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Floods, false hope, and the future

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Recent flooding in Asia has drawn worldwide attention (DFO, 2012). Floods in Pakistan in late July 2010 inundated one-fifth of the country, killed nearly 2000 people, and disrupted the livelihoods of about 20 million others. Heavy rains causing flooding throughout the 2010 monsoon period killed several thousand in China, many from rain-associated landslides. By the end of August, more than 15 million people had been evacuated from flood and landslide danger zones. Again in 2011, widespread floods caused catastrophic damage in nearly all Southeast Asian countries, including Thailand, Cambodia, Laos, Malaysia, Myanmar, and the Philippines (DFO, 2012).

The October–November 2011 flooding of the Chao Phraya River in Thailand was labeled the country's worst since 1942, when flood waters inundated much of Bangkok for more than 3 months (The World Bank, 2010; The Bangkok Post, 2011). Uncharacteristically, high rainfall and water management errors are believed to have exacerbated the estimated US $45 billion in damage, the loss of more than 500 lives, and the disruption of the livelihoods of millions of people caused by the flood (The World Bank, 2011). To some, the flood was hard evidence of a changing climate, one that will ultimately produce dramatic increases in rainfall, stream flow, and sea level – changes that will certainly bring more flooding (START, 2011).

One plausible consequence of global warming is acceleration of the hydrological cycle, which is simply the balance among global evapotranspiration, rainfall, surface runoff, and storage (Ziegler *et al*., 2003). Acceleration may increase the frequency and/or intensity of extreme events, which occur annually throughout monsoon Asia. However, most credible advocates of climate change are careful not to draw direct links between contemporary extreme events and climate change (Huntington, 2010). At spatial scales relevant to catastrophic flooding, such as that witnessed in 2011, acceleration in hydrological cycle components cannot yet be verified with certainty (Ziegler *et al*., 2003, 2005). With respect to extreme events, the most sophisticated prediction models can only provide approximations of what might occur in the future (Karl and Trenberth, 2003).

Tropical monsoon areas are a paradox in that annual excesses of streamflow often are accompanied by dry breaks in rainfall extending 2–4 months. Two competing goals therefore complicate water management: (i) maximizing water availability in the dry season; and (ii) minimizing flooding in the wet season – particularly late in the year in Southeast Asia when tropical storms from the South China Sea are most frequent (Lebel *et al*., 2011). Maintaining sufficient [empty] storage capacity in dual-purpose reservoirs as a safeguard against unpredictable late-season storms equates to a significant reduction of water available for dry season irrigation and commercial use. In the case of the Bhumipol and Sirikit dams, each located on major tributaries of the Chao Phraya River (Figure 1d), the volume of water needed to reduce flood risk is nearly 7 billion m^3 (RID, 2011).

Complicating reservoir management in 2011 was an unusual La Ninã event that produced higher-than-normal rainfall in the northern highland regions of Thailand early in the monsoon season (IRI, 2011; The Bangkok Post, 2011). The January–October rainfall in the entire basin surpassed that of prior years (Figure 1b,d). Rainfall in the north was particularly high at 2.6 standard deviations above the mean. In particular, the month of May had a rainfall anomaly three standard deviations higher than the mean

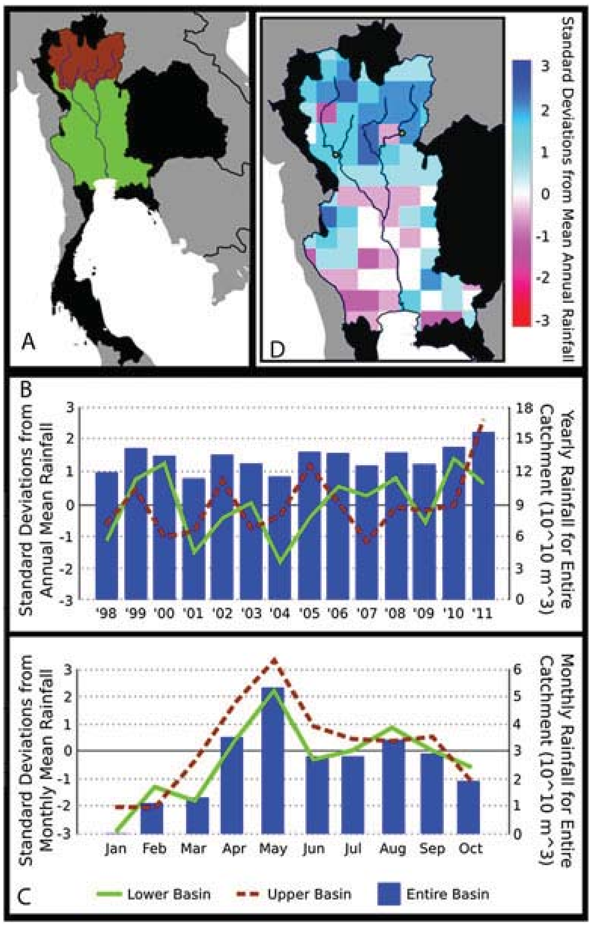

Figure 1. (A) Map of Thailand showing the Chao Phraya River sub-catchments that contributed to the large-scale flooding in late 2011. The blue lines represent the Chao Phraya River and four main upland tributaries. The brown and green areas correspond to the upper and lower sub-basin considered in this rainfall analysis. (B) January-October (yearly) rainfall for the entire Chao Phraya catchment (blue bars). Annual rainfall anomalies (represented as standard deviations from the mean rainfall), determined from the 14-year TRMM satellite archive (NASA, 2012) for the upper (brown line) and lower (green line) sub-catchments. Rainfall in 2011 was 10% higher than the second highest year on record. (C) 2011 monthly rainfall for the entire catchment (bars); and upper basin and lower basin monthly rainfall anomalies. The highest rainfall anomalies occurred in May when the total depth comprised 24% of the January–October total. (D) Map of the 2011 January–October rainfall anomaly in Thailand. The aggregated anomaly in the northern region upstream of the Bhumipol and Sirikit dams (circles) was 1.6 standard deviations above the mean

(Figure 1c). Early season wetting likely increased the proportion of subsequent rainfall that was converted quickly into storm runoff. By the time large storms such as Nock-Ten and Muifa occurred in late July 2011, both reservoirs had surpassed a conservative threshold storage level for safeguarding against the floods that were triggered by higher than normal rainfall in August and September.

Severe floods on the Chao Phraya River occur about once every 15–20 years – three in the last decade [The Bangkok Post, 2011]. Bangkok's location on floodplains where natural waterways and wetlands have been drained, filled, and replaced with urban structures makes the city vulnerable to flooding (Engkagul, 1993). Excessive pumping of groundwater has caused severe subsidence in some areas in and around the capital (Phien-wej *et al*., 2006), increasing the likelihood of local flooding and hindering storm runoff. High tides also slow the drainage of flood waters from inundated areas. The tidal influence on the Chao Phraya River extends more than 150 km upstream of Bangkok, past the historical capital of Ayutthaya to an area that is historically flood prone. Following large floods in 1983, 1995, and 2006, the Thai government invested heavily in extensive dike systems, pumping stations, underground drainage tunnels, retention ponds, and a state-of-the-art flood forecasting and warning system (Vitoonpanyakij, 2009; The World Bank, 2010). Although these measures have the potential to reduce flood damages under most circumstances, they were insufficient in 2011. New promises now being made about engineering a safer future also may fail (The Wall Street Journal, 2011).

Flood devastation such as in Thailand in 2011, or throughout southern Asia in prior years, is not simply the result of extreme rainfall and poor reservoir management. It results from failure to prepare for recurrent floods (Ziegler *et al*., 2012). Each year, the number of people living in flood prone areas increases. For example, 150 million people now live on the Ganges Delta in Bangladesh where recurrent floods – nearly 20 in the last century – kill thousands of people and destroy millions of homes (Mallick *et al*., 2005). The unfortunate location and continued development of large population centers in flood-prone areas means that catastrophic flooding will certainly reoccur unless we address key economic, social, and political issues that force some people, and allow others, to inhabit areas of high environmental risk. This point is well known for all types of hazards, but this process is slow or even ignored (UNESCO, 2007; Ziegler *et al*., 2009; Lebel *et al*., 2011; Mens *et al*., 2011). Meanwhile, we cling to the false hope that technological advances will protect us in the future (EEPSEA, 2010).

We might not be able to move cities, but we could redesign them to make space for water so that the

natural processes of flooding occur with minimized damage. This could be done through 'green' engineering solutions and more holistic catchment-wide flood management, which includes supportive policies, a regulatory framework, incentive systems, and public participation (DEFRA, 2004; FAO, 2005; Lebel *et al*., 2011; Ziegler *et al*., 2012). It also would require avoiding uncontrolled development within at-risk areas and relocating those living in high-risk areas. Metropolitan areas located on higher grounds could then be linked via appropriate transportation systems engineered through potential inundation zones. This approach is more realistic in the long run than Noah's Ark type solutions such as expanding continental-scale flood water drainage systems, building cascades of dual-purpose dams, or constructing higher dikes. Such short-term engineering solutions are potentially dangerous because as people grow complacent when small disasters are avoided, they become more vulnerable to catastrophic events (Newell and Wasson, 2002). This development approach also would serve a dual purpose of helping coastal cities combat sea-level rise, another major environmental problem facing many populated areas worldwide.

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