INTEGRATED ASSESSMENT OF THE 2010 PAKISTAN FLOODS

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The flooding of the Indus River system in Pakistan during the summer and autumn of 2010 represents not only a humanitarian disaster on a cataclysmic scale, but also a significant threat to U.S. security interests. The destruction wrought by the 2010 floods could set Pakistan back years or even decades, weaken its struggling civilian administration and add to the burdens on its military, distracting from its efforts to keep the Pakistani Taliban in check. We explore how the floods have acted as a threat accelerant to an already unstable nation. We then discuss lessons learned, and how a probabilistic forecasting scheme can help provide U.S. policymakers and operational commanders with information towards reducing some of the threat accelerant components of natural disasters.

Flood causes

Beginning in July 2010, the Indus River basin began flooding, progressing from north to south. In many areas, floodwaters did not subside for weeks and in some areas the flood waters still have not completely receded at the time of this report. The proximate causes were a function of elevated precipitation rates during 5 monsoon pulses in July and early August, in combination with deforestation and overgrazing in the north that allowed greater volumes of water to enter the system at a rate than would have been slower had proper conservation measures been in place.[1] [2] The floods began in the headwaters of Khyber-Pakhtunkwa province and made their way through Punjab and Sindh provinces. Only by mid-October had the floodwaters receded from Khyber-Pakhtunkhwa and Punjab. It was not till November that waters receded from Sindh.

During an active phase of the monsoon through July and early August 2010, five periods of intense rainfall covered north and northwest Pakistan. Heavy monsoon rains exceeded 10 inches in some locations over the period July 27-30. However, Pakistan water experts believe that poor land management, outdated irrigation systems, and logging are at least as much to blame as the rainfall.[3]

Illegal logging supported by the Taliban in the northwest province of Khyber-Pakhtunkhwa has felled as much as 70% of the forest in some districts. The lack of trees, combined with overgrazing by livestock, reduces the soil's ability to hold water and leads to soil erosion. Flash flooding in the northern, mountainous areas then sends silt downstream, reducing the amount of water the river channel can hold. Diverting the Indus through irrigation channels has encouraged people to build closer to or even in the historical or geological river channel.

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[1] Webster, P.J., V. Toma and H-M Kim, 2011: Were the 2010 Pakistan floods predictable? Geophys. Re. Lettrs. Accepted.

[2] Houze, R. A.,Jr., K. L. Rasmussen, S. Medina, S. R. Brodzik, and U. Romatschke, 2010: Anomalous Atmospheric Events Leading to the Summer 2010 Floods in Pakistan, Submitted to the *Bull. Amer. Meteor. Soc*.

[3] http://www.lfpress.com/news/world/2010/08/31/15194681.html

Many of the irrigation channels are built using techniques from the 18th century.

Whereas prominent Pakistani politicians, TV anchorpersons, and Punjab water engineers have stated that the catastrophe would not have occurred had the Kalabagh dam been built,[4] the Climate Himalaya Initiative[5] argues that engineering structures and human error may have played a major role and have been the main cause in the catastrophe. There are a substantial number of barrages (dams) on the Indus River that support irrigation and hydropower. The flood occurred when the rising river bed (owing to the huge silt deposition in the upstream areas) was trapped by the Taunsa barrage, obstructing the water flow. These heavy silt loads were then transported through western tributaries of the Indus River. Construction of protective levees and dykes has also contributed to raising the riverbed and the sedimentation of upstream areas; moreover, the rising riverbed levels have rendered protective levees ineffective. A rehabilitation project raised the crust level of the barrage by one foot so that silt entry into the right bank canal could be controlled; however the protective embankments were also to be raised by a foot but this was not done. Further, local accounts and media reports suggest that the barrage staff has failed to properly operate the newly installed motorized hoisting system. It has been reported 10 gates were not fully opened. Clearly, the situation is complex and further investigations are required to sort all this out.

Magnitude of the disaster

The Pakistan floods had dramatic impacts on Pakistani life, property, and infrastructure. The toll included:[6]

- 1,800 dead;
- 3,000 injured;
- 1,550,000 people displaced to other parts of Pakistan;
- Over 1 million farm animals lost
- 2 million homes destroyed;
- 400 miles of roads destroyed – including critical transportation linkages;
- 46 bridges washed away;
- Multiple railway lines and junctures destroyed;
- Summer crops ruined and planting for winter season largely abandoned.

The fate of flood refugees – or 'internally displaced people' (IDPs) – has varied throughout the country. Rural areas, depending on agriculture, were those that were hardest hit by the floods. In the parts of Pakistan where the flood first hit – Khyber-Pakhtunkhwa and Punjab – 95% of victims were able to return home by early November. However, during that same time period, 85% of the affected population in Sindh province remained unable to return to what remained of their homes.[6] Mines and artillery shells from fighting in Khyber-Pakhtunkhwa have been flushed downstream by the floods and scattered in some low-lying areas, posing a future risk to returning inhabitants (cited by the Wikipedia).

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[4] The Kalabagh dam was a proposed Pakistani hydroelectric facility. Its construction was cancelled in 2008. While the dam was intended to be a power generation facility, and not a flood control or water supply storage facility – it may have had some capacity to store excess water during high precipitation events. (http://en.wikipedia.org/wiki/Kalabagh_Dam (accessed January 5, 2011))

[5] http://chimalaya.org/2010/08/20/the-engineering-failures-behind-the-pakistan-floods/

[6] Dixon, Rebecca Anne, and Teresita Schaffer. 2010. "Pakistan Floods: Internally Displaced People and the Human Impact" in *South Asia Monitor*. Center for Strategic and International Studies. No. 147 (Nov. 1, 2010). 1.

As of November 2010, the Asian Development Bank and the World Bank have estimated that infrastructure losses amounted to $9.7 billion.[6] Further, many IDPs have moved – whether temporarily or permanently – to urban areas. This is putting great strains on existing public infrastructure – like drinking and waste water infrastructure and power generation and transmission facilities – in these areas, as these systems become overburdened by having to service significantly more individuals than in the past.

Prediction and predictability of the floods

Pakistan does have an administrative and technical infrastructure to forecast floods. Pakistan's Flood Forecasting Division[7] was established in 1978 with the support of the United Nations Development Programme (UNDP). An observational system supports measurement of discharge in the canals and also measurements of rainfall and snow melt in the catchment areas of the Indus. Quantitative precipitation measurement is supported by two precipitation radars in key locations of the catchment. A river routing model[8] tracks river discharge and two day flood forecasts are provided each day. On June 21, 2010 the Pakistani Meteorological Department's monsoon forecast[9] cautioned that urban and flash flooding could occur from July to September in the northern parts of the country. The initial flooding in the north was not predicted by the Flood Forecasting Division, although the subsequent downstream flooding was forecast[10] a day or two in advance by the river routing model.

The summer of 2010 produced Pakistan's worst flooding in 80 years. A perspective on this flood in the context of other natural disasters striking Pakistan can be found here.[11] Severe floods[12] were also seen in 1988, 1992 and 1995. Webster et al. (2010) also provides an historical perspective on the Pakistan floods. There have been 67 flooding events occurring since 1900 with a clustering of 52 events in the last 30 years [IDD, http://www.emdat.be].This clustering is consistent with the increase in intensity of the global monsoon during the last three decades (Wang et al. 2010) occurring with the warming of the last three decades. There have be other flooding events with similar death tolls and cost (e.g., 1950, 1977, 1998).

Webster et al. (2010) investigate two questions regarding the Pakistan floods:

- Was the rainfall abnormal compared to previous years?
- Could a high probability of flooding have been predicted with a lead time sufficient to allow timely evacuations, mitigatory water resource management decisions, the protection of infrastructure and the saving of agricultural and household effects?

They concluded that while the average May to August rainfall for 2010 was comparable in magnitude to previous years, it was the rainfall rate and the location of the deluges that conspired to produce the devastating floods. They used the ECMWF EPS 15-day ensemble forecast system to assess whether the rainfall over the flood-affected region was predictable. A multi-year analysis shows that, in general, the rainfall in Pakistan is highly predictable out to 6-8 days with indications of each heavy rainfall event seen 10-14 days in advance, which

[7] http://www.pakmet.com.pk/FFD/cp/floodpage.asp
[8] http://www.pakmet.com.pk/FFD/index_files/frm.htm
[9] http://pakmet.com.pk/MON&TC/Monsoon/monsoon(2010).html
[10] http://www.pakmet.com.pk/FFD/index_files/sindh.htm
[11] http://www.scribd.com/doc/35665996/Pakistan-Floods-Historical-Natural-Disaster-Events
[12] http://www.pakmet.com.pk/FFD/index_files/hpeak.htm

was similar to the predictability of other events in their multiyear analysis.

Webster et al. (2010) conclude that if the rainfall forecasts had been coupled to a hydrological model then the high risk of extensive and dangerous flooding could have been anticipated, enabling proactive actions to mitigate its effects. If such forecasts had been available to the regions of northern Pakistan, government institutions and water resource managers could have anticipated the rapid filling of dams with floodwaters – thereby releasing water ahead of the deluges. With warnings of high flood risk over a week in advance, evacuation of communities in peril and farm animals could have been accomplished.

Pakistan would benefit from a hydrological forecasting scheme similar to that developed by the Climate Forecast Applications Network for the Government of Bangladesh. The Bangladesh system incorporates the same form of statistically rendered ensemble precipitation forecasts as discussed above, but coupled to a hybrid hydrological model. Working with Government of Bangladesh authorities, these 10-day river forecasts are communicated to the union (county) and village level allowing time to prepare for the floods.

Implications for Energy and Food Security

The summary provided here is drawn from a report by Kronstadt et al. (2010) entitled "Flooding in Pakistan: Overview and Issues for Congress."[13]

Energy security

According to various media reports, the floods closed approximately 8% of Pakistan's total power generation capacity. Flooding damaged generation facilities and transmission infrastructure, and it cut off power plants from their supply of generation fuels such as oil and natural gas. Output at refining and natural gas facilities also was curtailed due to transportation disruptions. Most of this energy production and transportation capacity has been restored. However, the damage has highlighted and exacerbated Pakistan's pre-existing energy problems. Prior to the floods, the country was already suffering from a shortage of electricity generation capacity and rolling blackouts. The cost of recovering from flood damage sets back efforts to improve electricity supply.[13]

Food Security

Even before the flooding, FAO had estimated that about 60 million people were food-insecure in Pakistan, which accounts for about half of the country's population. FAO estimated that an additional 17 million people became food-insecure as a result of food price inflation in Pakistan over the past few years, and that the poorest households are now spending more than 70% of their incomes on food. The full extent of damage from the summer 2010 flooding has not yet been fully quantified. The affected populations have suffered severe crop, livestock, and grain stock losses. While the floods are causing severe negative effects on agricultural production in the current season, the damage and impacts will likely have broader implications for future agricultural production and food security in Pakistan. The harvest for winter 2010/2011 is questionable, owing non-availability of water owing to damage to the irrigation network, continued inundation of agricultural land, loss of

[13] Kronstadt et al. (2010) entitled "Flooding in Pakistan: Overview and Issues for Congress http://www.fas.org/sgp/crs/row/R41424.pdf

seeds for planting and agricultural inputs such as fertilizer, and massive migration of farmers due to floods. The floods have affected the most densely populated livestock areas in Pakistan, decimating the livestock in some regions. Many animals died because they had to be left behind when people were rescued. FAO stated that one of its primary priorities is maintaining and keeping healthy the surviving population of livestock, which continues to be a major challenge as supplies of animal feed such as straw and forage is in limited supply, and transportation of goods and services is severely limited due infrastructure damage.[13]

Security implications

A summary of the U.S. security concerns regarding Pakistan is provided by Kronstedt et al. (2010): "Pakistan is at the center of several crucial U.S. interests, including fighting terrorism and religious militancy, seeking stability in neighboring Afghanistan, and promoting nuclear non-proliferation, among others. . . U.S. interests in countering Islamist militancy in the region and strengthening Pakistan's democratic institutions are under greater threat due to the chaos and destruction caused by widespread flooding there . . . The aftermath of the floods . . . may undermine the already waning legitimacy of the civilian government by demonstrating its ineffectiveness to large numbers of Pakistanis in need of public services, while improving the status of Pakistan's powerful military by the more visible role it played in providing disaster relief. The crisis has also diverted attention and resources from other national priorities, at a time when Pakistan remains financially strapped." [13]

Repercussions for Stability and U.S. Interests

The 2010 Pakistan floods represented (and represent) both direct and indirect threats to U.S. security interests in the region. As a result, these floods – their cause, measures taken before they occurred (hydrologic prediction and notification of downstream communities), and U.S. and Pakistani responses – must be evaluated with regards to future natural disasters in this volatile region.

U.S. security interests, as well as assets, in the region were disrupted as a direct result of the floods. Some of these consisted of:

- Most logistical supplies for U.S. forces in Afghanistan are shipped to Afghanistan overland through Pakistan. Some of these supply shipments were disrupted and delayed due to the road and bridge destruction throughout the country – but especially in Khyber-Pakhtunkhwa province.[14]
- U.S. military assets were used on HA/DR missions.[15] These consisted, in part, of helicopter and fixed-wing transport to deliver humanitarian supplies to isolated groups and camps. Because they were being used for HA/DR operations, these assets were unavailable for active military operations – whether in Afghanistan or elsewhere in the region.
- The floods exposed weaknesses in the Pakistani government's ability to respond to natural disasters. As one of the few robust institutions in Pakistan, the Pakistani military played a central and valuable role in responding to the flood. In terms of

[14] Gall, Carlotta. 2010. "Pakistan Flooding Disrupts Afghan War Supplies." *The New York Times*. (August 24, 2010) (http://www.nytimes.com/2010/08/25/world/asia/25pstan.html (accessed January 5, 2011))
[15] American Forces Press Service. 2010. "Military Reaches Pakistan Flood Relief Milestone." (Oct. 28, 2010) (http://www.defense.gov/news/newsarticle.aspx?id=61461) (accessed 21 December, 2010) and (http://www.defense.gov/news/newsarticle.aspx?id=61181) (accessed 21 December 2010)

both attention and resources, this – at least temporarily – removed some focus away from Pakistan's operations against Taliban forces located in Pakistan, such as Tehrik-i-Taliban Pakistan. Given that U.S. progress in Afghanistan is contingent upon simultaneous efforts by Pakistan against Taliban forces in Pakistan itself, this opportunity cost had repercussions for U.S. operations in Afghanistan.

- Response efforts to the floods have been performed by a number of different entities, including some Islamic militant organizations.[16] Some of these groups are actively engaged in efforts directly counter to U.S. interests in both Pakistan and Afghanistan. While the scale of these efforts is such as to only make a marginal difference (in terms of both disaster response and political gains), the mere fact that a gap existed in response efforts which was filled by organizations hostile to U.S. interests magnifies the credibility of these groups amongst the local population (and conversely downgrades the credibility of U.S. and Pakistani response efforts.)

In an indirect sense, the 2010 floods have the potential to also have negative effects on U.S. security interests in the region. In addition to the destructive effects of the flood themselves, the floods resulted in increased levels of instability across most of the criteria discussed earlier in this section – which future natural disasters could then further exacerbate.

- Population density: The floods caused massive relocations of IDPs throughout Pakistan. Many of these IDPs, however, have moved towards urban areas. For example, as of November 2010, hundreds of thousands of IDPs were in camps around the city of Karachi (population 18 million). Karachi is already considered a hotspot for ethnic violence given rivalries between the majority Mujahirs and the Pashtuns (while formally considered a minority in Karachi, Pashtuns still comprise a population of 7 million residents in the city.) Tensions also exist between these groups and Sindhs living in the city. IDPs in Karachi come from a variety of ethnic groups and regions across Pakistan. Therefore, in addition to the mere addition to population density (a threat driver in its own right), the ethnic tensions in Karachi are added to by significant numbers of IDPs. Minor incidents of violence between groups, and government forces and groups have occurred since the floods began.[6]
- Household and community resilience: Following the floods, resources available to households and communities to bolster their resilience to natural hazards are significantly lower than they were before. In the rural areas impacted by the floods, entire communities are gone. While these villages can potentially be rebuilt, a major issue that Pakistan will have going forward concerns property rights. Many legal documents delineating property holdings have been permanently lost. As a result, disputes over land ownership are expected to develop.
- Agricultural resources – such as topsoil – have been depleted, and animals and farming equipment for thousands of farmers are gone. This will severely hinder economic development opportunities for those impacted by the floods – resulting in increasing poverty and negative financial ripples throughout the country.
- One of the key long-range issues involving security is poppy cultivation: "Poppy cultivation, unlike its replacement crop, wheat, creates more jobs over less acreage. But farmers will often sacrifice some profit and forgo illicit crop cultivation—which attracts insecurity, insurgents, and law enforcement—as long as the alternatives bring

[16] Ellick, Adam B., and Pir Zubair Shah. 2010. "Hard-Line Islam Fills Void in Flooded Pakistan." *The New York Times.* (August 6, 2010) (http://www.nytimes.com/2010/08/07/world/asia/07pstan.html?ref=2010pakistanfloods (accessed January 5, 2010))

them sufficient income. If efforts to that end succeed in Afghanistan—and as long as there is global demand for opiates—cultivation and heroin production could very likely move back to Pakistan. Such relocation would critically undermine the Pakistani state by empowering jihadists with profit and political capital."[17]

- Hundreds of thousands of IDPs remain in unstable camps. While these are intended to be temporary, concerns exist that these could become de facto permanent settlements. To avoid the beginning of a cycle of dependency, aid organizations are trying to limit structural dependency on food and financial aid by implementing work-for-food programs. Nevertheless, the large number of IDPs residing in camps and migrating into urban areas is destabilizing.[6]
- Governance systems and existing political violence: The 2010 floods highlighted a Pakistani governance system that is already under extreme stress. The floods clearly showed that the civilian government did not have the capacity to either warn communities of the growing flood levels or respond to the ongoing disaster in an effective manner. The Pakistani military, on the other hand, had the capability, heavy equipment, and resources to respond to many aspects of the flood. This has resulted in a perception and, to a degree, a reality of the Pakistani civilian government being even more reliant on the Pakistani military than it has been in the past. This has two negative ramifications. First, the rising preeminence of the military further erodes democratic governance in Pakistan. Second, the Punjabi ethnic group dominates the Pakistani military. A perception that the military – under the influence of a particular ethnic group – is taking more and more of a role in implementing government functions will result in further distrust and disengagement by large populations in Pakistan who are not Punjabi.

Political violence in Pakistan is extreme and ongoing. In addition to a series of assassinations and coups in recent decades, Pakistan is struggling to gain political control over major areas of the country, notably in Khyber-Pakhtunkhwa province. This transitional area is a stronghold for Pakistani Taliban insurgent groups, as well as terrorist organizations like al Qaeda, that operate in both Afghanistan and Pakistan. This unsettled area – in which Pakistani military operations are currently ongoing – is the very same area where the floods began and did considerable damage.[6]

Lessons from the 2010 Pakistan Floods

The 2010 Pakistan floods have exacerbated a mix of destabilizing elements that already existed within Pakistan. Similarly, future natural disasters and climate change impacts will occur in Pakistan and may add to the toxic mix of instability already present. Ultimately, if this cycle continues, the threat accelerant nature of natural disasters and climate change impacts may result in a failed state that could destabilize the entire region, and demand the highest levels of U.S. military and civilian resources. The question then arises – if, going forward, natural disasters will inevitably occur in Pakistan, what can the U.S. do to limit the probability of these natural disasters being threat accelerants that invariably result in Pakistan becoming a failed state?

Because the infrastructure capabilities of Pakistani cities are already overburdened, an active and ongoing effort exists to try to return IDPs to their regions of origin. In addition, reducing urban migration will reduce some of the ethnic tension that already exists in a number of urban areas. Following the floods, the government (civilian and military) are trying to

[17] http://www.brookings.edu/opinions/2010/0927_pakistan_drugs_felbabbrown.aspx

reestablish or build new community resources to encourage resilience (for example, medical clinics and schools), as well as rehabilitating rural areas to encourage a return to farming (i.e., a productive economic livelihood.) The U.S. and Pakistani militaries are still actively engaged in trying to suppress the insurgency throughout Pakistan, and especially in the Afghan-Pakistan border areas.

An area that has not been adequately addressed is to what extent improved understanding of flood vulnerability and monitoring and prediction of floods on timescales of days to weeks can be used to make operational decisions in terms of river management, prepositioning of resources, and providing advance evacuation warnings to communities. While relatively few lives were lost given the magnitude of the floods, substantial losses were sustained for livestock, crops and seed stock. Harvesting and/or transporting harvested crops away from flood regions in advance of floods, as well as evacuating livestock and seed stock, can substantially mitigate losses and speed recovery. Such an evacuation during the 2008 Bangladesh floods was accomplished with warnings that commenced a full nine days before the anticipated floods (Webster et al. 2010b).

Based upon the success of the flood forecasting, warning, and evacuation strategies that have been implemented in Bangladesh using CFAN forecasts, interest in developing a similar scheme for Pakistan has been expressed to us by individuals in the UNDP, USAID/OFDA, the World Bank, and RIMES. The overall situation seems mired in politics (international politics about which group is seen to be the source of the aid, funding, national level politics), and the most promising way forward for this seems to be through the World Bank and RIMES. The World Bank had made substantial progress on this with the Pakistan Ministry of the Environment (MoE). However, in late December, a contact at the World Bank informed us that the structure and function of the MoE will be significantly altered and its functions delegated to Pakistani provincial entities. This would essentially mean that MoE may not exist in the shape as it does today after 28 February 2011. As a result, the World Bank effort needs to be re-initiated with the individual provinces. RIMES, on the other hand, has already established working relationships with the provinces, which may be able to facilitate these negotiations and implementation.

The relative frequency of significant flooding in Pakistan, and the potential for an increase in frequency in the future, raises questions about if and how efforts to rebuild can improve the nation's resiliency with respect to future extreme weather events. Conversely, questions are raised as to how scenarios of future flooding frequencies can inform resilient rebuilding.

Following the floods, CFAN received a request from UNDP to determine the future return time for a flood of this magnitude, to support rebuilding efforts (i.e., the anticipated amount of time for a similar event to happen again in the future). Analyses conducted by CFAN resulted in predictions of a 5-year return time for total rainfall of this magnitude over Pakistan at large generally, and a 25-year return time for rainfall rate (i.e., mm/day) of this magnitude in North Pakistan in particular. A more extensive analysis is needed to assess future extreme weather and climate impacts on Pakistan infrastructure.

The value of providing probabilistic forecasts and future climate scenarios is that it will enable the U.S. to reduce the threat accelerant element of natural disasters and climate change impacts by allowing for proactive operational actions, as opposed to reactive responses. Given the destabilizing and accelerant nature of natural hazards, an approach to mitigate the impacts of these events – such as probabilistic forecasting – could have substantial benefits if

included in tandem with other military and civilian efforts to protect U.S. interests in Pakistan.