THAILAND FLOODS 2011

THE NEED FOR HOLISTIC FLOOD RISK MANAGEMENT

In 2011, Thailand is facing one of the biggest flood events of this century. Heavy monsoon rainfalls lead to inundation of the northern and central regions approximately three months before the waters surrounded the Bangkok Central area in the end of October. The aftermath of this catastrophe is terrible both in terms of human lives and economic losses. The death toll rose to 500 persons to date and the economic impact is significantly affecting the second largest economy of South East Asia. The private "University of Thai Chamber of Commerce" estimates the total flood damage at USD 17 billion. So far this has cut the forecast for economic growth from 4.1% to 2.6% for 2011 and generated a halt of production for most industries of around 6 month.

The Chao Phraya Basin

Overview

Figure 1. The Chao Phraya River Basin

The Chao Phraya River Basin (Fig. 1) has an area of 162,000km^2 and a length of approximately 700km. The Chao Phraya Basin is mountainous in the upper region, while the lower region is a highly productive flat alluvial plain intensively used for agriculture. The surface elevation of the flood plain is a few metres above mean sea level with an overall gradient towards the Gulf of Thailand of appr. 1.5m per 100km.

Monsoon weather dominates the area, with a rainy season lasting from May to October and with an annual rainfall between 1,000 and 1,400mm. About 90 percent of the annual rainfall occurs during this period, causing heavy floods. Tropical storms and cyclones penetrate the upper basin from June to September and the lower basin in April, May, October and November.

Socio-Economy

About 20 million people live in the basin (30% of the Thai population), of which 70% are farmers. Despite being the largest rice exporter worldwide, agriculture accounts for only 5% of the GDP in the basin, manufacturing for 33% and wholesale and retail trade for 17%. The small overall share of the agricultural sector is due to the large influence of industry that has developed around Bangkok and in the industrial estates.

Flooding

Floods are a natural phenomenon in the lower Chao Phraya River Basin and the local population has historically adapted their lifestyle to those repeated events. The lower basin receives flood waves travelling through the river system following monsoon rainfall in the upper basin and during heavy prolonged rainfall over the lower basin in October and November. Waters usually rise slowly and peak after 20 to 30 days.

Over the past decades, rapid urbanisation in Bangkok, the growth of provincial cities, and the intensification of agriculture have increased the exposure and also the vulnerability towards floods. Many flood control measures have been developed to mitigate the hazards, however sometimes without following sound engineering practice or even without proper maintenance programmes (Figure 2). One of the preferred flood protection measures has consisted in changing the drainage network e.g. by elevating embankments. This has significantly increased river discharges and flood levels. Together with increased urbanization, this has limited the discharge capacity of Chao Phraya River through the city of Bangkok to about 3,000 m^3/s, and thus created a bottleneck for the upstream flood drainage. As a result, the excess flow from the upper basin floods the plains upstream of Bangkok.

Figure 2. Examples of sound and unsound implementations of flood embankments in Rojana and Hi-Tech Industrial Estates(Source: DHI, previous studies)

Historical Floods

The highest floods in the Chao Phraya River Basin in terms of discharge were observed in 1831, 1942, 1983, 1995, 1996 and 2006. The return periods of these floods can be estimated from the long term record of annual maximum water levels at Ayutthaya, kept since 1831. The 1942 flood had a return period of about 100 years, the 1995 flood 50 years, the 1996 flood 25 years and the 2006 flood about 10 years.

The 1983 flood event was generated by unusually heavy rainfall throughout the basin from August to November, with Bangkok receiving 434mm in August alone, then 405mm in October and November. Large areas of the lower basin were unprotected and the flooding was extensive.

The 1995 flood was the most serious flood event in the basin since 1942. The river flow at Bang Sai south of Ayutthaya increased gradually from the beginning of September up to the peak in October, estimated at 5,000m^3/s. With a maximum discharge capacity of 3,000m^3/s through Bangkok, the excess flow spread across the flood plain. Flooding to a depth of 0.5 to 2 metres remained for 2 to 3 months into December.

2011 Flood Event

An exceptionally wet year over the whole Chao Phraya River Basin

Following an already wet first semester, the Upper and Lower Chao Phraya River Basin received between 800 to 1000mm of rainfall during the months of July, August and September 2011 with a total of 1400mm to 2000mm rainfall accumulated during the overall monsoon season (May-October 2011). The accumulated rainfall since January 2011 and departure from normal are presented in Figure 3.

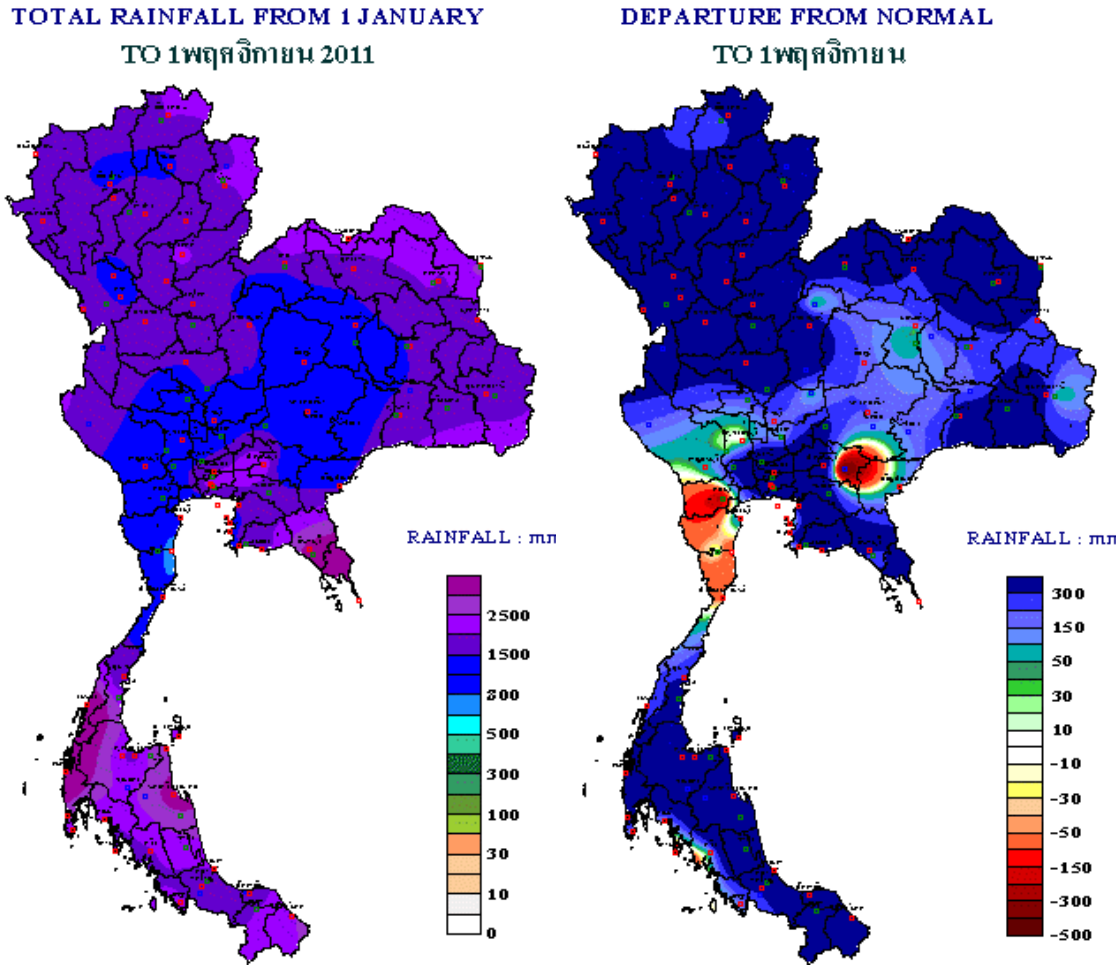

Figure 3. Accumulated rainfall from 1 January 2011 to 2 November 2011 and departure from normal (Source: Thai Meteorological Department)

Estimate of return period: A Flood Event above 100Y

Based on several hydrologic studies, mathematical modelling carried out by DHI since the 1990's in the Chao Phraya River Basin and on the peak water level measured to date (3 November 2011), the return period of the event is estimated to be above 100 years (Table 1). The 2011 peak water level is believed to be underestimated as inflowing water had already been diverted upstream to other rivers and flood plains.

Table 1. Peak Water Levels in Chao Phraya (metres above mean sea level)

STATION	Observed Peaks			Estimated Return Period (years)					
	1983	1995	2011	2	5	10	25	50	100
Ayutthaya	4.7	5.1	5.92	3.4	4.1	4.7	5.1	5.4	5.6
Bang Sai	3.1	NA	4.21	2.6	3.1	3.4	3.7	3.8	4.0
Pakret	2.2	2.6	3.20	2.15	2.61	2.72	2.86	2.96	3.07

Estimate of expected flood duration

According to the Global Disaster Alert and Coordination System (GDAC, 2011), the flood has affected a region of approximately 96.000 km^2 (see time series of flood maps in Figure 4). Based on previous modelling studies realized by DHI in the basin, maximum discharges of the Chao Praya River and Tha Chin River are estimated at 3,500 m^3/s and 1,500m^3/s, respectively. With an average water level of 1 m in the flooded zones, the flood duration could possibly extend over 3 months into January 2012.

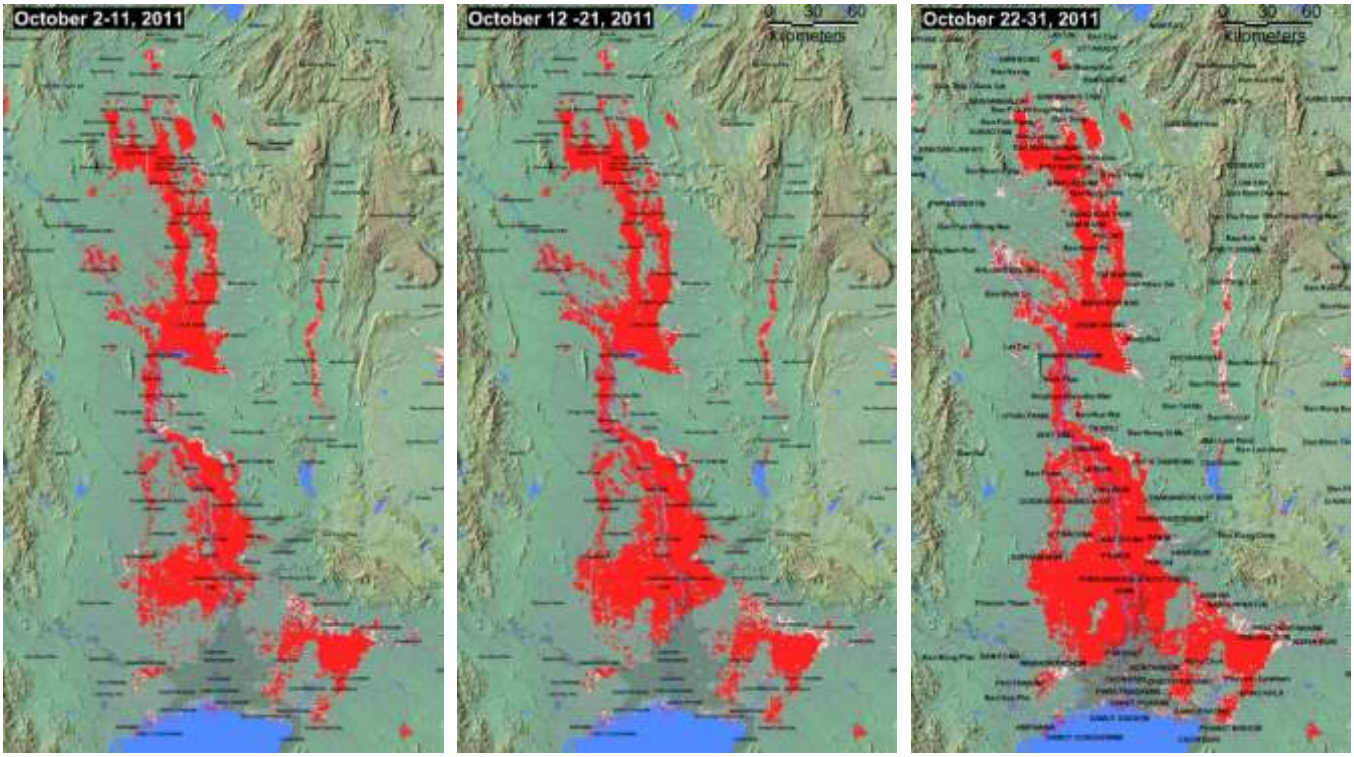

Figure 4 Chao Praya River Basin Flood extent 2-11, 12-21 and 22-31 October 2011 (Source: Darmouth Flood Observatory)

Figure 5 shows water level at Ayutthaya, including the present water level and two historical floods in the years 2010 and 2003. The flood started at Ayutthaya in September and reached its maximum

flood level within 1 month. Subsequently, it steadily receded (Fig. 5). Estimates based on a similar rate from October until now (see green dash line in Fig.5) suggest that the water level will go down below flood level around mid December. The total duration of this flood in Ayutthaya is then 3.5 months. For the industrial estate in Ayutthaya, it is possible to start pumping out water when the water level has decreased to below the original dike surrounding the industrial estate, flooding duration will then be less than estimated above. For Bangkok, there are several flood protection measures applied, such as dikes, water gates and pumping stations, therefore flood duration will also be shorter than estimated above.

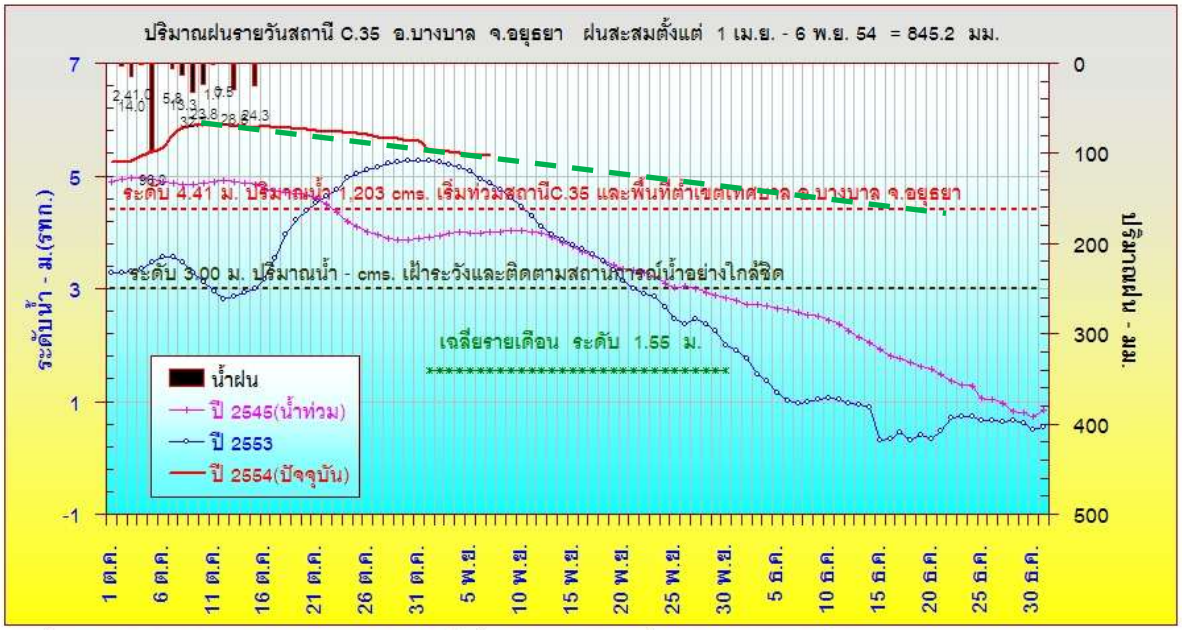

Figure 5 Water level at Ayutthaya, plotting of flowing year 2011 in red, 2010 in blue and 2003 in pink, horizontal red is flood starting level at 4.41 m MSL, horizontal black is warning level at 3.00 m MSL (Source: Royal Irrigation Department of Thailand)

Bangkok flood dynamics

Water flows very slowly (slope of 2.5m over 90km) on the lower Chao Praya Basin. In this area, the drainage system is regulated by dikes, channels, water gates and pumping stations and is not designed to accommodate such a large amount of water inflow from the upper basin. Water started to accumulate at the northern dyke of Bangkok and started to overflow it in late October. Flooding waters slowly spread to the southern areas irregularly according to land level and secondary flood protection systems. Pumping of flood water is currently operating at full capacity, alleviating the flood effect in central and south Bangkok but with little influence on the northern areas. It is estimated that flooding of the northern areas of Bangkok will take 1 to 2 weeks to dry out provided the water level upstream drops below the northern dike level.

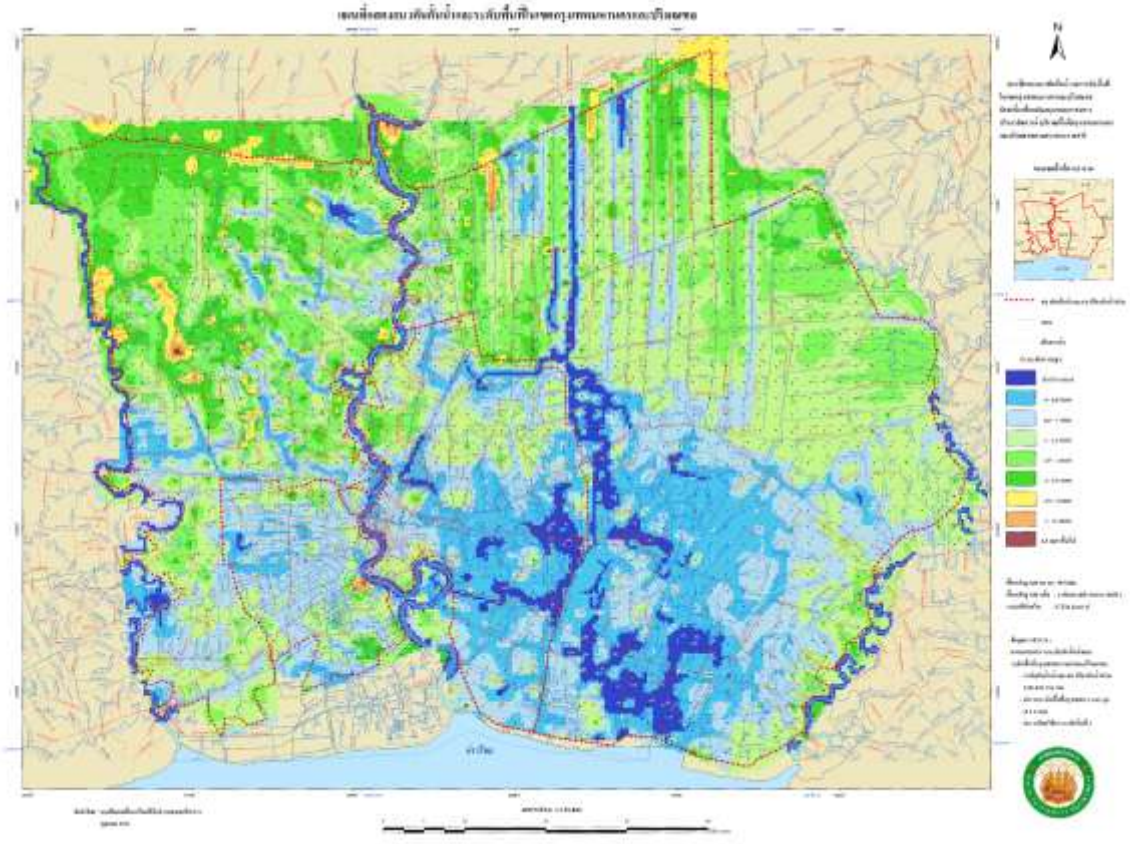

Figure 6. Topography of Lower Chao Phraya River Basin (Source: Royal Thai Survey Department)

Figure 7. Average flow direction map - 9 November 2011- in Bangkok area (Source: Royal Thai Survey Department)

Why are the damages so significant?

- **Hydrological and geomorphological changes.** While heavy rainfalls have been evidenced, other underlying factors can be pointed out including sea level rise in the Gulf of Thailand (19-29 cm until 2050) and subsidence among other due to groundwater extraction. In the 1970s, Bangkok was sinking 10cm/year but it is currently "only" subsiding 1-3cm per year.

- **Increase of exposure.** During the past decades, the region has undertaken a fast growing industrialization and urbanization. Exposure of population and economic assets has increased considerably and is expected to do so even more in the future. Bangkok is ranked by the OECD in the 10th top cities for population and assets exposed to coastal flooding in the 2070s based on both climate change and socio-economic changes (Nicholls and al., 2007).

- **Preparedness and protection**
  In the Chao Phraya Basin, flood mitigation strategies include both structural (e.g. dykes, storage areas) and non-structural measures (diversion schemes and flood retarding areas). However, in many cases structural solutions failed: Flood walls broke after a prolonged flood period in many areas including the ancient city of Ayutthaya, some Industrial Estates, others are about to break even in the Bangkok areas. For example, part of the embankment of the Hi Tech Industrial Estate located north of Bangkok broke due to leaking failure weakening its structure. Moreover, the emergency reinforcement failed (The Bangkok Post, 2011). In previous site investigations DHI warned that none of the five investigated Industrial Estates plains would be able to face a 50Y flood event due to too low structure crest (e.g. Rojana IE) or unsound engineering design and maintenance (e.g. Hi-Tech IE).

  The media has been very clear in the interpretation of the catastrophe stating that the sensitive economic areas were most likely not adequately prepared, over-confident in their protection system or simply disorganized (The Nation, 2011).

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