

CLIMATE VARIABILITY/CHANGE AND IMPLICATIONS FOR REGIONAL STABILITY: INTEGRATED SOUTH ASIA STUDY

Prepared by Climate Forecast Applications Network

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Asia, broadly speaking, is a flashpoint for climate change impacts and natural disasters. The National Intelligence Council states, “The principal regional challenges generated by climate change in South Asia will most likely be cross-border migration and water scarcity.”¹ The combination of location (the tropics – resulting in a higher frequency of tropical cyclones, fast-rise and slow-rise floods, droughts), the large number of states, the high populations, the dramatically varying scales of economic development, and infrastructure located in coastal areas make many parts of Asia highly susceptible to conflict, migration, terrorism, and humanitarian disasters.

This case study focuses on natural disaster and climate change impact threats in South Asia – Pakistan, Afghanistan, Bangladesh and India. The objectives of this section are to relate our regional weather and climate predictive capability to a comprehensive regional analysis of weather hazards and climate impacts as security threat accelerants, and to propose how effective use of this predictive capability could proactively reduce the threat acceleration associated with these events. This section highlights the interplay between security and uncertainty in a number of South Asian nations across areas that are highly susceptible to climate change impacts: food security, energy, and water resources. Climate, weather, and hydrologic forecasting tools can be highly applicable to increasing predictability and reducing uncertainty regarding these areas. As a result, these tools are of significant use to U.S. operational commanders, as well as policy-makers, in proactively responding to threats as they are developing.

The Center for Strategic and International Studies (CSIS) has identified Asia as a center of hazard exposure risk.² Among the major findings of CSIS are:³

- Globally, the top ten countries at risk for the highest number of people exposed to flooding are located in Asia;
- Asia has the highest absolute exposure to tropical cyclones;
- Asia has extremely high population and economic development growth. It is expected that, by 2050, Asia will comprise 60% of the global population – consisting of approximately 5.5 billion individuals;

¹ National Intelligence Council. 2009. *India: The Impact of Climate Change to 2030; Geopolitical Implications*. (CR 2009-07). 3.

² Freeman, Charles, Michael J. Green, and Robert S. Wang, 2010. *Asia's Response to Climate Change and Natural Disasters: Implications for an Evolving Regional Architecture*. Center for Strategic & International Studies: Washington, DC.

³ White, Stacey, 2010. “Disaster Management in Asia: The Promise of Regional Architecture” in *Asia's Response to Climate Change and Natural Disasters: Implications for an Evolving Regional Architecture*. Center for Strategic & International Studies: Washington, DC. pp. 64-65.

- Asia is urbanizing and much of the population movement is pointed towards coastal cities. However, their coastal location – the particular characteristic that makes them attractive and economically productive – simultaneously makes them significantly more susceptible to tropical cyclone landfalls, coastal flooding, and sea level rise.

The United States has two commands covering the countries assessed in detail: the U.S. Pacific Command (Bangladesh, India) and the U.S. Central Command (Afghanistan, Pakistan). Based on their 2010 Posture Statements, both of these commands are cognizant of the destabilizing roles that climate change impacts and natural disasters can have on U.S. security interests in areas under their cognizance.

- U.S. Pacific Command: In its 2010 Posture Statement, the U.S. Pacific Command highlights the sizable role that humanitarian assistance and disaster response (HA/DR) operations play in its activities. “In the Asia-Pacific, we respond to natural disasters about every 60 days...[Overseas Humanitarian, Disaster, and Civic Aid (OHDACA)] projects offer a significant and sometimes unique opportunity in the region; and have been particularly helpful to decreasing the operating space of terrorists and violent extremists. OHDACA is a critical element in PACOM’s comprehensive approach to counter-terrorism in South Asia; specifically in Bangladesh and Sri Lanka.”⁴
- U.S. Central Command: The 2010 Posture Statement for the U.S. Central Command states: “To complement [disrupting narcotics trafficking], we support and promote viable agricultural and economic alternatives and the requisite infrastructure to help Afghans bring licit products to market for sale and distribution.”⁵ Given the close connection between climate change impacts and food security, Central Command’s efforts to facilitate agricultural development in Afghanistan can be facilitated by reductions in the uncertainty regarding upcoming seasonal and long-term climate conditions for the areas in question.

Summary of country level security environment and threats

An overview is given to provide the context of climate-related security threats for each of the four countries considered: Afghanistan, Pakistan, Bangladesh, India.

Afghanistan

Afghanistan remains highly susceptible to destabilization from climate change impacts and natural hazards. Specifically, Afghanistan is susceptible to droughts and competition over water resource uses. Therefore, drought and water resource monitoring and forecast capability will be necessary ingredients towards realizing the success of U.S. security interests in Afghanistan.

Because of its current and past history as a terrorist safe haven, the ongoing conflict, and the large number of U.S. military personnel currently conducting operations there, Afghanistan occupies a singular and central interest in U.S. security interests. Upgrading Afghanistan’s ability to respond

⁴ Willard, Admiral Robert F. 2010. “U.S. Pacific Command Posture.” Testimony: Senate Armed Services Committee. (24 March, 2010) 33. (<http://armed-services.senate.gov/statemnt/2010/03%20March/Willard%2003-26-10.pdf>)(accessed 21 December, 2010)

⁵ Petraeus, General David H. 2010 “The Posture of U.S. Central Command.” Testimony – Senate Armed Services Committee. (16 March, 2010) .27. (<http://armed-services.senate.gov/statemnt/2010/03%20March/Petraeus%2003-16-10.pdf>) (accessed 21 December, 2010)

to and neutralize natural hazards can be important pillars in the United States' ability to resolve the ongoing conflict and improve the Afghan economy.

Including consideration of climate change and natural hazard impacts on agriculture – is central to U.S. success in Afghanistan. Indeed, President Obama, in his March 2009 strategy regarding the future role of the U.S. in Afghanistan and Pakistan, recognized that agriculture is a central issue in U.S. success in Afghanistan, in terms of undercutting the appeal of al Qaeda and its allies among underemployed youths⁶ and developing crop substitution and alternative economic programs to counter narcotics.⁶

The President's focus on agriculture is well-placed: 50 % of Afghanistan's gross domestic product (GDP) comes from agriculture and livestock;⁷ and, as opposed to Iraq, the majority of Afghanistan's people live in rural areas.⁸ Providing Afghanistan with tools to address and buttress its agricultural needs is critical, as currently 75 % of arable land is at risk of desertification.⁷ These products should consist of drought and hydrologic monitoring and forecasting tools and information. Given the combination of these marginal agricultural lands, the reliance of the Afghan economy on agriculture, and President Obama's policy of supporting Afghan agriculture – it would be enormously destabilizing for both Afghanistan and U.S. security interests if these lands were allowed to become unproductive.

Pakistan

Like Afghanistan, agriculture is a major driver in the economy. Pakistani agriculture is responsible for 25 % of GDP, comprises 66 % of the labor force, and accounts for 80 % of Pakistan's exports.⁷ And – in terms of agriculture, industry, droughts and floods – water resources and water availability play critical roles in determining the success of the country's economy. Therefore, U.S. security interests regarding Pakistan are driven, in major ways, by the presence of a successful agricultural economy.

Water resources play a profound role in the success of Pakistan's agriculture. Pakistan has the world's largest irrigation system – whereby 80 % of cropland uses irrigated water.⁷ Most of this is rain-fed irrigation. In other words, the majority of farmland – and thereby sizable portions of the Pakistani economy – is ultimately dependent on precipitation and its distribution. This dependence on seasonal rainfall has resulted in poor agricultural practices – resulting in a negative cycle that degrades the land, increasingly placing the agricultural economy at risk, and then a need for increasingly destructive 'quick-fixes' with regards to rainfall and agricultural practices. Due to the existing high variability of precipitation, farmers provide water to their crops when it is available – not necessarily when it is needed. This "over-watering" has resulted in deteriorated soil quality through salinization, decreased agricultural productivity, and water scarcity.⁷ The World Bank reports that 25 % of Pakistan's arable land is highly degraded due to salinity – resulting in an annual loss of 1 % of GDP per year.⁹ This water scarcity and water pollution (as a result of both agricultural practices and industry) has resulted in a reduction in the supply of water needed for Pakistani agriculture.⁷

⁶ Executive Office of the President. 2009. *White Paper of the Interagency Policy Group's Report on U.S. Policy towards Afghanistan and Pakistan*. Washington, DC. 2.

⁷ Parthemore, Christine and Will Rogers. 2010. *Sustaining Security: How Natural Resources Influence National Security*. Center for a New American Security: Washington, DC. p.12.

⁸ Kaplan, Robert D. 2010. *South Asia's Geography of Conflict*. Center for a New American Security: Washington, DC. p. 12.

⁹ World Bank. 2006. *Pakistan: Strategic Country Assessment, Vol. I*. Washington, DC. pp. 1,16.

Providing Pakistan with seasonal hydrologic and drought monitoring tools in order to reduce uncertainty about upcoming precipitation will allow for better agricultural planning, higher yields, and, ultimately, an improved economic outlook for farmers. An advanced water management system will allow for the more optimal allocation of water between the competing forces of energy production and agriculture.

As is the case in Afghanistan, President Obama has recognized the central importance of the success of Pakistani agriculture to U.S. security interests in both Pakistan and throughout the surrounding region. In his March 2009 strategy regarding the future role of the U.S. in Afghanistan and Pakistan, the President emphasized the role that agricultural development and assistance will play as part of that effort. He noted: “Our assistance should focus on long-term capacity building, on agricultural sector job creation, education and training, and on infrastructure requirements.”⁶

Bangladesh

Bangladesh is a significant strategic and security interest to the United States. It sits at a prime location within Asia and is a nation that is growing in geopolitical and commercial importance. Bangladesh is located both at the top of the Bay of Bengal on the delta of two of the largest rivers in the world (the Ganges and Brahmaputra), and, in essence, between two of the dominant regional (and, even more so in recent years, global) powers: India and China. Increasingly, it is an important trading partner for the U.S., India, and China. Most importantly, however, it is one of the few moderate, democratic Islamic countries in South Asia. As a result – especially given the ongoing security efforts of the U.S. in Afghanistan and Pakistan – the continued viability of Bangladesh’s current political regime is of central importance to the security interests of the United States.

Bangladesh is extremely vulnerable across all measures of a threat hazard framework. It has a very poor population, it has high levels of population density, its population is projected to grow significantly, it has low levels of household and community resilience as a function of its poverty, it has a historically weak governance system, and as a function of its geography it is extremely vulnerable to natural hazard and climate change impacts.

Bangladesh, a nation with a population of more than 160 million people, is considered one of, if not the, most vulnerable countries to the consequences of climate change and natural hazards. The World Bank has classified Bangladesh as being at the highest levels of risk for droughts, flood, storms, sea-level rise, and agricultural crop loss. As such, it has been listed as one of 12 countries that are most at risk for climate-related problems.¹⁰

Bangladesh’s landscape is dominated by low-lying river deltas through which flows five major river systems flow into the Bay of Bengal. As a result of its low-lying geography, approximately 40% of its total land area is flooded each year.¹¹ Similarly, because of its location at the northernmost reaches of the Bay of Bengal it is particularly susceptible to the impacts of tropical

¹⁰ Matthews, Alexandra, 2009. “Bangladesh’s Climate Emergency” in *South Asia Monitor*. Washington, DC: Center for Strategic and International Studies. (Dec. 1, 2009)

¹¹ Vaughn, Bruce. 2010. *Bangladesh: Political and Strategic Developments and U.S. Interests*. Washington, DC: Congressional Research Service. (R41194)

cyclones. These cyclones have resulted in, on average, 16 major floods per decade.¹¹ Most flooding is short-lived or in lower lying areas but once every 5 years or so extensive floods persist for periods longer than 10 days. Every decade, floods may persist for longer than a month. In 1998, floods covered 60% of the country for 3 months.**Error! Bookmark not defined.Error! Bookmark not defined.Error! Bookmark not defined.**

Coastal and delta flooding from anticipated and ongoing sea level rise is also expected to have major impacts on Bangladesh. A one-meter increase in sea level could flood 18-33 % of the nation, and result in the displacement of 20-40 million people.¹⁰ Sea level rise has already laid claim to some of Bangladesh's territory in the Bay of Bengal. New Moore Island has already been submerged, and at least ten other islands are predicted to disappear.¹¹ Currently, 4 million Bangladeshis live on the numerous low-lying islands off the coast of Bangladesh.¹² These may be amongst the first Bangladeshis to be displaced as a direct result of climate change impacts. Similarly, many Bangladeshis without property have, for decades, lived and farmed throughout the delta region on silt islands, known as chars. Chars are geologically unstable and already vulnerable during the annual monsoon season – and are even more so during the floods produced by cyclones, sea level rise, and heavy upstream precipitation. This large and poverty-stricken population is also at risk to become climate refugees.¹⁰

Bangladesh's food security is very much at risk as a function of the impacts of climate change and natural hazards. Sea level rise has already been attributed to salt water intrusion of coastal agricultural areas that has resulted in decreased productivity across 830,000 hectares of agricultural land.¹¹ As a result, some rural residents of coastal areas have abandoned farming and moved to urban areas, or switched from rice to prawn farming as a result of decreased productivity of their rice fields.¹¹

Bangladesh has already experienced political instability as a function of food insecurity and natural disasters. Cyclone Sidr destroyed nearly 10 % of Bangladesh's anticipated rice harvest in 2007.¹¹ Rice prices doubled the following year because of the reduced supply as a result of floods and the cyclone. Subsequently 20,000 workers rioted in Bangladesh's capital city of Dhaka, over the high cost of food.¹¹ That year food costs made up approximately 70 % of the average income of a Bangladeshi household.¹¹

Because of its location at the northern-most portion of the Bay of Bengal, Bangladesh's location offers security and trade advantages to the United States. Its location, in relative terms, between China and India also makes Bangladesh a strategically valuable location in terms of the future regional balance of power.

In terms of location and future energy supplies, Bangladesh sits on major trading routes between the two trading powers in the region: India and China. In recent years, Bangladesh has made significant overtures to both of these countries. Road and rail routes through Bangladesh's ports of Chittagong and Mangla to the northeast of India have promoted the cementing of trade ties and relations with India.¹¹ Similarly, early in 2010, Bangladesh's Prime Minister Hasina visited China to discuss port improvements at Chittagong, and the development of a road for increased trade between Chittagong and Kunming, China.¹¹ This trip was underscored by a robust and growing trade relationship between China and Bangladesh. Bilateral trade in 2009 was \$4.58 billion, and is expected to increase to \$5 billion in 2010.¹¹ U.S. entities are also actively exploring what are expected to be very significant offshore natural gas deposits in Bangladeshi waters in the Bay of

¹² Podesta, John, and Peter Ogden. 2007. *Global Warming: The Security Challenges of Climate Change*. Washington, DC: Center for American Progress.

Bengal.¹¹ The American energy firm, Chevron, is the primary interest involved in exploration of these sites.

Given the political and religious instability of some of Bangladesh's South Asian neighbors, such as Pakistan and Afghanistan, the U.S. has a strategic security interest in ensuring that Bangladesh remains "a largely moderate and democratic Muslim country."¹¹ The United States military has taken active efforts to conduct joint training exercises with Bangladesh, as well as to provide humanitarian assistance. The U.S. Pacific Command has worked closely with the Bangladesh military to improve their capabilities across a variety of areas: counterterrorism, peacekeeping, humanitarian assistance, disaster relief, and maritime security.¹¹ U.S. Pacific Command sees Bangladesh as a "strong partner who works closely with the U.S. to enhance regional security."¹¹

India

From a hazard exposure perspective, India is better able to face the challenges of climate change and natural disasters than some of its South Asian neighbors. Nevertheless, because it sits in close proximity to states that are more susceptible to the threat accelerant capacity of climate change – India stands to be both directly and indirectly impacted.

It is important to reiterate here, that the instability of a number of India's neighbors, as a result of political and economic circumstances, can be exacerbated by the destabilizing impacts of climate change and natural disasters. Consequently, India's own security and development are imperiled by these indirect climate change effects. A prime example of this would consist of the destabilizing impacts of millions of Bangladeshi 'climate refugees' attempting to migrate to the higher ground and better economy of India as a function of any combination of floods, sea surface increase, or tropical cyclone landfalls in Bangladesh.

Nevertheless, India is inherently more stable (i.e., lower hazard exposure) than many other South Asian states. The National Intelligence Council states: "Despite the serious climate related challenges India may be subjected to in the next two decades, India is a large and resilient state and society with considerable coping capacity."¹³ Among the reasons cited for India's resilience are: a history of encountering and responding to natural disasters; an upward economic growth trajectory; a democratic and federalized political system that can 'absorb' political 'shocks' and instability; and a robust civil society network that is and can be applied to the climate change and natural disaster impacts.¹³

This is not to say, by any means, that India is immune from the impacts of climate change and natural hazards. Indeed, it has suffered significant consequences from droughts, floods, and tropical cyclones – and will in the future. A report from the National Intelligence Council notes that: "India is...one of the most vulnerable countries in the world to projected climate change. The country is already experiencing changes in climate and the impacts of climate change, including water stress, heat waves and drought, severe storms and flooding, and associated negative consequences on health and livelihoods. With a 1.2 billion but growing population and dependence on agriculture, India probably will be severely impacted by continuing climate change."¹³

In addition, as China and India have grown into global economic powers, they have developed overlapping spheres of naval influence in the Arabian Sea and the Bay of Bengal. China has

¹³ National Intelligence Council. 2009. *India: The Impact of Climate Change to 2030; Geopolitical Implications*. (CR 2009-07). p. 4.

invested huge amounts of economic and military assistance to construct modern port facilities in locations that effectively surround India: Kyaukpyu, Burma; Chittagong, Bangladesh; Hambantota, Sri Lanka; and Gwadar, Pakistan.¹⁴ In response, India has expended considerable resources to develop significant naval port facilities in Karwar, India and Sittwe, Myanmar.¹⁴ As a result, these facilities and their associated infrastructure – crucial for a balance of power to develop in Asia – are more susceptible to climate change impacts and natural hazards such as tropical cyclones and sea surface rise. Subsequently, the stability and security interests of India – and consequently the regional interests of the U.S. itself – rest on its ability to develop both robust infrastructure to protect these facilities as well as adopt the monitoring and forecasting tools that will allow proactive and protective steps to be taken in light of an approaching natural disaster, like a destructive tropical cyclone.

Riparian Security Threats

Major rivers originating in the Himalayas include the Ganges, Indus, Brahmaputra, Yangtze, Mekong, Irrawaddy, and Yellow Rivers. Their combined drainage basin is home to 3 billion people, including Afghanistan, China, India, Pakistan, and Bangladesh. The headwaters of these rivers lie in the Himalayas in Tibet, parts of which are under the control of the People's Republic of China. Given the large and growing population of South and Southeast Asia and the increasing demand for water for irrigated farming and industry, transboundary disputes over water are ongoing and are significant and growing concerns, particularly if a major drought looms in the future. These disputes are central to food security, energy needs and resources and the future of water resources in the region. Riparian security issues are key for two major rivers in the region – the Ganges and Brahmaputra Rivers - and climate change (particularly drought) might act as a threat accelerant in riparian conflicts in South Asia.

Brahmaputra River

The Brahmaputra River is a transboundary river that spans China, India, and Bangladesh. It begins in southwestern Tibet (in China), flows through the Himalayas into India. In India it transverses the Indian states of Arunachal Pradesh and Assam, and then enters Bangladesh. In Bangladesh it eventually merges with the Ganges River to create a significant delta area, and ultimately empties into the Bay of Bengal.

Competition over water resources uses, including power, agriculture, and navigation, are the primary issues facing China, India, and Bangladesh with regards to the Brahmaputra. In its upper Himalayan reaches, the Brahmaputra is considered the last major undammed river in Chinese Tibet.¹⁵ China is currently in the midst of constructing a series of massive facilities on the upper reaches of the Brahmaputra, in the Himalayas. Construction was once considered to have been infeasible because of the altitude and rugged terrain – but recent engineering achievements and advances have made the possibility of dam construction a reality. China has planned construction of a series of 28 dams.¹⁵ The Zhangmu facility is amongst these and is projected to be completed in 2015. It is predicted to provide 450-500 MW per year. While the Zhangmu Dam is large, it is

¹⁴ Kaplan, Robert D. 2010. *South Asia's Geography of Conflict*. Center for a New American Security: Washington, DC. 15.

¹⁵ Watts, Jonathan. 2010. "Chinese Engineers Propose World's Biggest Hydro-electric Project in Tibet." *The Guardian*. (May 24, 2010) (<http://www.guardian.co.uk/environment/2010/may/24/chinese-hydroengineers-propose-tibet-dam> (accessed January 5, 2011))

dwarfed by the planned Yarlung Tsangpo facility. This planned dam facility will provide 38 GW, and will be 50 % larger than China's Three Gorges dam. Some analysts have described the potential power output of Yarlung Tsangpo as having "a capacity nearly half as large as the UK's national grid."¹⁵

The Zhangmu and Yarlung Tsangpo facilities are ostensibly intended to provide only power for China and not top divert water. However, some downstream users in both India and Bangladesh are apprehensive that the waters of the Brahmaputra – currently used for agriculture and navigation – will be diverted permanently out of the system. The Chinese government has insisted, however, that these dams will be used only for hydropower, and not for water supply storage and not for eventual diversion.

Even if the water is used solely for hydropower purposes, given the size of some of these facilities, the timing of dam releases will be of critical importance for downstream agricultural users. Similar to the Mekong and Indus Rivers – if adequate flows are not released during the dry seasons, the value of the water for downstream agricultural users drops significantly. This is a very real and very serious issue with regards to dam operations. While hydropower dams may not involve geographic water diversion – they can, and often have, involved what we refer to as 'temporal diversion.' Temporal diversion is the storage of water in impoundments whereby it is released downstream at a later point in time than would have occurred in the natural environment. As a result, downstream ecosystems and users (irrigated agriculture, for example) are negatively – and potentially, severely, impacted. For example, low dry season flow could lead to salt water intrusion through the deltas. Given the vast numbers of people in northern India and Bangladesh that rely on the waters of the Brahmaputra River for agricultural purposes, the temporal diversion of its waters may cause as much social and economic havoc as geographic diversion.

The impacts of temporary diversion in the lower reaches of the major rivers would certainly be exacerbated by climate change impacts speeding the retreat of Himalayan glaciers – already a major source of water and flow during the South Asian dry season. Reduced flows as a result of decreased glacier melt will make dam operations less predictable and therefore more challenging.

Temporal diversion of waters need not be a necessary consequence of hydropower operations, however. The monitoring, collection and sharing of flow data above and below dams can be used to help guide the operation of hydropower facilities so that they can simultaneously release water at the rates necessary to produce needed power, as well as serve the needs of downstream communities – even in the dry season. This process of data collection and sharing is, of course, successfully facilitated through the framework of a transboundary agreement – in this case between China, India, and Bangladesh. As noted below, however, such an agreement does not exist at this time. As a result, the threat of temporal diversions with regards to dam construction on the Brahmaputra River remains a visceral threat that could become a significant source of regional instability under drought conditions.

The Chinese construction of these hydropower facilities must also be viewed in the context of regional geo-political competition between India and China. As it develops economically, India also has sizable power needs. *The Guardian* newspaper references a number of Chinese engineers who see the dam construction "as the ultimate goal in an accelerating race with India to develop water resources in one of the planet's last remote regions."¹⁵ India has responded by beginning the planning process for hydropower dam construction along its stretches of the Brahmaputra. Jairam Ramesh, the Environment Minister for India is quoted in *The Guardian*: "India needs to be more aggressive in pushing ahead hydro projects [on the Brahmaputra]... That would put us in better negotiating position [with China]..."¹⁵

No major international agreements exist for resolving and coordinating the use of the resources in the Brahmaputra River basin. However, efforts exist in the non-governmental community to move in this direction. A group of water resource experts met in Dhaka, Bangladesh in 2010 and, through the [non-governmental] Dhaka Declaration on Water Security, 2010, called for increased collaboration regarding the Brahmaputra, including the provision of flow data during the low-flow dry season.¹⁶

Ganges River

The Ganges River flows through India and into Bangladesh. Its headwaters sit within India's portion of the Himalayan Mountains. Flowing in a southeasterly direction, it transverses northern India, enters Bangladesh where it ultimately joins with the Brahmaputra River in a great delta and empties into the Bay of Bengal.

Use of the Ganges River water resources by India and Bangladesh are currently governed under the 1996 Ganges Water Sharing Treaty. While this agreement has resulted in improved coordination and use of Ganges waters, it succeeds a series of failed agreements between the two nations. The primary point of contention between India and Bangladesh is the Indian diversion of water from the Ganges, resulting in damages to Bangladeshi agriculture, navigation, and public health.

In 1975, India completed construction of a dam and canal project, known as the Farakka diversion.¹⁷ The diversion is located in West Bengal, and sits only 10 km from Bangladesh.¹⁷ This project diverts flow from the Ganges system to the Bhagirathi-Hooghly River, which empties close to the Indian city and port of Calcutta. The intent of the Farakka diversion was to increase flows in the Bhagirathi-Hooghly in order to keep the port open during the dry season, and to also keep the port functioning by flushing the harbor of silt deposits.¹⁷

Bangladesh was opposed to the project even before it was completed. Bangladeshi concerns – which ultimately proved valid – were that the reduced flow in the Ganges River would result in the negative impacts to fishing and navigation interests, and that salt-water intrusion into Bangladeshi agricultural areas would increase.¹⁷ This did, in fact, play out. In addition, Bangladesh has suffered human health impacts as a result of decreased fresh water flows. In addition, Bangladeshi migration to India has increased since 1975, in part because of the decreased economic opportunities that resulted as a function of the diversion.¹⁷

Between 1975 and 1996, India and Bangladesh signed a series of water-sharing agreements to govern and coordinate more adequately the diversion of Ganges River water.¹⁷ Most of these were short-term agreements, however. Invariably, as soon as the terms of the agreements were complete, India would unilaterally reduce flows again. Understandably, this raised tensions between the neighboring countries.

The Ganges Water Sharing Treaty, signed in 1996, has proved to be a more sustainable and successful framework document for Ganges River water resource governance than earlier iterations. First, the agreement is intended to last 30 years – significantly longer than earlier agreements.¹⁷ This provides a sense of surety and predictability – especially to Bangladesh, the

¹⁶ http://en.wikipedia.org/wiki/Brahmaputra_River (accessed January 5, 2011)

¹⁷ Roy, Robie and I. Samanta. 1997. "India-Bangladesh Water Dispute." (<http://www1.american.edu/ted/ice/indobang.htm> (accessed January 4, 2011))

downstream user. The agreement also has a number of important triggers that govern when and under what conditions water will and will not be diverted from the Ganges.¹⁷ In general terms, the treaty guarantees Bangladesh dry season (January-May) flows. In more specific terms: below certain flow rates, Bangladesh and India will share half of the water; if the flow is above a certain level, Bangladesh is guaranteed a minimum flow; and if the flow exceeds a higher, identified level, India will withdraw a defined amount and Bangladesh will receive the balance of the flow. Significantly – and as a foundational element of the treaty – the agreement recognizes Bangladesh’s right as a lower riparian user under international law.¹⁷ This results in an obligation for Bangladesh to receive an equitable share of existing flow.

While the 1996 Ganges Water Sharing Treaty has been successful at coordinating the use of Ganges River water resources – and, significantly, in reducing tensions between India and Bangladesh – issues do remain. Chief amongst these are the provision and perceived reliability of data.¹⁷ India does not provide its river flow data to Bangladesh, and hence the only upstream information Bangladesh has is from flow meters near the border. This makes water resource management decisions more difficult – and sustains uncertainty for water users.

Energy, Food, and Water Security Issues in South Asia

Energy, water and food are inextricably linked throughout South Asia with regards to economic growth, national security, and regional stability.

Energy

Most, if not all, South Asian nations have significant and largely unaddressed energy needs. India, Bangladesh, and Pakistan have had frequent power outages in population centers. Bangladesh and Pakistan have been subject to public protests as a result. In 2006, Nepal’s state-owned energy company teetered on the edge of bankruptcy.¹⁸ 40 % of Nepal’s and 20 % of Myanmar’s populations do not have access to electricity.¹⁸ And energy transmission infrastructure throughout the region is insufficient and in poor repair.¹⁸

The choices made by these South Asian nations in meeting these energy demands – as well as by the United States in facilitating these processes – must take into account the potential impacts of climate change and natural disasters on new energy sources and infrastructure. For example, some nations are turning to hydroelectric facilities to satisfy increased power demands. In this regard, Nepal has considerable untapped resources in the hydropower sector. Some energy analysts believe that it has tapped only 0.3 % of its available hydropower.¹⁸ Yet, Himalayan glaciers and snowpack are retreating – thereby making the management of hydroelectric facilities more challenging. Similarly, some nations will look to increase the number of coal-fired or nuclear power facilities. These, however, require massive amounts of water for cooling purposes. South Asia will be subject to changing drought patterns under climate change conditions – so the siting of these facilities must be determined with great care. Some nations, such as Pakistan, are situated close to oil shipping routes and look to improve their harbor facilities to take advantage of this locational advantage (i.e., for the import of oil, or the export of natural gas). However, many of these ports may be subject to more frequent and intense tropical cyclones under conditions of climate change, as well as sea surface level increases. As such, infrastructure planners must take these climate change impacts into account as they design port and energy infrastructure facilities.

¹⁸ Mills, Elizabeth. 2006. “Averting An Energy Crisis in South Asia.” *Asia Times Online*. (September 14, 2006) (http://www.atimes.com/atimes/South_Asia/HI14Df01.html (Accessed January 2, 2011))

Recent discoveries of vast natural gas in Bangladesh and the Bay of Bengal may help alleviate energy shortages in South Asia. Whether or not these resources will be used locally or serve as a source of revenue remains to be seen.

India's economic growth has resulted in possessing the second-fastest energy market growth in the world.¹⁹ Specifically, in recent years, India's growth rate was 7 % per annum. Energy analysts believe that this growth rate will require corresponding increases of 4 % energy consumption, annually.¹⁹ While India is a major energy producer (ranked eleventh globally), it is still a net energy importer – being the sixth largest energy consumer.¹⁹ While it primarily uses coal for its energy needs, India is still heavily reliant on oil from the Middle East – importing 60-70 % of its supply.¹⁹ To address its energy needs, India is turning to both hydropower and nuclear power. While hydroelectric infrastructure expansion is currently ongoing, some estimates place existing Indian hydropower storage capacity at only 52 %.^{20 21} The United States entered into an agreement with India in 2005 to facilitate the development of a local nuclear power sector in India. While this agreement resulted in closer ties between these two nations, it also aggravated relations with some of India's neighbors – chiefly Pakistan – about the nuclear nature of the deal. Therefore, in addition to considerations of water resources with regards to its nuclear power sectors, India (and the United States) must take into account geo-political issues in the promotion of its energy sectors.

Pakistan has significant unmet energy needs. Oil and natural gas supply the vast majority – 80 % – of Pakistan's energy demands.²² However, Pakistan produces only 18.3 % of the oil it consumes.²² This results in the need for a massive import of energy resources. In a 2006 address to the Woodrow Wilson International Center for Scholars, Mukhtar Ahmed, the principal energy advisor to Pakistan's Prime Minister at the time, noted that over 40 % of Pakistani households do not have electricity. He also predicted that in the next twenty years, Pakistan's energy needs will increase by 350 %.²²

Pakistan does have considerable untapped energy resources: chiefly coal and hydropower. While, in relative terms, hydropower is a significant source of Pakistan's power supply mix – it remains quite underutilized. Some energy analysts place Pakistan's current hydropower use at only 14 % of its potential.²³

¹⁹ Center for Strategic and International Studies. 2006. "India's Energy Dilemma." *South Asia Monitor*. No. 98. (September 7, 2006).

²⁰ Sinha, Uttam Kumar. 2010. "Water and Energy: A Flashpoint in Pakistan-India Relations?" *Journal of Energy Security*. (December 14, 2010). (http://www.ensec.org/index.php?option=com_content&view=article&id=271:water-and-energy-a-flashpoint-in-pakistan-india-relations&catid=112:energysecuritycontent&Itemid=367 (accessed January 2, 2011))

²¹ India's development of its hydropower sector will be discussed in more detail in the following section.

²² Wilson Center, 2006. "Fueling the Future: Meeting Pakistan's Energy Needs in the 21st Century." (http://www.wilsoncenter.org/index.cfm?fuseaction=events.event_summary&event_id=185919 (accessed January 2, 2011))

²³ Sinha, Uttam Kumar. 2010. "Water and Energy: A Flashpoint in Pakistan-India Relations?" *Journal of Energy Security*. (December 14, 2010). (http://www.ensec.org/index.php?option=com_content&view=article&id=271:water-and-energy-a-flashpoint-in-pakistan-india-relations&catid=112:energysecuritycontent&Itemid=367 (accessed January 2, 2011))

The development of Pakistan’s hydropower sector has, however, been hindered “by administrative problems, aging infrastructure, and significant inter-provincial rivalry.”²³ Tensions between Pakistani provinces have resulted in the slowing of the development of new hydropower facilities. For example, the Pakistani province of Punjab – being an economic, industrial, and population center – has advocated for the construction of new hydroelectric dams, as it would receive many of the power generation benefits. However, the poorer province of Khyber-Pakhtoonkhwa has resisted such efforts, as significant amounts of agricultural land would be lost in the process. Similarly, the province of Sindh has resisted the construction of new facilities because it fears being the recipient of decreased water flows as a result.²³ In addition, severe damage to hydropower infrastructure occurred during the recent floods.

The internal Pakistani debates over hydropower – and subsequent delays in constructing new facilities – ultimately have resulted in a hampering of the growth of the Pakistani economy. As such, this case illustrates how energy security – or a lack thereof – can serve to amplify U.S. security issues in the region.

Water

South Asian sources of fresh water come predominantly from two sources, Himalayan snowmelt and the South Asian Monsoon. From the rugged mountains of remote Afghanistan to the near sea level plains of Bangladesh, each country in the region deals with different climate regimes and water supply challenges. However, as can be seen in Table 1,²⁴ the predominant use of freshwater withdrawal each year remains for agricultural use. This highlights the point that even as countries like India look to advance toward fully developed nation status, the region will continue to face high water supply stresses as the projected populations in the region grow. Regional populations are expected to increase in excess of 30 % overall, and in some cases double for individual countries.²⁵ While the region as a whole will deal with water-related risk exposure going forward, the challenges, as well as opportunities, with respect to water use vary greatly for each country.

<u>Country</u>	<u>Year</u>	<u>Total Freshwater Withdrawal (km³/yr)</u>	<u>Per Capita Withdrawal (m³/p/yr)</u>	<u>Domestic Use (%)</u>	<u>Industrial Use (%)</u>	<u>Agricultural Use (%)</u>
Afghanistan	2000	23.26	779	2	0	98
Bangladesh	2000	79.40	560	3	1	96
China	2000	549.76	415	7	26	68
India	2000	645.84	585	8	5	86
Pakistan	2000	169.39	1,072	2	2	96

Table 1 – South Asia countries total per capita water usage and demand by sector

While Afghanistan’s population is relatively small and sparsely situated by South Asian standards, years of unrest have left the country generally in a predominantly rural and agrarian structure. Over 80 % of Afghanistan’s population lives outside urban areas.²⁶ While the far

²⁴ United States Energy Information Administration, 2010: International Energy Statistics, Department of Energy

²⁵ <http://esa.un.org/UNPP/>

²⁶ <http://www.fao.org/nr/water/aquastat/countries/afghanistan/index.stm>

eastern areas of the country experience some monsoon influence, the vast majority of the country exists in an arid climate. Accordingly, snowmelt each year serves as the essential water source for Afghanistan. The agricultural system uses 98 % of the extracted water from snowmelt.²⁶ The conflicts within the country have damaged an estimated 36 % of irrigation systems around the country. However, Afghanistan continues to rely on self-supplying its primary crop of wheat with pre-war estimates of irrigated lands supplying over 77 % of total wheat production and over 85 % of total food and crops.²⁶ During recent reconstruction years, two distinct trends have developed.²⁶ The first is that over three quarters of the agricultural sector budget has been dedicated to irrigation projects. The second is a marked increase in groundwater use, raising concerns about depletion of these resources.²⁶ Both of these trends point to a growing demand for an often-sparse resource (exacerbated by the overall arid climate of the country) as well as highlighting a resource that is nonetheless critical to the country's long-term stability.

India is the second most populous country on the planet; it is both blessed and cursed by its water supply situation. The balance of snowmelt from the Himalayas and monsoon driven rainfall provide a year-round supply of water at least in the Ganges and Brahmaputra basins in the north of the country. However, both the tension with neighboring countries regarding water supplies from trans-border rivers as well as the extreme amounts of water delivered by monsoons in terms of floods and droughts make India extremely susceptible to water supply issues. These are further complicated by water pollution issues facing the Ganges-Brahmaputra-Meghna system, which supplies some 62 % of the country's water resources.²⁷ However, India has benefited from positive trends with respect to water use in recent years. Its GDP dependency on agriculture has fallen 8 % between 1998-2008.²⁷ Even though 71 % of its population is estimated to live in rural areas, over 88 % of the population has access to some degree of improved water²⁷. India has hydropower generation numbers that result in its ranking 5th globally.²⁸ Even with these positive trends, however, India continues to face stresses on its water supply. Agricultural demand, even though not as critical to the economy as it once was, still accounts for 91 % of annual water usage.²⁷ Only 31 % of India's population has access to improved sanitation.²⁷ The extensive amounts of water that leave the country before reaching the sea also place India in constant state of dealing with its neighbors regarding any efforts to increase hydropower or adjust flows to meet its internal needs. India's simultaneous quandary of having too much and too little water highlights its water supply and water use challenges as it looks to continue its strong development in the coming years and decades.

For Bangladesh, water supply issues are not related to the function of overall availability of water as it has one of the highest per capita availability levels of any country around the world.²⁹ Issues with distribution in timing, headwater sources, proximity to the Indian Ocean and topography, however, lead to the major challenges Bangladesh faces with respect to water supply. The vast majority of the total annual rainfall occurs during the summer monsoon months. As a result, Bangladesh has a very dry winter season. Because the source headwaters of its vast river system generally lie outside the country's boundaries it is dependent on water treaties to ensure reasonable levels of streamflow outside the monsoon season.³⁰ While tropical cyclones can provide needed rainfall in spring and fall, the general alluvial lowland structure of most of its land means significant rains from cyclones can trigger flooding events. This issue is, of course, also a concern during each year's monsoon cycle. Agricultural water use accounts for roughly 88 % of

²⁷ <http://www.fao.org/nr/water/aquastat/countries/india/index.stm>

²⁸ United States Energy Information Administration, 2010: Country Analysis Briefs - India, Department of Energy

²⁹ <http://chandrashekharsandprints.wordpress.com/2009/11/20/poisoning-bangladesh/>

³⁰ <http://www.fao.org/nr/water/aquastat/countries/bangladesh/index.stm>

water withdrawal in Bangladesh.³⁰ While agriculture accounts for only 19 % of the GDP it has been long felt that agriculture is key to helping the country achieving developed status.³⁰ However, while vast areas of land are available for multiple harvests in a given year, solving issues related to pronounced droughts and floods as well as providing consistent irrigation availability will be essential in truly exploiting Bangladesh's agricultural potential.

During 2010, the Indus River Basin gained worldwide attention as a result of the devastating floods that occurred in its confines. It is the basin itself, however, that captures the essence of all of the water supply issues facing Pakistan. With its main headwaters in the Himalayas, the 190 10⁶ m³ of snowmelt that enters the Indus each year³¹ creates a natural tension point with its neighbor India through which the water first flows. Upon entering Pakistan, the Indus basin covers over 70 % of the geography of Pakistan.³² This river is at the core of Pakistan's key agricultural economy which accounts for approximately 23 % of GDP, employs about 43 % of the labor force and provides about 60 % of the country's export earnings.³² Between snowmelt and monsoon streamflow contributions, Pakistan is able to take advantage of two major growing seasons: winter crop-spring harvest and summer crop-fall harvest. Nearly 80 % of the cropped area is irrigated and this produces about 90 % of Pakistan's total farm output.³² It is also important to note that 94 % of the total river withdrawal is to support agricultural efforts.³² Probably the most troubling concern for Pakistan's reliance on the Indus River basin is a decrease of annual flows combined with increasing population.³¹ This has the potential of causing increased periods of water supply shortfalls and rising tensions with its neighbor, India.

Climate Impacts on Water Resources

Climate change is expected to have demonstrable and significant effects on South Asia as a function of water resource impacts. While natural disasters – floods, droughts, and tropical cyclones – have been historical realities across South Asia, the change in timing and intensity of these events is anticipated to have severe social, economic, and security impacts. In combination with other risk drivers – population increases, rural poverty, and weak governmental institutions – climate and natural disaster impacts on South Asian water resources are having, and are expected to continue to have, substantive negative effects.

Climate change is expected to increase the flow rate of the Yangtze River by the end of the 21st century although not matching roughly the impact of population growth in the region.³³ Although the projected population growth in China is projected to be lower than in other Asian countries, the fresh water availability per capita is projected to decrease. In the Ganges and Brahmaputra, where population increases are projected to be more substantial, the fresh water availability is expected to reduce considerably, overwhelming increase in river flow associated with a livelier monsoon.⁷⁶

In many parts of Asia, water storage by dams and barrages (flat land dams), for example, is extremely limited. Rural populations rely instead on rain-fed agriculture (in all about 68%) and irrigation systems. Rain-fed agriculture depends on local rainfall. Irrigation water from diverted river flow has a source that is an integral of regional rain. Himalayan glaciers and snowpack provide natural storage for water upon which much South Asian agriculture relies, especially Pakistan. However, through climate change, Himalayan glaciers have been melting at rates

³¹ <http://earthjournalism.net/content/rivers-source-rising-tension-between-pakistan-and-india>

³² <http://www.fao.org/nr/water/aquastat/countries/pakistan/index.stm>

³³ Webster, P.J. and J. Jian, 2011: Probability, Uncertainty and prediction: A pathway towards the alleviation of poverty in the developing world. (invited) To appear Phil. Trans. Roy. Soc

faster than they can recharge. In 2010 the United States Geological Survey (USGS) released a report highlighting Himalayan glacial retreat attributing these changes to climate change, and noted that the glacial “retreat impacts water supplies to millions of people, increases the likelihood of outburst floods that threaten life and property in nearby areas, and contributes to sea-level rise...”³⁴

Given the changes to the Himalayan snowpack, as well as the changes in timing and intensity of droughts, water resource experts have called on South Asian governments to change the way they use their water resources. The Asian Development Bank has stated that the current inefficient use of water resources is a function of South Asian governments not managing water properly and that it will subsequently hold back future economic growth.³⁵ Changes in precipitation patterns accompanying climate change will only exacerbate the retardation of economic growth. Similarly, a report from the Woodrow Wilson International Center for Scholars concerning Pakistan’s water resource problems notes that Pakistan’s water resources infrastructure is inefficient and is essentially designed for a pre-climate change world: “While dams, canals, barrages, and other massive engineering projects have helped establish an extraordinary irrigation system, these structures can be expensive, environmentally unfriendly, and inefficient. Instead of repeatedly building immense new structures that only create more water inefficiency, Pakistan should boost investment in repairing and maintaining existing infrastructure in order to decrease water profligacy – thereby lowering costs and safeguarding precious water supply.”³⁶

Water Resource-related Natural Disaster Impacts

In many areas of the developing world – certainly in South Asia – growth has primarily occurred in coastal areas and near large rivers. These are loci for trade and foreign investment, and are correspondingly locations in which impoverished rural residents may move in hopes of securing more gainful employment. Yet, because of their very locations, these sites have resulted in an increased frequency of natural disasters involving water resources: floods, tropical cyclones, and coastal flooding and storm surges.

Analyses from the United Nations International Strategy for Disaster Reduction (UNISDR) have highlighted the water resource-related disaster impacts of a number of the countries included in this study. Bangladesh, India, and Pakistan consistently rank among the nations with the highest propensities for natural hazard risk – and are also amongst the nations most subject to water resource-related natural disasters.³⁷

- Absolute number of people exposed per year to tropical cyclones: India – #4; Bangladesh - #6; Pakistan - #17;

³⁴ United States Geological Survey, 2010. “Glaciers Retreating in Asia.” (August 25, 2010) (http://www.usgs.gov/newsroom/article.asp?ID=2573&from=rss&utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+USGSNewsroomPartial+%28USGS+Newsroom+-+Partial+Descriptions%29&utm_content=Google+Reader (accessed January 3, 2011))

³⁵ Abbugao, Martin. 2010. “Asia Gripped by Water Crisis: Asian Development Bank” *AFP*. (June 29, 2010) (<http://www.google.com/hostednews/afp/article/ALeqM5hVBSmEJA1GQGOD2obhXqW516GUzA> (accessed January 3, 2011))

³⁶ Kugelmann, Michael, and Robert M. Hathaway, eds. 2010. *Running on Empty: Pakistan’s Water Crisis*. Washington, DC: Woodrow Wilson International Center for Scholars – Asia Program. p. 20.

³⁷ United Nations International Strategy for Disaster Reduction Secretariat. 2009. *Global Assessment Report on Disaster Risk Reduction*. United Nations. pp. 30-46. (<http://www.preventionweb.net/english/hyogo/gar/report/index.php?id=9413> (accessed January 3, 2011))

- Absolute number of people exposed per year to storm surges from tropical cyclones: Bangladesh - #1; India - #3;
- Relative number of people exposed per year to storm surges from tropical cyclones:³⁸ Bangladesh - #20;
- Absolute GDP exposed as a function of tropical cyclones: India - #9; Bangladesh - #13;
- Absolute number of people exposed per year to floods: Bangladesh - #1; India - #2; Pakistan - #9;
- Relative number of people exposed per year to floods: Bangladesh - #2; India - #5;
- Absolute GDP exposed per year to floods: Bangladesh - #3; India - #4;
- Relative GDP exposed per year to floods: Bangladesh - #3; India - #8
- Absolute number of people exposed per year to drought: India - #2; Bangladesh - #6; Pakistan - #8;
- Absolute crop area exposed to drought per year: India - #2; Pakistan - #17.

Food and agriculture

The role of the agriculture sector throughout South Asia is paramount. Representing 20 % of the region's GDP³⁹ and over 45 % of South Asia's employment^{39 40}, agriculture plays an essential role to the regional economy. In terms of land surface area, over 50 % of the region's land area is committed to agricultural efforts.³⁹ This vast spatial coverage and degree of economic importance make this sector particularly susceptible to the most influential cause in annual production variances – weather and climate. **Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined.** The impacts are not confined to the production season but can also cause post-harvest spoilage and loss up to the point of consumption. For example, in India, spoilage estimates are in excess of 12.8 billion dollars a year.⁴¹

Food insecurity predominates in South Asia. Countries such as Pakistan and Bangladesh have high populations of rural poor that are subject to food insecurity – as well as the destabilizing impacts of climate change and natural hazards. Under the Obama Administration, the United States has recognized both the humanitarian and security importance of food security and has committed considerable financial resources to increasing food security.

Switzerland's Agency for Development and Cooperation released a report in 2010 that highlighted the dramatic – and increasing – status of food insecurity in Pakistan.⁴² Among its key findings are that food insecurity affects 48.6 % of the Pakistani population; 34 % of Pakistan's districts are characterized as “extremely food insecure” – a doubling since 2003; and that Pakistan's poor spend 61.6 % of their household income on food – an increase of 5 % since 2005-06.⁴²

In response to the high levels of food insecurity in Bangladesh, the United States has committed significant resources to promoting food security there. In 2010, the Administrator of the United States Agency for International Development (USAID), Rajiv Shah, announced a food security partnership with Bangladesh.⁴³ As part of a \$3.5 billion Obama Administration effort to increase

³⁸ According to UNISDR's methodology, the relative number of people subject to an event is determined by the proportion of the absolute number of people exposed per the country's population.

³⁹ World Bank Indicators - <http://data.worldbank.org/indicator/SL.AGR.EMPL.ZS/countries>

⁴⁰ Economic Survey, Ministry of Finance, Government of India

⁴¹ The Environmental Food Crisis, 2010, UNEP/GRID

⁴² Swiss Agency for Development and Cooperation. 2009. *Food Insecurity in Pakistan*.

⁴³ <http://geneva.usmission.gov/2010/06/02/food-security-bangladesh/> (accessed January 2, 2011)

food security, the United States committed \$15 million that year for agricultural and nutritional efforts in Bangladesh. In addition, the U.S. promised \$4 million for nutrition interventions for infants and young children. These funds represented an increase of twenty-times over levels provided the year before.

Commenting on the U.S. commitment to food security in Bangladesh, Administrator Shah has stated: “We will commit to maintaining or increasing our bilateral investments in future years, if Bangladesh maintains its commitment to this plan.”⁴⁴ This demonstrates the U.S. interest in bilateral efforts to increase food security on the part of both Bangladesh and the United States. However, such contingencies do not necessarily imply a cognizance of the dramatic impacts that climate change impacts could have on Bangladesh’s food security – regardless of Bangladesh’s commitment to improving the situation.

The primary weather and climate differential influence throughout the region is precipitation. The majority of annual precipitation comes during the 4 month monsoon rainy season, but is supplemented by two periods of tropical cyclone activity in the Northern Indian Ocean (during April-May and October-November) and annual snowfall over the Himalayas. While the combination provides an optimal balance to support natural (rain-fed) and irrigated food production throughout South Asia year round, the potential extremes can be devastating to agricultural efforts. Too much water, exemplified by the 2010 Indus River floods in Pakistan, can completely destroy agricultural output for a season and cause long-lasting damage and subsequent losses to viable crop and livestock areas. It is estimated that the damages for Pakistan’s agricultural sector in 2010 have already cost in excess of 2.9 billion dollars, with expectations that losses will escalate when long-term implications are factored in.⁴⁵ The opposing extreme can also be catastrophic, such as the drought of 2002 which impacted over 50% of India’s land area,⁴⁶ and resulted in an estimated crop loss value in excess of 360 million dollars.⁴⁷ These annual events could become further compounded by climate shifts that may cause multi-year or decadal impacts on Indian Monsoon behavior and influence recurring snowpack levels in the Himalayas.

In contrast, the abundant water supplies in the region provide significant potential for all the countries. The availability of extensive areas of double and even triple crop zones (i.e., multiple harvests in a single year) could support significant economic advancement, particularly for less developed countries in the region such as Bangladesh. The keys lie in reducing the tie of agricultural production and output solely to the whims and ebbs in annual precipitation quantities. This involves steps such as improved irrigation systems that demand less water withdrawal, and modernization of systems to speed and protect crops from harvest to consumption or export points. However, all this also hinges on ability to better control flows throughout the vast river systems, some through better management of existing systems and some through construction of new reservoirs and protective levee infrastructure.

Reducing regional threats with weather and climate information

Climate, weather, and hydrological forecasts available to South Asian countries lag substantially behind the state-of-the-art forecast methods that are available to many parts of the world. Further, the tools used by the U.S. Military in this region for weather beyond a few days also lag

⁴⁴ <http://geneva.usmission.gov/2010/06/02/food-security-bangladesh/> (accessed January 2, 2011)

⁴⁵ Farm, livestock sectors suffer colossal loss, Dawn Newspaper, SI Raza, Friday, 13 Aug, 2010

⁴⁶ Drought, coping mechanisms and poverty, 2009, International Fund for Agricultural Development

⁴⁷ Assistance to Drought Victims ASIN-24

behind the state-of-the-art operational forecast products and research for this region. An example of success in implementing state-of-the-art forecast tools is CFAN's provision of forecasts of floods and tropical cyclones to the Bangladesh government.⁴⁸ With initial funding from USAID, CFAN worked with the Bangladesh Flood Forecasting and Warning Centre and the Bangladesh Meteorological Department to produce operational flood and tropical cyclone forecasts that were coupled with a community based communications network. It is critical to develop a similar system for Pakistan. It has been shown that the precipitation deluges that produced the flooding were predictable 8-10 days in advance.⁴⁸ These projects are doable and, while they likely will not result in stopping the floods, they will mitigate the disastrous outcomes of the flooding if effectively implemented.

The United States has both pressing humanitarian and strategic interests in ensuring that South Asian nations receive HA/DR services as soon as possible following a natural disaster. Governments themselves may fall as a result of natural disasters, and such nations may subsequently become failed states susceptible to militant and terrorist activity. Given the significant negative consequences that can very likely result in states like Bangladesh and Pakistan as a result of natural disasters, it has been an imperative that the U.S. military provide expeditious HA/DR services. In the case of Cyclone Sidr, U.S. aid was provided a full week after landfall. Advance warning of such events would reduce the range of uncertainty that U.S. Pacific and Central Command commanders must operate in – allowing them to make security decisions more quickly. Integrating advanced climate, weather (including tropical cyclone prediction and tracking), and hydrologic forecasting tools into its operational decision-making processes would support more rapid deployment of HA/DR services.

Integration of adaptation aid into U.S. foreign assistance funding for Pakistan and Bangladesh by providing these governments and communities with improved hydrologic, flood, and tropical cyclone forecasting information will increase security and rural viability – and, therefore, enhance U.S. security interests. The aftermath of Cyclone Sidr illustrated the civil unrest that followed increased food prices as a function of reduced food supply. Given that climate change-induced natural disasters are likely to become more frequent, we can anticipate such shocks to the food supply system going forward – unless adaptation steps are taken. Therefore, it is directly in the security interests of the United States – especially given both increasing Bangladeshi and Pakistan populations, and land areas impacted by more frequent flooding and sea level rise – that it provide services that will allow farmers to make informed decisions about planting and harvesting. Hydrologic and flood forecasting tools – provided at both the governmental and community levels – can help farmers reduce uncertainty and make better decisions. The provision, adoption, and implementation of such tools will be necessary for Bangladesh to continue as a moderate, democratic Muslim nation in the light of increased climate change impacts that we know, with a high degree of certainty, will increasingly be faced by Bangladesh. A similar case with perhaps much greater urgency can be made for Pakistan – given the instability of its political regime.

The success of CFAN's flood forecasting for Bangladesh illustrates the potential for this approach. Slow rise floods occur in Bangladesh occur every year. However, only one in every 5 years results in a flood lasting longer than 10 days. CFAN has calculated flood probabilities for

⁴⁸ Webster, P. J., V. E., Toma and H. M. Kim, 2010: Were the 2010 Pakistan floods predictable? *Geophys. Res. Lett*

Bangladesh on 10- and 15-day time scales.⁴⁹ These forecasts used 1-15 day forecast data from the European Center for Medium-Range Weather Forecasting (ECMWF). Probabilities of flooding were passed down to community levels where risk was determined relative to local economies. As a result of the forecasts, regions were successfully evacuated along the Brahmaputra during the three extensive flooding periods. Years 2007/2008 proved to be “proof of concept” years. The saving of lives and property were extensive.⁵⁰ Rather than each flood or tropical cyclone strike resulting in millions of people being placed into perpetual poverty,⁴⁸ robust forecast information enables resilience-building at the community level.

Long-term planning for major projects such as the building of water supply dams and barrages and hydroelectric projects needs viable and reliable probabilities of the changes in weather, climate and demographics over the next century. Initial studies have been conducted by CFAN, but only for three river basins. A second study⁴⁹ looked at the long-term changes in the statistics of flooding in the Ganges, Brahmaputra and the Yangtze rivers. Climate models were examined using ensemble multi-model forecasts and in each river it was determined that there was a high probability that river discharge would increase by about 15% by the end of the 21st century and that this increase would be coupled to an increase of flooding frequency. The probability is high that the return time of a 10-day Brahmaputra flood would happen, for example. However, these changes in discharge and flooding were found to be dwarfed in the Ganges and Brahmaputra basin by population growth with fresh water availability become a distinct problem through the 21st century.

Hydrological probabilistic predictions of river flow and snow accumulation, coupled with probabilistic demographic projections are needed for the entire Asian Tibetan-Himalayan river complex. These projections are needed at national and international levels to facilitate careful and deliberate decision-making for major projects that have impacts across international borders. Transboundary water disputes, particularly in times of drought, seem inevitable. River flow data is not shared among countries, with few exceptions (Pakistan-India and the Indus flow); this makes it difficult to monitor treaty abidance and fuels distrust in the region. One of the key challenges CFAN faced in forecasting floods for the Ganges and Brahmaputra Rivers was that India does not provide Bangladesh with streamflow information. Hence, CFAN devised a novel method⁵¹ to estimate the streamflow in India from observed and predicted rainfall amounts and a river routing model. Application of this method to all of the rivers in this region would provide a basis for better water management in downstream countries and monitoring of water treaty abidance, both of which could enhance security in the region.

In summary, given the potential of environmentally induced destabilization, provision of better climate, weather, and hydrologic forecasting services to the Bangladeshi and Pakistani government and communities, in concert with providing capacity building and technology transfer tools, could enable the nations to deal better with the impacts of climate change and

⁴⁹ Webster, P.J., J. Jian, T. M. Hopson, C. D. Hoyos, J., H-R. Chang, P. Agudelo, J. A. Curry, T. N. Palmer, A. R. Subbiah, R. L. Grossman, 2010: Extended-range probabilistic forecasts of Ganges and Brahmaputra floods in Bangladesh. In press November issue: Bull. Amer. Meteor. Soc.

⁵⁰ Asian Disaster Preparedness Centre, 2009: Flood Forecasts Application for Disaster Preparedness: Post Flood Forecasts Assessment 2008: Community Response to CFAN Forecasts. Available at <http://www.adpc.net/v2007/> and <http://pacific.eas.gatech.edu/~pjw/FLOODS>.

⁵¹ Hopson, T.M., and P.J. Webster, 2009: A 1-10 day ensemble forecasting scheme for the major river basins of Bangladesh: forecasting severe floods of 2003-2007. J. Hydromet

impending natural disasters. Similarly, inclusion of such forecasting tools in the United States military regional command structure would allow it to reduce uncertainty in its operational decision-making. In the immediate sense, this will allow for faster HA/DR operations. In a strategic sense, however, tools that reduce uncertainty about the operational environment within which the U.S. military operates will advance the strategic security interests of the United States.