarcities and Violent Conflict: Evidence from cases, 1994). As a recent United Nations report concluded, "Environmental factors are rarely if ever the sole cause of conflict, but exploitation of resources is present in each stage of the conflict cycle" (United Nations Environment Program, 2009, p. 5). Second is the increasing focus of many institutions with a traditional security focus on climate change and instability. In 2007 the United Nations Security Council held its first-ever debate on climate change, and a major US Centre for Naval Analyses report found that "Climate change acts as a threat multiplier for instability in some of the most volatile regions of the world" (Center for Naval Analyses, 2007, p. 6).

In addition, the concept of human security is relevant to discussions of some of the water-related impacts China is likely to face as a result of climate change. According to one widely accepted definition, "The objective of human security is to safeguard the vital core of all human lives from critical pervasive threats, in a way that is consistent with long-term human fulfilment" (Alkire, 2002). Human security thus entails issues, such as an equitable distribution of resources, that do not fall within more traditional or restrictive conceptions of security (Morton, 2008, p. 54). Here, however, the value of a human security perspective is that it facilitates the analysis of water-related climate impacts within the context of China's pervasive regional, ethnic, and economic disparities.

Applying these broadened conceptions of security to water-related climate impacts focuses this paper on the social and political consequences of shifting water resource

distributions within China. from this perspective, it is possible to understand more concretely the security consequences of a changing climate in china, and to discuss how these consequences can and should guide both Chinese and international approaches to global climate cooperation. To begin this discussion, this paper turns now to a scientific assessment of water-related climate impacts for China and its Asian neighbours.

Water-Related Climate Change Impacts in China and Asia: the Scientific Basis

The eastern portion of the Asian landmass, of which China is a part, faces particularly acute changes in water availability and distribution as a result of climate change. While climate modeling is subject to significant uncertainties, this section identifies two such changes which are of particular relevance to non-traditional security issues (discussed in the subsequent section). First, the incidence of extreme water-related phenomena, such as prolonged drought and severe flooding, is likely to increase. Second, some regions, many of them already under water stress, are likely to be heavily, and perhaps catastrophically, impacted by changes in water availability. This section indicates that, based on existing scientific research, whatever the precise nature and distribution of water-related climate change impacts in China and its neighboring countries, they will be acute and pervasive.

Many Asian nations are already under water stress, and the Asian continent has the lowest per-capita water allocation of any continent save Antarctica (Asia Society, 2009, p. 9); (See Table 1 below).

Table 1: Water Resources and Dependency (From Asia Society, Asia's Next Challenge: Securing the Region's Water Future, p. 44)

Country	*Total Internal Renewable Water Resources (km3)*	*Total External Renewable Water Resources (km3)*	*Dependency Ratio (%)*
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

Moreover, as a recent Intergovernmental Panel on Climate Change (IPCC) report has concluded, "Asia has a very high population that is growing at a fast rate, low development levels and weak coping capacity. Climate change is expected to exacerbate the water scarcity situation in Asia, together with multiple socio-economic stresses" (Bates, Kundzewicz, Wu, & Palutikof, 2008, p. 85). In India, for example, over-exploitation of groundwater resources and population growth is expected to reduce per capita water availability by almost 50% by 2025 (China Daily, 2007, p. 6). In north China, the water use to availability ratio was three to four times the level in the south as of 2000 (Shalizi, 2006, p. 8). In China and its immediate neighbourhood, climate change threatens to exacerbate this already tenuous water situation in several ways.

The hydrology of Eastern Asia is dominated by two processes: atmospheric circulation, principally the Asiatic monsoon and El Nino-Southern Oscillation (ENSO), as well as a snow- and glacial-melt regime situated on the Himalayan region (Barnett, Adam, & Lettenmaier, 2005); (Xu, Takeuchi, & Ishidaira, 2004, p. 108). In China, for example, changes in aridity are determined primarily by summer precipitation, mostly the East Asian monsoon (Yang, Ding, Chen, & Liu, 2005, p. 177). Atmospheric circulation, though relatively poorly understood, appears to be set to increase the variability of precipitation and the risk of flooding as a result of climate change, while glacial melting will cause significant changes in the flow of Asia's major rivers. Both have the potential to impose large economic costs and to disrupt agriculture.

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 (National Development and Reform Commission, 2007, p. 22). This assessment draws largely from 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 (Bates, Kundzewicz, Wu, & Palutikof, 2008, pp. 85-86). Yang, et al., for example, note that as a result of climate change precipitation is decreasing in eastern China agricultural areas, with drought-related agricultural losses increasing steadily since the mid-twentieth century (Yang, Ding, Chen, & Liu, 2005, p. 184). Tao, et al. similarly predicted that soil degradation under a changing climate would lead to higher probability of "disastrous drought and floods" in central, southwestern, and northeastern China (Tao, Yokozawa, Hayashi, & Lin, 2005, p. 169).

A tendency toward more extreme climate events is also predicted for other regions. A major study of the Indian Himalaya found that climate change will increase the variation of seasonal flows significantly (Singh, Arora, & Goel, 2006, p. 1991). In the Mekong, Southeast Asia's most important river system, maximum monthly flows are expected to increase by 35-41% by mid-to late century over 20th century levels in the river basin, while the minimum monthly flows are expected to decline by 17-24% (Bates, Kundzewicz, Wu, & Palutikof, 2008, p. 87).

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" (Bates, Kundzewicz, Wu, & Palutikof, 2008, p. 87). In the case of the Mekong, this variability is enhanced by additional risks from sea level rise and resulting salt water intrusion poses a profound threat to agricultural production in the river's delta region (Wassmann, Hien, Hoanh, & Tuong, 2004, p. 89).

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% is possible by 2050 as

global temperatures rise (Intergovernmental Panel on Climate Change, 1997, p. 14). This is significant as glacial melt water accounts for some 70% of summer flow in the Ganges river system, and 50-60% of the flow in other major Asian river systems (Barnett, Adam, & Lettenmaier, 2005, p. 306). One major study predicted that Himalayan melt-fed water systems would peak at 150-170% of initial flow by 2050-2070, with annual mean flow declining thereafter by 33% and 4-18% less in the western and eastern Himalayan regions, respectively (Rees & Collins, 2006, pp. 2167-2168). As Barnett, et al. conclude, 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" (Barnett, Adam, & Lettenmaier, 2005, pp. 304-306).

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% of its mean annual flow (Liu & Chen, 2006, p. 298). Other areas of north-western 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. Between 20% and 40% reductions in runoff per capita in Ningxia, Xinjiang and Qinghai Provinces are *likely* by the end of the 21st century" italics original (Bates, Kundzewicz, Wu, & Palutikof, 2008, p. 87).

Changes of similar magnitude are predicted for major river systems elsewhere in China and Asia. A major study by Manabe, et al., which attempted to model the effects of a quadrupling of atmospheric carbon dioxide concentrations above pre-industrial levels, concluded that most major Asian rivers, including the Chang Jiang (Yangtze) and Huang He (Yellow River) in China, and the Ganga/Brahmaputra in the Indian Subcontinent, were likely to experience large increases in flow on a one-hundred year timescale, but that the Mekong was expected to experience a 6% decrease (S. Manabe, Milly, Delworth, & Stouffer, 2004, p. 65); (see Table 2 below).

Table 2: Changes in flow of major East Asian rivers under climate change (Adapted from S. Manabe, Milly, Delworth, & Stouffer, 2004, p. 65)

River system	Chang Jiang	Huang He	Ganga/Brahmaputra	Mekong
% change in annual mean rates of simulated discharge (D, 103 m3 s−1)	+28	+18	+49	-6

Uncertainty and variability are also dominant themes in projections of changes regarding precipitation patterns. For instance, in a wide-ranging simulation of climactic and soil conditions, Tao et al. predicted that areas of central, western, and south-western China would face large soil-moisture deficits as a result of climate change, which in turn reduces precipitation (Tao, Yokozawa, Hayashi, & Lin, 2005, p. 193). The IPPC, however, notes that 2/3 of modelling studies on the same area predicts an increase in precipitation (Bates, Kundzewicz, Wu, & Palutikof, 2008, p. 88).

While some studies suggest that in north China only 70% of irrigation needs can be met under climate change scenarios, a major study of Chinese agricultural production under climate change indicates that the country will be able to meet its food requirements under any of the IPCC climate warming scenarios, assuming a carbon-dioxide fertilization effect

(Xiong, Lin, Ju, & Xu, 2007, p. 208).[3] Other research has broadly supported this conclusion, predicting increased production of staple food crops in China (Lobell, Burke, Tebaldi, Mastrandrea, Falcon, & Naylor, 2008, p. 609) and an increase in global food production generally under various climate change scenarios (Parry, Rosenzweig, Iglesias, Livermore, & Fischer, 2004, p. 63).

The best summary of these potential water-related climate impacts appears to be that water distribution patterns will become much more variable. Another characterization might be that 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 northern and north-western China and the Mekong river system, will be more impacted, and by a greater combination of factors, than others. This conclusion has important implications for both China's national and regional security.

Strategic-Security Analysis of Water-Related Climate Impacts in China and Surrounding Countries

The scientific assessment presented above predicts that water-related climate impacts will be acute not only in China, but in surrounding nations as well. As a result, this strategic-security analysis first considers implications for China's regional security and foreign relations, before turning inward, to examine threats posed to food production, disaster management capacities, and internal stability within China. This section argues that water-related climate impacts will stress the disaster response and emergency management capacities of key institutions, such as the armed forces, and imperil many of the government's key strategic development objectives, such as the Western Development Strategy.

It is clear that water-related climate impacts spill over China's borders, which will increase the importance of water issues in China's foreign and regional security policies. Indeed, regional actors are already expressing growing concern over such water issues. At the 2008 World Economic Forum, 81% of business leaders ranked climate change and water issues as being those of greatest concern to Asia (Info-Prod Research, 2008). The Filipino Defense Secretary made a similar pronouncement with his recent statement that climate change is a greater long-term threat to his country's security than religious or social conflict, in large part due to water supply concerns (Antiporda, 2009).

This concern is reflected in the attitudes of China's neighbours. In Pakistan, for instance, officials have suggested that changes in Himalayan melt water could devastate agriculture in this already fragile country (Das, 2008). A recent study from the Earth Policy Institute makes clear the heavy dependence of vast numbers of people on glacial melt water-fed agriculture (Brown, 2008); (see Table 3 below). Given such dependence, transboundary water issues are certain to become an issue of growing importance for China. As the Asia Society's report on water and security has concluded, hydropolitics will be an increasingly potent force in Asian security (Asia Society, 2009, p. 13).

[3] A carbon-dioxide fertilization effect asserts that increased fixation of carbon dioxide, resulting in increased crop growth and yield. However, the extent of CO2 fertilization effects is contentious. See, for example, L. Hartwall Allen, Jeff Baker and Ken Boote, "The CO2 fertilization effect: higher carbohydrate production and retention as biomass and seed yield," Food and Agriculture Organization, http://www.fao.org/docrep/W5183E/w5183e06.htm, accessed May 26, 2009.

Table 3: Vulnerability of major Asian river systems to changes in glacial melt water (Adapted from Earth Policy Institute and U.N. Environment Programme, Global Outlook for Ice and Snow (Nairobi, Kenya: 2007), p. 131)

River system	*Population (million)*	*Basin area (thousand square kilometres)*	*Cropland (%)*	*Dependence on glacial melt water*
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

In particular, certain Asian river systems seem to be more contentious than others. Based on their study of conflict and cooperation over water, Yoffee, et al. developed a "Basins at Risk" indicator, which ranks the Ganges, Indus, and Mekong as at risk for conflict (Yoffe, Wolf, & Giordano, 2003, p. 1123). Among these, the Mekong River System presents particular challenges for China's security. Relations between China and its downstream neighbours in the Mekong basin have long been fragile (Morton, 2008, p. 8). 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 (Asia Society, 2009, p. 17).

This particular power asymmetry is of special significance, since Yoffee, et al.'s research suggests that a high density of dams is associated with conflictive behaviour, unless freshwater treaties are involved (Yoffe, Wolf, & Giordano, 2003, p. 1116). China has steadfastly refused to join such "hard law" regimes in the Mekong region (Nielsen, 2007, p. 217). Thus, it seems reasonable to assert that China will have to improve its cooperative frameworks if it is to avoid significant diplomatic tension with Mekong nations as the flow of the river changes along with the climate. Simply put, Beijing will almost certainly have to devote more diplomatic attention to the Mekong and other potential Asian "water hotspots" as climate change impacts accelerate.

In mainland China, specific regional impacts also appear to represent the most pressing security challenges. Several of China's most strategically important regions are predicted to suffer significant water resource shortages as a result of climate change. As Barnett, et al. have observed, some 23% of China's population lives in western regions where glacial melt water provides the principal dry season water source (Barnett, Adam, & Lettenmaier, 2005, p. 306), and as glaciers melt, water will become increasingly scarce during the dry season. One study, describing the disappearance of an oasis in north-western Gansu province, 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 socioeconomic costs on an already poor area (Kang, Su, Tong, Zhang, Zhang, & Davies, 2008, p. 444). 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 (Davis, 2008).

These Changes in water availability in China's restive 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 the

Tibetans and Uyghur (Bhattacharji, 2008). As the Asia Society report has 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 favourable treatment in water resource allotment" (Asia Society, 2009, p. 19). 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" (Lu, 2008).

Second, water scarcity could increase the numbers of "environmental refugees" from China's northwest, potentially inflaming ethnic tensions and increasing socioeconomic burdens (round out this sentence) as they seek opportunity elsewhere in China. A study by Kang, et al. found that increasing numbers of farmers in Gansu province are abandoning their lands as a result of "the rapid deterioration of [their] water environment" (Kang, Su, Tong, Zhang, Zhang, & Davies, 2008, p. 446). Similar phenomena have been described in Tibet, where a variety of challenges are inducing higher rates of out-migration of ethnic Tibetans (Morton, Climate Change on the Tibetan Pleateau: a new human security challenge, 2009). In the high Himalaya, minorities may be affected less by water shortages and more by increasing exposure to geologic hazards, such as the threat of flooding from glacial melt waters and landslides as permafrost melts (Hewitt, 2009). Nonetheless, the potential for environmental refugee outflows to increase exists in both regions.

The danger posed by such environmental refugees[4] is that they may be deprived of the means to sustain livelihoods in their new homes. Research has indicated that gradual environmental deterioration, as may be expected under climate change, affects the very poor disproportionately; already bereft of resources, they have little capacity to re-establish themselves elsewhere (Bates D. , 2002, p. 469). As Yan and Qian have described, arable land is scare in China, and environmental refugees, pulled away from their livelihoods and kinship networks, often have great difficulties in setting up livelihoods when forced to resettle (Yan & Qian, 2004, pp. 631-632). 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" (Homer-Dixon, Terror in the weather forecast, 2007).

Additionally, climate-related water shortages pose threats 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" (*Jiduan qihou shijian*) attributable to climate change (Liu Y. , 2009), illustrates these security implications. This drought, which occurred during the winter of 2008-2009, was the worst in 30 years, and affected China's principal wheat-growing areas, damaging 2.7 million *mu* of farmland[5] (Zhang & Wang, 2009). News reported indicated that about 40% of China's winter wheat crop would be affected (Li, 2009), and that the drought was expected to decrease the wheat harvest, one of China's most important, by 5% nationally, and by 20% in some areas, such as Henan province (Xinhua News Agency, 2009).

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 (Liu S. , 2009). Political factors dictate that food security is an especially sensitive issue in China, as the government

[4] There is a technical though important distinction between "refugee" and "migrant." Refugees, according to the United Nations, are persons who are compelled to migrate by external factors, while migrants are those who choose to do so for other, typically economic reasons.

[5] This figure is equivalent to approximately 180,000 hectares (1 mu= 0.0667 hectares).

is anxious to insulate the large population of rural poor from food price shocks (Brown, 2008). While it is unclear whether, as Xiong, et al. have indicated, climate change will actually threaten China's total domestic food supply, it is clear that the government cannot afford to ignore extreme weather events, placing increasing pressure on the country's military and paramilitary institutions to develop disaster management and assistance capabilities.

Indeed, the drought provides an illustration of the increased need for such operations. The paramilitary People's Armed Police (*Renmin wuzhuang jingcha*) mobilized some 2400 troops over eight provinces, with commanders pledging to "make all-out efforts to fight the drought and prevent disaster," while also joining a "battle to snatch a bumper harvest." Additionally, assets from the People's Liberation Army, including seven Air Force aircraft and engineers from the country's strategic nuclear forces, were called into service. The Jinan Military District accompanied its mobilization with the exhortation to "call upon the [Sichuan] earthquake relief spirit" (*Fachang kangdi jiuzai jingshen*) (Wang, et al., 2009). With climate models predicting increasing incidence of 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.

In addition to posing challenges to the country's military, it is clear that 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 200 million RMB per year for at least the next three years (Watts, 2009), a considerable sum for one of China's poorer areas. A large-scale study by Kirshen, et al. also sheds light on the costs of adaptation to water distribution changes in China. After compiling water storage costs and modelling 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 USD$4.5 billion in the southern Xi Jiang river area, and less than USD$2 billion in the central Chang Jiang, for example. Most noticeably, it will become increasingly difficult and expensive to enhance water storage capacity (reservoirs, catchments, etc) in water-stressed areas like north China (Kirshen, McCluskey, Voegl, & Strzepek, 2005, p. 327).

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" (Stuhltrager, 2008, p. 38). This characterization seems particularly appropriate with respect to China. Water-related climate impacts will be severe in several regions, both within China and in its border regions. In addition, these impacts have the potential to foster general instability. However, it is difficult to identify any of these security implications as direct. What appears more certain, however, is 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. With this conclusion in mind, the next section investigates Chinese political and strategic discourse on climate change and water issues.

The Geopolitics of Water and Climate in China

It is clear that the distribution and availability of water resources in China and neighbouring countries will be severely impacted by climate change, a prospect which in turn entails significant security implications. What remains is to assess how China perceives this situation, and how it is responding. This final section thus discusses Chinese governmental? Too broad reactions and discourse on climate change, water, and security. It first describes

changing Chinese perspectives on security, before more focusing more specifically on steps that China has taken to address water-related climate impacts, both within and outside the country's borders. This section argues that the Chinese government is particularly concerned about the consequences, both traditional security and otherwise, of water-related climate change impacts, presenting opportunities to open a strategic, security-focused international dialogue on climate change (addressed in the Conclusions section).

In recent years, Chinese analysts, have, mirroring their Western colleagues, have articulated a broader conception of security. China's "New Security Concept" (*Xin anquan guan*), promulgated since the late 1990s, addresses environmental and social issues, and also emphasizes cooperation and dialogue as a means of conducting foreign relations (Liu G. , 2006). 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. Citing the broadening definition of security in the West, Liu et al., for example, advocate creating a special policy research group that focuses on the political and security dimensions of environmental change (Liu, Ge, Fang, & Zhang, 2006, p. 350).

Chinese security commentators have been even more prolific in citing American analyses of the security threats posed by climate. A series of such reports, including a widely-read 2004 Department of Defense study, prompted commentary within China over the possibility that climate-related resource shortages could lead to conflict or even war (Lin, 2005). Some non-official commentators have gone so far as to extrapolate upon such analyses to suggest that the threat of water-related conflict may increase between China and neighbouring countries (Guoji Xuanqu Daobao, 2004). Several more official Chinese commentators have similarly but more soberly cited American national security analyses to focus on the potential for water-related conflict to increase in politically unstable regions of the world, such as the Middle East (Tong, 2007).

The Chinese government, in contrast, does not appear to view climate change, or any of its attendant impacts, as a security issue. For most officials, climate change simply does not rise to the level of national security (Zha, 2009). 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" (China Daily Editorial Board, 2007). 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" (Le, 2007).

Moreover, the Chinese government has proven to be visibly reticent on some major transboundary water issues. It has consistently refused to participate in the Mekong Basin Commission (Morton, 2008, p. 58), despite the fact the Mekong system's headwaters are all in China, making it impossible to fashion a comprehensive water management system without Beijing. China has also been hesitant to support the creation of an International Biosphere Reserve in the Tumen River Delta area, since most of the environmental threats to the area come from China (Nam, 2005).

The picture becomes a bit more complicated when this analysis is expanded to non-governmental sources. Among Chinese security and international relations analysts, climate-related security issues are not taken very seriously (Zha, 2009). Nonetheless, several prominent Chinese analysts are increasingly outspoken in their advocacy for greater US-China climate cooperation. Zhang Haibin, a professor at Peking University, has written that "from a high-level strategic perspective actively promoting US-China climate cooperation will advance the mutual interests of all of humanity" (Zhang H. , 2009). Meanwhile, Chinese government media gave favourable coverage to the US Deputy National Security Adviser's

April 2009 message to China that the United States wished to enhance clean and renewable energy technology cooperation (Wang, 2009).

In addition, water issues have become more prominent in China's relations with some neighbouring 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 (Ministry of Foreign Affairs, 2003). Furthermore, the Shanghai Cooperation Organization (SCO), which Beijing initially promoted largely as a body for expanding security cooperation and countering Western influence, 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 to broaden cooperation on water resources (Asia Society, 2009, p. 38).

At the domestic level, Chinese officials 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" (Plafker, 2005). 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" (Lin, 2005). 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" (Xinhua News Agency, 2009).

Indeed, the government's response to the winter drought is indicative of the seriousness with which it takes water issues. Beijing declared a state of emergency as a result of the winter drought, and has earmarked some 400 million RMB for drought relief (Xinhua News Agency, 2009). State media coverage also highlighted government investment in water management, including an investment of some 62 billion RMB in rural water conservation from 2000-2008 (Xinhua News Agency, 2009). Government water officials further reiterated their intention to "strengthen control" of water resources, and to implement conservation practices (Xinhua News Agency, 2009).

Much of this effort seems to be specifically motivated by concerns for food and water security. In statements to the press, China's Minister for Water Resources stressed the need to redress inequities in the distribution of water resources to urban and rural residents (Beijing Qingnian Bao, 2009). Premier Wen Jiabao similarly emphasized the need to provide peasants with economic security and stability in a time of drought, saying "It's of vital significance to the overall economy to boost steady growth of grain production and farmers' income" (Xinhua News Agency, 2009). State media further repeated the theme of uneven access, including one report illustrating a peasant who pays five times the urban price of water just a few kilometres away (Hun, 2009).

Paralleling this focus on water security is an even more long-standing preoccupation with the fear that water shortages will impair food security. 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 (Wang W. , 2008). China further appears to take the issue of water availability in the Himalaya seriously, flying several cloud-seeing sorties a month to increase rainfall and water availability on the Tibet-Qinghai Plateau (Zha, 2009). 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 (Xinhua News Agency, 2009).

Chinese discourse on climate, water, and security is clouded. As this section has indicated, there remains a high-level reticence to link climate change issues and security. However, some commentators have instead emphasized these linkages. Moreover, 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, as outlined in the last section, this is of some concern. With this in mind, this paper turns to its conclusions, which include implications for global climate change cooperation and negotiations.

Conclusions: A Way Forward for Climate, Water, and Security in China and Asia

This paper has attempted to probe the intersection of climate, water, and security. In the process, it has examined the physical science basis of water-related climate change impacts, their security implications, and Chinese political and security discourse. In many ways, this is uncharted academic terrain. Scientific assessments of climate change and its impact on hydrological systems are subject to large uncertainties, while the security and political dimensions of the climate issue exist in a fluid context of popular and elite opinion. Nonetheless, this paper has advanced a consistent theme, namely that water-related climate change impacts will increasingly bear on China's security, foreign relations, and political discourse.

Beneath this over-arching conclusion, this analysis has uncovered several cross-cutting issues at the intersection of climate, water, and security. First among them is uncertainty. The climate system is incredibly complex, making precise scientific assessment of climate change impacts, particularly on water, extremely difficult. Indeed, one of the most confident predictions that can be made is that climate change will increase the variability in precipitation patterns. 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. Such uncertainty makes tinges climate security studies with a generic air. But this does not detract from their gravity: as security analyst James Stuhltrager has noted, climate change fundamentally represents uncertainty and risk, both of which are integral to security assessment and planning (Stuhltrager, 2008).

A second inter-related issue deals with 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 cross-cutting issue identified in this analysis 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. While Chinese discourse provides evidence of a foundation for developing such capacities, they are unlikely to be sufficient to deal with the full scale of the climate change challenge. Finally, 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 investment is almost certain to increase political tensions.

With these observations more fully articulated, this paper can at last approach the issue of implications for global cooperation on climate change. Before doing so, a caveat is appropriate. It is evident that, from the perspective of China and most other developing countries, the climate issue is defined primarily by political and economic issues. China's stated goals for the Copenhagen climate change conference, for example, emphasize adaptation and technology transfer, with funding responsibilities borne entirely by developed nations (National Development and Reform Commission, 2009).

These points of contention, rather than security or strategic dialogue, will define upcoming global climate negotiations. Indeed, Chinese leaders may continue to resist linking climate change and its national security, since as scholars have long noted there is little risk that climate change will foster interstate violence, the traditional focus of security (Deudney, 1990, p. 461). There is thus a limit to the benefit to be gained by "securitizing" the issue of climate change. However, this paper's conclusion that water-related security issues will be of increasing importance under climate change carries at least three significant implications for global climate cooperation.

First, water-related security issues present a particularly good opportunity to broaden and deepen bilateral and regional cooperation on climate change. Fundamentally, it presents an opportunity for strategic dialogue on the long-term impacts of climate change, rather than shorter-term disagreements over technology transfer or verifiable emissions reductions. Acute institutional vulnerabilities, such 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 paper, for example, recommends that the US military integrate climate-related extreme weather response into its regional command structure (Busby, 2007, p. 21); building dialogue between such commands, their Chinese and other Asian counterparts could dramatically improve the efficacy of international disaster response efforts.

This kind of cooperation could be further strengthened by focusing developed-country climate adaptation funding to address acute strategic issues. For example, the US Agency for International Development has launched a program in cooperation with the Gates Foundation to develop new rice varieties capable of surviving various climate change-related stresses, thereby enhancing food security throughout South Asia. The USD$35 million project will focus on enabling farmers in the region to obtain higher rice yields even in the face of climate change, and with fewer inputs of fertilizer and irrigated water (US Federal News Service, 2009). Similar models could be explored, possibly with a greater degree of co-financing, in China.

Additionally, a recent cooperative venture between the Chinese Academy of Sciences and the US Department of Agriculture illustrates how bilateral technical assistance can focus on ameliorating water-related climate change impacts. The program, founded in 2005, is focused on preventing erosion in China's Loess Plateau, which is expected to experience severe flooding under climate change. Cooperative modeling between the two agencies identified no-till farming practices that can reduce soil loss by 85% under climate change, helping protect farmers from economic and ecological destruction (Zhang & Liu, 2008, p. 22A). Replicating similar programs can help target adaptation funding to averting the worst

hydrological impacts of climate change (and attendant security effects), while also expanding bilateral climate cooperation.

The third and final implication of this analysis for global climate cooperation is to view such cooperation not only as an ecological imperative, but also as a strategic one. As a Council on Foreign Relations report 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 (Busby, 2007, p. 19). This interest is heightened when the security ramifications of climate change, such as have been detailed in this paper, are considered. Fundamentally, these ramifications serve to highlight the fact that climate change impacts, both water and other, will reverberate across borders and traditional disciplinary distinctions between science, politics, and security. High-level security dialogue between China, the United States, and other countries can serve as a focal point for such discussions, and can be a component of existing initiatives, such as the US-sponsored Major Economies Process on Energy and Climate.

Climate change and its consequences will cast a growing shadow over international politics and relations in the coming years. Much about the issue is uncertain, but it seems safe to assert that policymakers and analysts in a wide variety of fields will be compelled to pay more attention to climate issues. This analysis is intended as a first step towards probing the issues involved for such actors at the intersection of climate change, water, and security, especially with respect to China and Asia. It will almost certainly, however, not be the last. Scientific assessments of climate change impacts are likely to improve in accuracy and detail, as is the analysis of the political, social, and strategic issues entailed in climate change. Such work is essential for sharpening the focus of this paper- to think broadly and critical about the manifold consequences of climate change, for China, Asia, and the world at large.

References

Alkire, S. (2002, 2 16). *Commission on Human Security.* Retrieved 5 24, 2009, from Conceptual Framework for Human Security: http://www.humansecurity-chs.org/activities/outreach/frame.pdf

Antiporda, J. (2009, 3 28). Climate change poses greatest security threat--DND. *McClatchy-Tribune Business News.*

Asia Society. (2009). *Asia's Next Challenge: securing the region's water future.* New York: Asia Society.

Barnett, T., Adam, J., & Lettenmaier, D. (2005). Potential impacts of a warming climate on water availability in snow-dominated regions. *Nature* , pp. 303-309.

Bates, B., Kundzewicz, Z., Wu, S., & Palutikof, J. (2008). *Climate Change and Water. Technical Paper of the Intergovernmental Panel on Climate Change.* Geneva: IPCC Secretariat.

Bates, D. (2002, 5). Environmental refugees? Classifying human migrations caused by environmental change. *Population and Environment* , pp. 465-477.

Beijing Qingnian Bao. (2009, 2 16). *Woguo jin 2/3 chengshi queshui; shuiguanli wanyuan GDP haoshui jiang 6 cheng* . Retrieved 5 25, 2009, from Renmin Wang: http://env.people.com.cn/GB/8806061.html

Bhattacharji, P. (2008, 9 29). *Uighurs and China's Xinjiang Region.* Retrieved 5 25, 2009, from Council on Foreign Relations: http://www.cfr.org/publication/16870/uighurs_and_chinas_xinjiang_region.html

Brown, L. (2008, 3 20). *Melting mountain glaciers will shrink grain harvests in China and India.* Retrieved 5 24, 2009, from Earth Policy Institute: http://www.earthpolicy.org/Updates/2008/Update71_data.htm

Busby, J. (2007). *Climate Change and National Security: an agenda for action.* Council on Foreign Relations. New York: Council on Foreign Relations .

Center for Naval Analyses. (2007). *National Security and the Threat of Climate Change.* Alexandria, VA: CNA Corporation.

China Daily Editorial Board. (2007, 4 24). Not a security threat. *China Daily* , p. 10.

China Daily. (2007, 4 2). Impact of climate change on different regions. *China Daily* , p. 6.

Das, S. (2008, 3 8). *Glacier melting to hit Pakistan's agriculture.* Retrieved 5 25, 2009, from Financial Express: http://www.financialexpress.com/printer/news/280876/

Davis, E. v. (2008, 1). *Uyghur Muslim Separatism in Xinjiang.* Retrieved 5 25, 2009, from Asia-Pacific Center for Security Studies: www.apcss.org/Publications/APCSS--%20Uyghur%20Muslim%20Separatism%20in%20Xinjiang.doc

Deudney, D. (1990). The Case Against Linking Environmental Degradation and National Security. *Millennium- Journal of International Studies* , pp. 461-476.

Guoji Xuanqu Daobao. (2004, 7 22). *Qihou bianhua weixie guojia anquan; daozhi zhongguo yu lingguo chongtu?* Retrieved 5 24, 2009, from Zhonghuawang junshi: http://military.china.com/zh_cn/critical2/23/20040722/11794797_1.html

Hewitt, K. (2009, 2 12). *Glaciers and climate change in the Karakoram Himalaya: Developments affecting water resources and environmental hazards.* (K. Hewitt, Performer) Woodrow Wilson International Center for Scholars, Washington, DC, USA.

Homer-Dixon, T. (1994). Environmental Scarcities and Violent Conflict: Evidence from cases. *International Security* , pp. 5-40.

Homer-Dixon, T. (2007, 4 27). *Terror in the weather forecast.* Retrieved 5 25, 2009, from New York Times: http://www.homerdixon.com/articles/20070424-nytimes-terrorintheweatherforecast.html

Hun, J. (2009, 2 13). *Yige zhonghan shancun de chi shui zhang: 10yuan yitun; shi chengshi shuijia 5 cheng.* Retrieved 5 25, 2009, from Renmin Wang: http://env.people.com.cn/GB/8799166.html

Info-Prod Research. (2008, 6 16). Survey puts climate change and water shortage as top concern at close of World Economic Forum on East Asia. Ramat Gan, Israel.

Institute for Environmental Security. (2004, 5). *Institute for Environmental Security.* Retrieved 5 24, 2009, from What is environmental security?: http://www.envirosecurity.org/activities/What_is_Environmental_Security.pdf

Intergovernmental Panel on Climate Change. (1997). *The Regional Impacts of Climate Change: an assessment of vulnerability.* Intergovernmental Panel on Climate Change.

Jingshi, L., Hayakawa, N., Mingjiao, L., Shuhua, D., & Jinyong, Y. (2003). Hydrological and geocryological response of winter streamflow to climate warming in North East China. *Cold Regions Science and Technology* , pp. 15-24.

Kang, S., Su, X., Tong, L., Zhang, J., Zhang, L., & Davies, W. J. (2008, 10). A warning from an ancient oasis: intensive human activities are leading to potential ecological and social catastrophe. *International Journal of Sustainable Development and World Ecology* , pp. 440-447.

Kirshen, P., McCluskey, M., Voegl, R., & Strzepek, K. (2005). Global analysis of changes in water supply yields and costs under climate change: a case study in China. *Climactic Change* , pp. 303-330.

Landler, M. (2009, 2 22). Clinton Paints China Policy with a Green Hue. *New York Times* , p. A8.

Le, T. (2007, 4 24). Security Council 'not right place' to discuss climate. *China Daily* , p. 1.

Li, H. (2009, 2 13). *Wo guo rengyou jin 40% xiaomai shougan; sanxiang zhongdian quanli kanghan.* Retrieved 5 25, 2009, from Renmin Wang: http://env.people.com.cn/GB/8801027.html

Lin, E. (2005, 10 20). *Cong guojia anquan jiaodu kandai qihou bianhua wenti.* Retrieved 5 24, 2009, from Hebei sheng Lingshou xian nongye xinxi wang: http://www.sjzls.heagri.gov.cn/default3.aspx?id=6228

Liu, G. (2006, 3 20). *Zhongguo xin anquan guan.* Retrieved 5 21, 2009, from Chinese Academy of Social Sciences: http://www.cass.net.cn/file/2006032056857.html

Liu, S. (2009, 2 13). *Duonian chixu ganhan touzhi Huabei shui ziyuan; reng wu wanzheng jiejue fangan.* Retrieved 5 25, 2009, from Renmin Wang: http://env.people.com.cn/GB/8799218.html

Liu, Y. (2009, 2 12). *Guojia qihou zhongxin zhuren Xiao Ziniu: zhimian hanqing; kexue yingdui.* Retrieved 5 25, 2009, from Renmin Wang: http://env.people.com.cn/GB/8793040.html

Liu, Y., & Chen, Y. (2006). 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* , pp. 295-305.

Liu, Y., Ge, Q., Fang, X., & Zhang, X. (2006, 4). Quanqiu huanjing bianhua yu zhongguo guojia anquan. *Qidiu kexue jinzhan (Advances in Earth Science)* , pp. 346-351.

Lobell, D. B., Burke, M. B., Tebaldi, C., Mastrandrea, M. D., Falcon, W. P., & Naylor, R. (2008). Prioritizing Climate Change Adaptation Needs for Food Security in 2030. *Science* , pp. 607-610.

Lu, W. (2008, 7 2). *Lun huanjing baohu yu guojia anquan: yige "Xibu da kaifa" de shijiao.* Retrieved 5 21, 2009, from Zhongguo Anquan Tiandi Wang: http://www.aqtd.cn/aqlw/HTML/162835.html.

Mathews, J. (1989, Spring). Redefining Security. *Foreign Affairs* , pp. 162-177.

Ministry of Foreign Affairs. (2003, 6 30). *China's Territorial and Boundary Affairs.* Retrieved 5 24, 2009, from Ministry of Foreign Affairs of the People's Republic of China: http://www.fmprc.gov.cn/eng/wjb/zzjg/tyfls/tyfl/2626/t22820.htm

Morton, K. (2008, 11 1). China and Environmental Security in the Age of Consequences. *Asia-Pacific Review* .

Morton, K. (2008, 11 1). China and Environmental Security in the Age of Consequences. *Asia-Pacific Review* , pp. 52-67.

Morton, K. (2009, 2 12). *Climate Change on the Tibetan Pleateau: a new human security challenge.* (K. Morton, Performer) Woodrow Wilson International Center for Scholars, Washington, DC, USA.

Nam, S. (2005). Building a Tuman River Transboundary Biosphere Reserve. *China Environment Series* , pp. 83-88.

National Development and Reform Commission. (2007). *China's National Climate Change Program.* Beijing: National Development and Reform Commission.

National Development and Reform Commission. (2009, 5 20). *China's Position on the Copenhagen Climate Change Conference.* Retrieved 5 25, 2009, from Climate Change Info Net: http://www.ccchina.gov.cn/en/NewsInfo.asp?NewsId=17509

Nielsen, E. (2007). *Networked Governance: China's Changing Approach to Transboundary Environmental Management.* Cambridge, MA: Massachussetts Institute of Technology.

Parry, M., Rosenzweig, C., Iglesias, A., Livermore, M., & Fischer, G. (2004). Effects of climate change on global food production under SRES emissions and socioeconomic scenarios. *Global Environmental Change* , pp. 53-67.

Plafker, T. (2005, 12 16). China, parched and polluted, puts a price on water. *International Herald Tribune* .

Rees, H. G., & Collins, D. (2006). Regional differences in response of flow in glacier-fed Himalayan rivers to climactic warming. *Hydrological Processes* , pp. 2157–2169.

S. Manabe, R. W., Milly, P., Delworth, T., & Stouffer, R. (2004). Century-Scale Change in Water Availability: CO2-Quadrupling Experiment. *Climactic Change* , pp. 59-76.

Shalizi, Z. (2006, 4 18). *Addressing China's Growing Water Shortages and Associated Social and Environmental Consequences.* Retrieved 5 25, 2009, from World Bank: http://www-wds.worldbank.org/external/default/WDSContentServer/IW3P/IB/2006/04/18/000016406_20060418155242/Rendered/PDF/wps3895.pdf

Singh, P., Arora, M., & Goel, N. (2006). Effect of climate change on runoff of a glacierized Himalayan basin. *Hydrological Processes* , pp. 1979-1992.

Stuhltrager, J. (2008). Global climate change and national security. *Natural Resources and Environment* , pp. 36-41.

Tao, F., Yokozawa, M., Hayashi, Y., & Lin, E. (2005). A perspective on water resources in China: interactions between climate change and soil degradation. *Climactic Change* , pp. 169-197.

Tong, G. (2007, 12 18). *Quanqiu qihou bianhua jiang weiji guojia anquan.* Retrieved 5 24, 2009, from Ministry of Natural Resources Information Center, People's Republic of China: http://www.lrn.cn/zjtg/societyDiscussion/200712/t20071218_179813.htm

United Nations Environment Program. (2009). *From Conflict to Peacebuilding: the role of natural resources and the environment.* Nairobi: United Nations Environment Program.

US Federal News Service. (2009, 2 27). New partnership to ensure South Asia's food security in face of climate change. Washington, DC, USA.

Wang, S. (2009, 4 27). *Meiguo qidai yu Zhongguo jinxing "huoban" shi hezuo gongtong yingdui qihou bianhua.* Retrieved 5 24, 2009, from Zhongguo qihou bianhua xinxi wang: http://www.ccchina.gov.cn/cn/NewsInfo.asp?NewsId=17157

Wang, W. (2008, 8 14). *Vice Minister: China to raise water price.* Retrieved 5 25, 2005, from Zhongguo Wang: http://www.china.org.cn/business/news/2008-08/14/content_16223967.htm

Wang, Y., Wu, A., Lai, Z., Tan, C., Chen, S., Guo, Y., et al. (2009, 2 13). *Hanqing sinue; Jiefang Jun he Wujing budui faqi kanghan zongdongyuan.* Retrieved 5 25, 2009, from Renmin Wang: http://env.people.com.cn/GB/8800182.html

Wassmann, R., Hien, N. X., Hoanh, C. T., & Tuong, T. P. (2004). Sea level rise affecting the Vietnamese Mekong Delta: water elevation in the flood season and implications for rice production. *Climactic Change* , pp. 89-107.

Watts, J. (2009, 3 2). China plans 59 reservoirs to collect meltwater from its shrinking glaciers. *Guardian* , p. 21.

Xinhua News Agency. (2009, 2 6). *China ramps up spending to blunt impact of drought.* Retrieved 5 25, 2009, from China.org.cn: http://china.org.cn/environment/report_review/2009-02/06/content_17232567_4.htm

Xinhua News Agency. (2009, 2 15). *China to strengthen water control in light of shortage* . Retrieved 5 25, 2009, from Renmin Wang: http://english.people.com.cn/90001/90776/90785/6592957.html

Xinhua News Agency. (2009, 2 6). *Highest level of emergency for drought declared.* Retrieved 5 25, 2009, from Zhongguo Wang: http://china.org.cn/environment/policies_announcements/2009-

02/06/content_17232716_5.htm
Xinhua News Agency. (2009, 2 6). *Lingering drought highlights water-saving agriculture.* Retrieved 5 25, 2009, from Zhongguo Wang: http://china.org.cn/china/opinion/2009-02/06/content_17238691.htm.
Xinhua News Agency. (2009, 2 17). *N. China drought rings alarms to insufficient rural water supplies.* Retrieved 5 25, 2009, from Zhongguo Wang: http://china.org.cn/china/news/2009-02/17/content_17292682.htm.
Xinhua News Agency. (2009, 2 9). *Premier urges 'top priority' on drought relief.* Retrieved 5 25, 2009, from Zhongguo Wang: htto://china.org.cn/environment/policies_announce-ments/2009-02/09/content_17244718.htm.
Xiong, W., Lin, E., Ju, H., & Xu, Y. (2007). Climate Change and Critical Thresholds in China's Food Security. *Climactic Change* , pp. 205-221.
Xu, Z., Takeuchi, K., & Ishidaira, H. (2004). Correlation between El Nino-Southern Oscillation (ENSO) and precipitation in South-east Asia and the Pacific region. *Hydrological Processes* , pp. 107-123.
Yan, T., & Qian, W. (2004, July). Environmental Migration and Sustainable Development on the Upper Reaches of the Yangtze River. *Population and Environment* , pp. 613-636.
Yang, J., Ding, Y., Chen, R., & Liu, L. (2005). Fluctuations of the Semi-Arid Zone in China, and Consequences for Society. *Climactic Change* , pp. 171-188.
Yoffe, S., Wolf, A. T., & Giordano, M. (2003). Conflict and cooperation over international freshwater resources: indicators of basins at risk. *Journal of the American Water Resources Association* , pp. 1109-1126.
Zha, D. (2009, 6 11). Climate change, water, and security. (S. Moore, Interviewer)
Zhang, H. (2009, 3 24). *Gao diaotui tuidong Zhong-Mei qihou bianhua hezuo.* Retrieved 5 24, 2009, from Zhongguo shehui kexue yuan: http://www.cass.net.cn/file/20090324225153.html
Zhang, X., & Liu, W. (2008, 1). US-China collaboration on conservation. *Journal of Soil and Water Conservation* , p. 22A.
Zhang, Y., & Wang, H. (2009, 2 13). *Tian bu bangzhu; dadi hanke; kao keji xiang laotian yao yushui.* Retrieved 5 24, 2009, from Renmin Wang: http://env.people.com.cn/GB/8798005.html