GUY CARPENTER

Thailand Flood 2011

One Year Retrospective

October 2012

MARSH & McLENNAN COMPANIES

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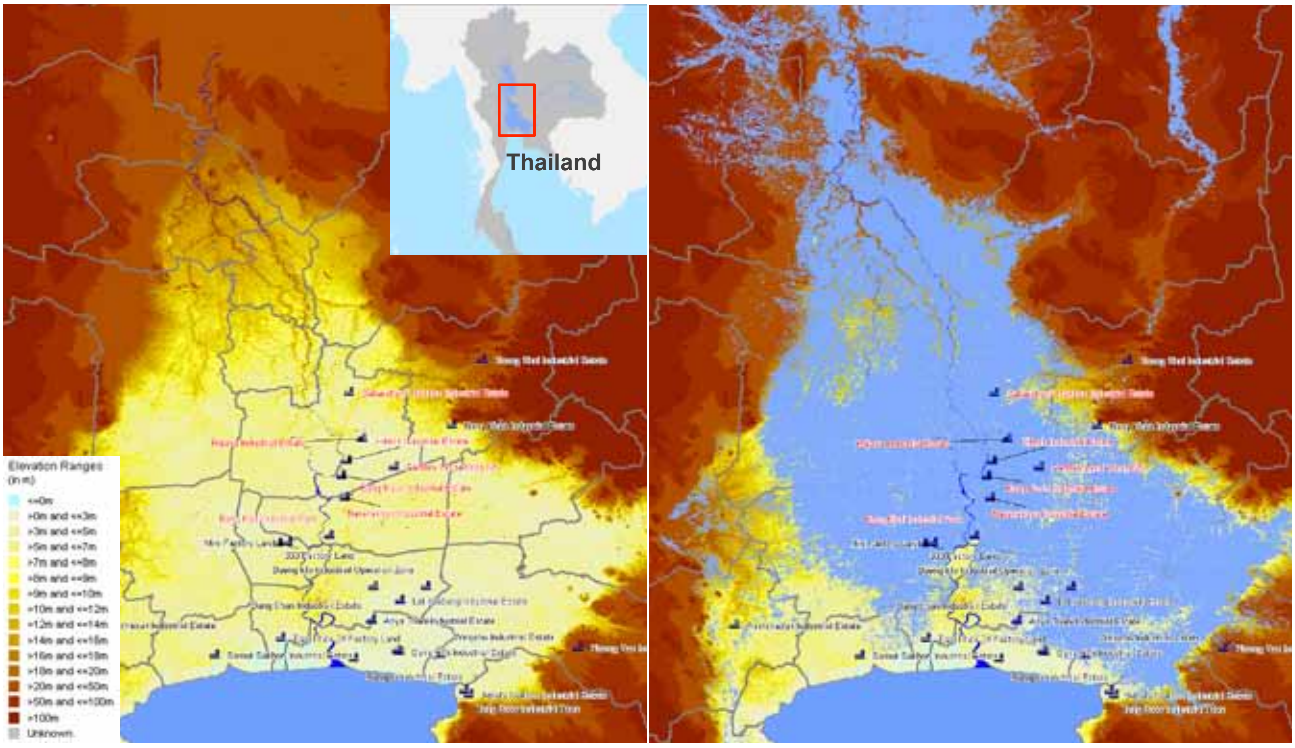
EXECUTIVE SUMMARY

In 2011, Thailand experienced its worst flooding in years, leaving more than 800 people dead and causing severe damage across northern and central regions of the country. The floods, lasting a few months, severely damaged and disrupted manufacturing operations in Thailand. Flooding also forced seven huge industrial estates in central regions to close, causing damage to the industrial sector in the billions of U.S. dollars. It is interesting to note that prior to 2011, none of the industrial parks in Thailand had been flooded over the past 40 years. During the last major flood in 1995, the dykes in the industrial parks kept floodwaters out. In last year's flooding, however, heavy machinery was reportedly not brought in to raise the height of dykes for fear of damaging them and instead sandbags were used, which ultimately gave way to the floodwaters.

Damage and disruption to the manufacturing sector was massive after defenses protecting several industrial estates were breached. The Labour Ministry said that more than 14,000 businesses nationwide had to close because of the floods. Factories in the provinces of Ayutthaya and Pathum Thani were particularly badly hit. Reports said around 1,300 factories across central Thailand were affected by the floods, disrupting manufacturing supply chains inside and outside of Thailand. Many of these industrial estates housed both local and international factories and businesses, with large numbers manufacturing electronic components and car parts



Elevation map and flooding extent 2011 flood (Source: NASA SRTM and Thailand Flood Monitoring System)

The production of cars, electronics and other goods was suspended for months as hundreds of factories were under water. Disruption to supply chains also halted operations, causing a knock on effect on global manufacturing. The disruption to operations lasted several months and had an impact on production similar to that caused by the Tohoku earthquake in March 2011. Thailand plays a critical role in the global supply chain and companies needed to organise alternative production facilities or supply routes for parts.

The intention of this report is to provide an in-depth review of the meteorological and man-made factors, including the concentration of risks in industrial parks, that contributed to the scope and cost of the flood event. The report also reviews how Guy Carpenter can assist clients in measuring the potential for future losses resulting from floods in Thailand.

Chao Phraya River Basin (Source: Wikipedia)

SUSCEPTIBILITY OF CHAO PHRAYA BASIN TO FLOODS

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

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

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 (33%) and wholesale and retail trade (17%) have a higher share of the GDP. 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.

Flood is 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 but allegedly without always following sound engineering practice or even without proper maintenance programmes. Flood protection has been carried out, changing the drainage network e.g. by elevating embankments. This has significantly increased river discharges and flood levels and together with increased urbanization limited the discharge capacity of Chao Phraya River through the city to about 3,000 m^3/s (260 million m^3/day), creating a bottleneck for the upstream flood drainage. As a result, the excess flow from the upper basin floods the plains upstream of Bangkok.

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.

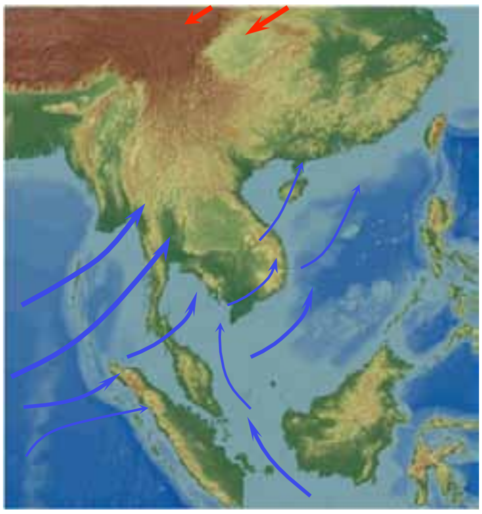
The 1983 flood event was generated by unusually heavy rainfall throughout the basin from August to November, with Bangkok receiving 434mm in August alone, then 405mm in October and November. Large areas of the lower basin were unprotected and the flooding was extensive.

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 5,000 m^3/s. With a maximum discharge capacity of 3,000 m^3/s through Bangkok, the excess flow spread across the flood plain. Flooding to a depth of 0.5m to 2.0m remained for 2 to 3 months into December.

THAILAND MONSOONS AND CYCLONES

A place is said to experience monsoon if its low-level winds persist in one direction for a period of several months and then switch direction for another period within the year. Much of Southeast Asia is within the monsoon regime.

The climate of Thailand is under the influence of monsoon winds of seasonal character i.e. southwest monsoon and northeast monsoon. The southwest monsoon which generally starts in May and ends in October brings a stream of warm moist air from the Indian Ocean towards Thailand causing abundant rain over the country, especially the windward side of the mountains. Rainfall during this period is not only caused by the southwest monsoon but also by the Inter Tropical Convergence Zone (ITCZ) and tropical cyclones which produce a large amount of rainfall. May is the period of first arrival of the ITCZ to the Southern Part of Thailand. It moves northwards rapidly and lies across southern China around June to early July which generally causes a dry spell over upper Thailand. The ITCZ then moves in a southerly direction to lie over the Northern and Northeastern parts of Thailand in August and later over the Central and Southern parts in September and October, respectively. The northeast monsoon which generally starts in October and ends in February brings the cold and dry air from the anticyclone in China over major parts of Thailand, especially the Northern and Northeastern parts which is higher latitude areas. In the Southern part, this monsoon causes mild weather and abundant rain along the eastern coast.



Southwest Monsoon (Source: EOS)

Northeast Monsoon (Source: EOS)

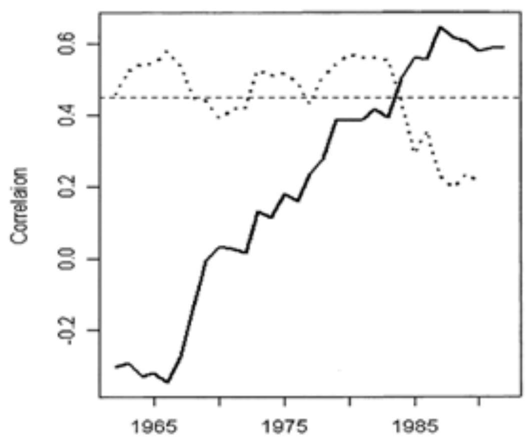
Tropical cyclones affecting Thailand usually move from the western North Pacific Ocean or the South China Sea. Thailand is normally affected by tropical depressions because of its location farther inland and due to some mountain ranges which obstruct and decrease the wind speed before moving into Thailand. Only the Southern part has a relatively high risk of tropical storms and typhoon. Some recent examples: tropical storm "HARRIET" hit Nakhon Si Thammarat province in October 1962; typhoon "GAY" hit Chumphon province in November 1989; and typhoon "LINDA" hit Prachuap Khiri Khan province in November 1997 as a tropical storm. By considering the annual mean, tropical cyclones usually move across Thailand about 1 to 2 times a year. They usually pass through the Northern and Northeastern parts in early southwest monsoon season and move across southern Thailand from October to December.

Region	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
North	-	-	-	-	5	2	10	17	25	11	1	-	71
Northeast	-	-	-	-	1	6	4	18	31	24	4	-	88
Central	-	-	-	-	2	1	1	-	7	9	2	-	22
East	-	-	-	-	1	1	1	-	3	12	2	-	20
South	-	-	-	1	1	-	-	-	3	15	24	9	53

The frequency of tropical cyclones moving through Thailand during 61 years (1951 - 2011) (Source: Thai Met Dept)

CORRELATION BETWEEN ENSO (EL NIÑO-SOUTHERN OSCILLATION) AND THAILAND MONSOONAL RAINFALL

While the long-term trends in temperature and precipitation may be linked to global trends, it is important to understand the interannual and interdecadal variations associated with ENSO.



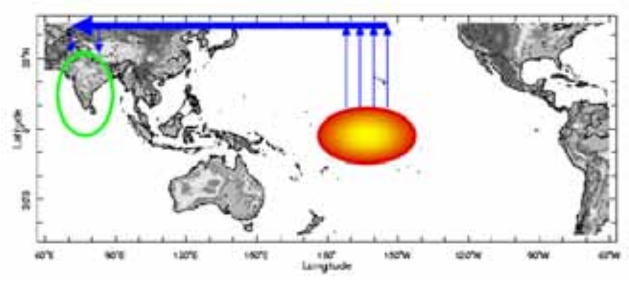
The 21-yr moving window correlation between the Thailand monsoon rainfall and the SOI index (solid line) and between the Indian summer monsoon and the SOI (dotted line). The dashed line at 0.45 is the 95% significance level (Source: Singhrattna et al, 2004)

ENSO is a quasi periodic climate pattern that occurs across the tropical Pacific Ocean roughly every five years. The Southern Oscillation refers to variations in the temperature of the surface of the tropical eastern Pacific Ocean (warming and cooling known as El Niño and La Niña respectively) and in air surface pressure in the tropical western Pacific. The two variations are coupled: the warm oceanic phase, El Niño, accompanies high air surface pressure in the western Pacific, while the cold phase, La Niña, accompanies low air surface pressure in the western Pacific. Mechanisms that cause the oscillation remain under study.

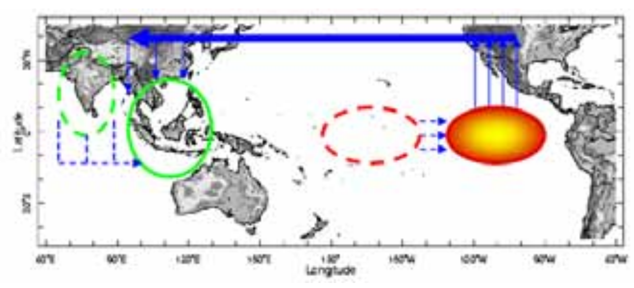
The extremes of this climate pattern's oscillations, El Niño and La Niña, appears to cause extreme weather (such as floods and droughts) in many regions of the world. Developing countries dependent upon agriculture and fishing, particularly those bordering the Pacific Ocean, are the most affected.

For a 21-year moving window, correlations between Thailand monsoon rainfall and the Southern Oscillation index (SOI), a sea level pressure–based ENSO index, are plotted (solid line). Significant correlations are seen after 1980. Prior to 1980 there is hardly any relationship.

The variability in recent decades (post-1980) seems to be strongly linked with ENSO. Interestingly, during the same period, the Indian monsoon shows a weakening in its relationship with ENSO. Around 1980, the Indian monsoon starts to lose its correlation with ENSO while the Thailand monsoon picks up correlation.



Walker circulation subsidence due to El Nino phase of ENSO during pre-1980 period (Source: Singhrattna ,1995)



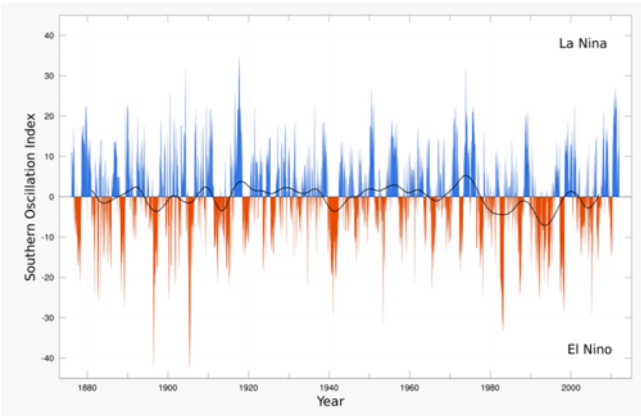
Walker circulation subsidence due to El Nino phase of ENSO during post-1980 period (Source: Singhrattna, 1995)

The eastern Pacific–centered ENSOs tend to constrain the descending branch of the Walker circulation within the Pacific domain, thereby, reducing convection in the tropical western Pacific regions and consequently, impacting the rainfall in these regions (including the Thailand monsoon). In this situation, the Indian subcontinent is not directly influenced by ENSO, and land surface processes (e.g., snow cover) are the dominant driving force for monsoonal variability. On the other hand, if the ENSOs are centered over the International Date Line then the descending branch of the Walker circulation has a wider reach over the Indian subcontinent. This decreases convection, and the Indian monsoon gets impacted much more than the Thailand monsoon.

The findings seem to argue for tropical-wide ENSO-related circulation shifts with more eastern Pacific–centered ENSOs in recent decades. The question to be answered is what causes the shifts in ENSO-related Sea Surface Temperature (SST) patterns in the equatorial Pacific? It could be a result of enhanced mid latitude warming, natural variability of the tropical Pacific system or it could be something else.

INCREASED RISK OF THAILAND TYPHOON ACTIVITY AND RAINFALL DURING LA NIÑA

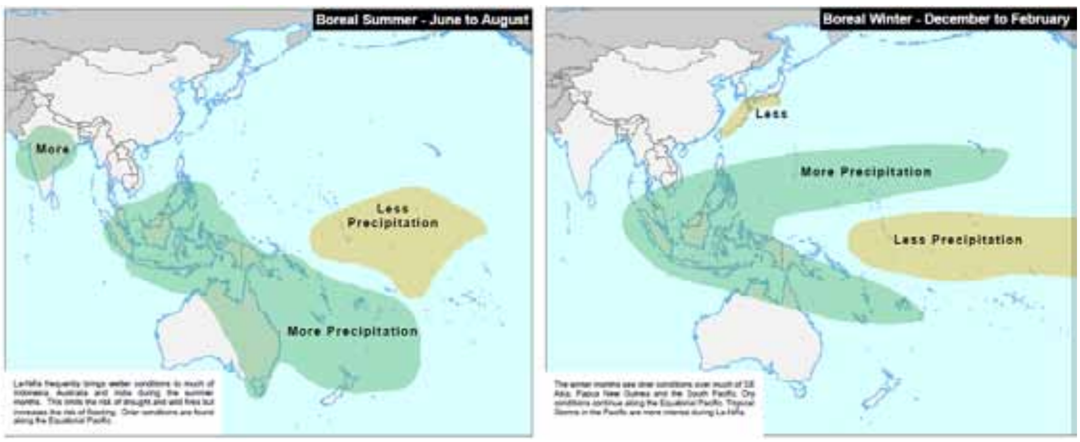
The Southern Oscillation Index (SOI) is a standardized index based on the observed sea level pressure differences between Tahiti and Darwin, Australia. The SOI is one measure of the large-scale fluctuations in air pressure occurring between the western and eastern tropical Pacific (i.e. the state of the Southern Oscillation) during El Niño and La Niña episodes. The negative phase of the SOI represents below-normal air pressure at Tahiti and above-normal air pressure at Darwin. Prolonged periods of negative SOI values coincide with abnormally warm ocean waters across the eastern tropical Pacific typical of El Niño episodes. And conversely, prolonged periods of positive SOI values coincide with abnormally cold ocean waters across the eastern tropical Pacific typical of La Niña episodes.



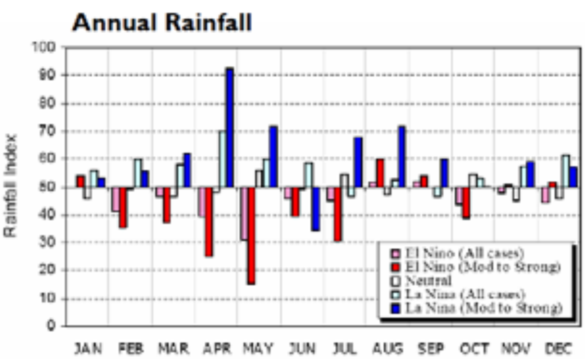
Southern Oscillation Index time series 1876-2011 (Source: Wikipedia)

In the Western Pacific (northern and southern hemisphere) there tend to be fewer cyclones during a El Niño event and more during La Niña - which was evident in 2011.

The occurrence of both wetter and drier regions on the maps below reflect the tendency of La Niña events to displace rainfall patterns geographically as well as enhance or decrease local precipitation. Effects are more robust around the Pacific and in tropical regions.



Schematic maps indicative of typical rainfall tendencies during a La Niña event. Precise geographical detail is not implied although evidence does exist to support country correlation of a higher flooding risk in South East Asia in La Niña years. (Source: OCHA)



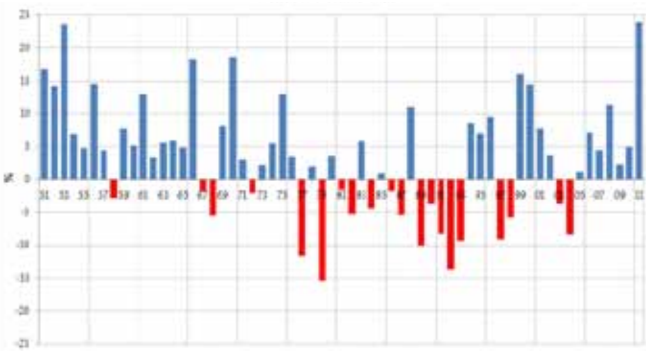
Affect of ENSO event on monthly rainfall in Thailand (Source: Chamnong Kaeochada, 2005)

In any individual year the observed climate anomaly over a region may be a complex combination of many factors, of which La Niña is just one. These other factors will include local sea surface temperatures, other modes of natural climate variation, volcanic eruptions and solar variations. Rainfall in Thailand is highly related to El Niño and La Niña phenomena as shown in the graph above.

During the last several decades the number of El Niño events have increased, and the number of La Niña events have decreased, although we may need to observe ENSO for much longer to detect robust changes. The question is whether this is a random fluctuation or a normal instance of variation for that phenomenon or the result of global climate changes toward global warming. It remains unanswered for now.

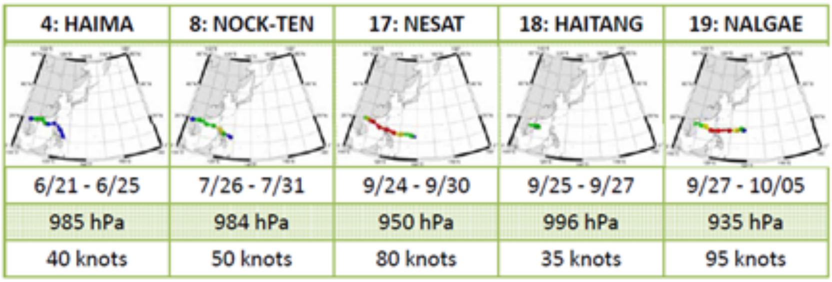
INCREASED NUMBER OF TYPHOONS AND RAINFALL AMOUNT IMPACTING THAILAND IN 2011

In 2011, monthly rainfall exceeded the average rainfall for the entire rainy season, with higher July and September rainfall than any recorded during 1971 to 2000. The total rainfall during the 2011 rainy season was 1,439mm, which is 124% of the average rainy season rainfall during 1971 to 2000. In addition, 5 typhoons made landfall in Thailand in 2011. The average number of typhoons per year during 1951 to 2011 was 1.5, with 5 or more typhoons making landfall in Thailand in a year only three times: 1964, 1971 and 1972 (1964 & 1971 were La Niña years). The prevalence of typhoons strongly influenced the rainfall in 2011.

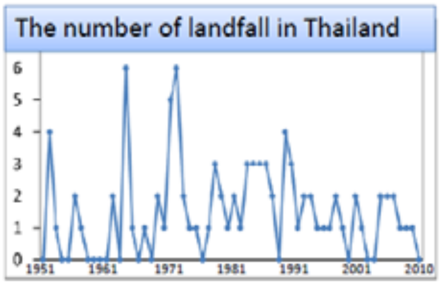


Mean Annual Rainfall in Thailand above-below normal in percentage (Normal: 1971-2000) (Source: Thai Met Dept)

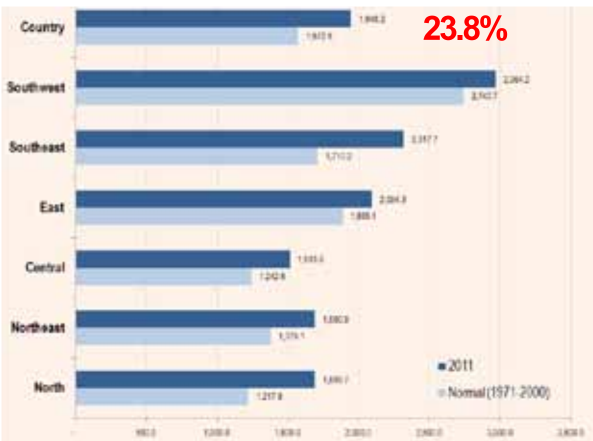
It can be assumed that there was no major difference in rainy season evaporation and infiltration rates between the flood year and other years, because rice paddies, namely a wet surface, are consistently the major type of land use in Thailand. Taking, for example, observation data (1971 to 2000) by the Thai Meteorological Department (Phitsanulok observatory) in the Yom River watershed, which has many rain-fed paddies, the normal values of cumulative rainfall and pan evaporation in the rainy season were 1,192mm and 842mm respectively.



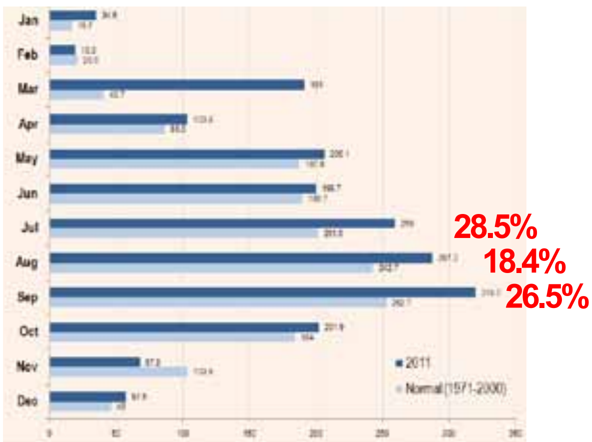
Typhoons affecting Thailand in 2011 (Source: Komori, 2011)



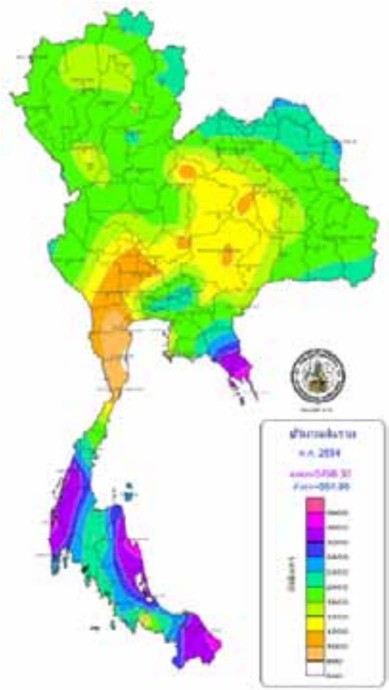
Considering the water budget, the 350mm difference is regarded simply as runoff, which flows into rivers. Assuming there is almost no change in evaporation rates, it is estimated that runoff was approximately 860mm during 2011, which is 246% of normal values. The total discharge of the Chao Phraya river at Nakhon Sawan in 2011 was 32.6 billion m^3, which was 232% of the average value for 1956 to 1999. This is a similar value to previous estimates of runoff at the Phitsanulok Observatory. Total discharge recorded in the flood year of 1995 was 23.5 billion m^3, which is 167% of the average during 1956 to 1999.



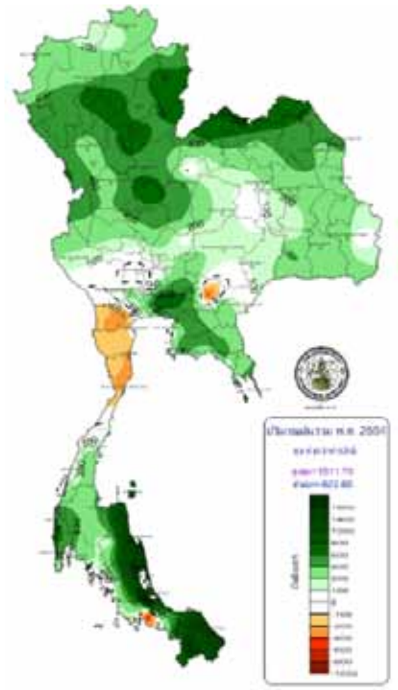
Rainfall distribution – by Region (in mm) (Source: Thai Met Dept)



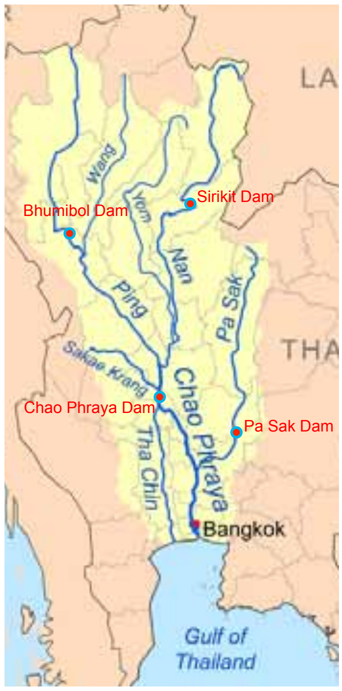
Rainfall distribution – by Month (in mm) (Source: Thai Met Dept)



Annual Rainfall (mm) in 2011
(Source: Thai Met Dept)



Annual Rainfall anomalies (mm) in 2011
(Source: Thai Met Dept)



Location of Dams
(Source: Wikipedia)

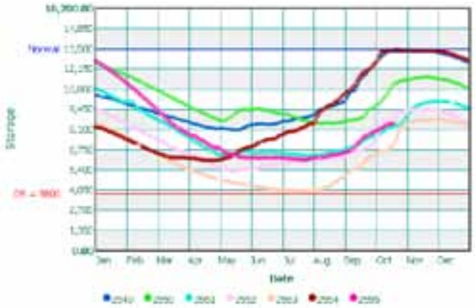
The top 5 events in terms of total discharge during 1956 to 1999 and 2011 at Nakhon Sawan occurred in 2011, 1970 (28.4 billion m^3), 1961 (24.8 billion m^3), 1975 (24.1 billion m^3), and 1995. According to the Royal Irrigation Department, which is responsible for the operation of the Chao Phraya Dam, the threshold discharge capacity of the lower watershed of the Chao Phraya River above which flooding occurs is 2,000 m^3/s. The discharge in 2011 exceeded the threshold in the middle of August, as well as in the middle of September. A peak discharge of 4,698 m^3/s was recorded on October 13. Not until the end of October, did the discharge drop below the discharge capacity of Nakhon Sawan. These results show that flooding in 2011 continued about one month longer than in other years, and that the cumulative excess discharge area estimated to have flooded downstream was an extremely large 12 billion m^3 .

ROLE OF THE DAMS

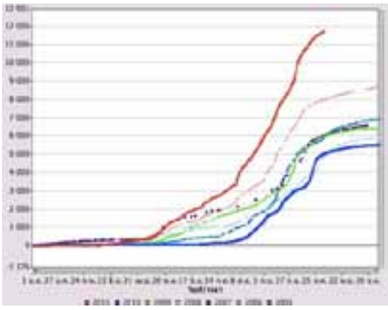
In the upper watershed, the Ping River (watershed area 33,900 km^2), Wang River (watershed area 10,800 km^2), Yom River (watershed area 23,600 km^2), and Nan River (watershed area 34,300 km^2) flow down from the northern mountain system and join together at Nakhon Sawan. The total area of the upper watershed is approximately 110,000 km^2. For the purposes of irrigation and power generation, the Bhumibol Dam (reservoir capacity 13.5 billion m^3, catchment area 26,000 km^2, built in 1964) was constructed on the Ping River, and the Sirikit Dam (reservoir capacity 9.5 billion m^3, catchment area 13,000 km^2, built in 1974) was constructed on the Nan River. Another 5 dams have been constructed for the Ping, Wang, and Nan River watersheds, bringing the total reservoir capacity including the Bhumibol and Sirikit Dam reservoirs to 24.7 billion m^3. In the Yom River watershed, plans have been made to build the Kaeng Sua Ten River Dam (1.15 billion m^3) and a conduit to the Sirikit Dam reservoir, but these are yet to be constructed.

In the lower watershed, the Chao Phraya River joins with the Sakae Krang River (watershed area 5,000 km^2) from the right bank between Nakhon Sawan and the Chao Phraya Dam (built in 1957), which was constructed 96 km downstream from Nakhon Sawan. This dam controls the discharge of the Chao Phraya River, and irrigation water is diverted to the left and right banks of the river. The Tha Chin River and the Noi River branch off from the right bank upstream of the dam. The Tha Chin River flows down to the sea, but the Noi River joins the Chao Phraya River south of Ayutthaya. Downstream of Ayutthaya, the Chao Phraya River joins with the Pa Sak River (watershed area 14,300 km^2). The Pa Sak River Dam (960 million m^3) was constructed on the Pa Sak River in 1999, and another 2 dams (total 409 million m^3) have been built on the right bank of the Tha Chin River.

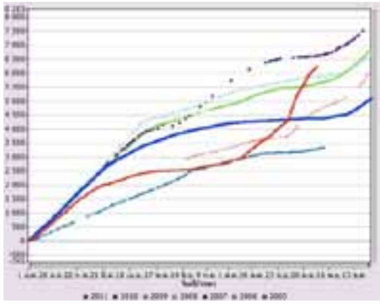
The following three charts for Bhumibol dam below should be considered together.



Amount of water stored in the Bhumibol Dam
(Source: Asian Correspondent)



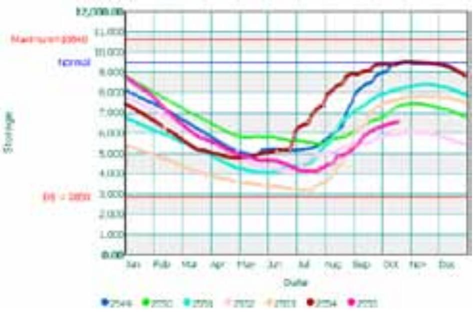
Accumulated Inflow of water
(Source: Asian Correspondent)



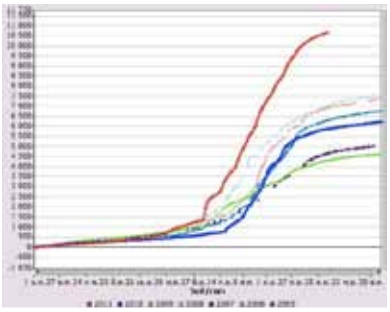
Accumulated Outflow of water
(Source: Asian Correspondent)

The storage is in million cubic meters and the years from left to right are 2006 (2549) to 2011 (2554). The Inflow and Outflow is in million cubic meters as well. 2011 has the most amount of water entering the dam reservoir. It is in early June that water entering the dams in 2011 exceeds previous years, but one can also see the line goes up much earlier than most years. The accumulated inflow of water on August 1 is 3.353 billion m^3 and increased to 11.689 billion m^3 on November 1. This is 8.336 billion m^3 over three months or an average of around 90 million m^3 a day. Arguably, not enough water was discharged early on the rainy season and particularly from March to July before the flooding started.

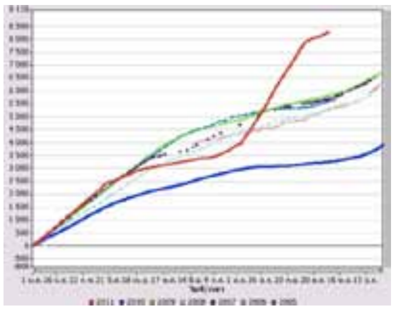
If we consider the three charts for Sirikit dam below.



Amount of water stored in the Sirikit Dam
(Source: Asian Correspondent)



Accumulated Inflow of water
(Source: Asian Correspondent)



Accumulated Outflow of water
(Source: Asian Correspondent)

The storage is in million cubic meters and the years from left to right are 2006 (2549) to 2011 (2554). The Inflow and Outflow is in million cubic meters as well. The inflow increased almost 1 billion m^3 from 5.201 billion m^3 to 6.140 m^3 in the week to July 2. By late June 2011, dam capacity was higher than the previous six years. On the other hand, little water was discharged between March 25 and July 13.

When tropical storm Haima hit in June, the country's free-flowing rivers, including the Sakae Krang, the Yom and the Wang, all burst their banks and caused flooding in Phitsanulok, Sukhothai, Phichit and Nakhon Sawan. Both the Bhumibol Dam and the Sirikit Dam halted water discharges during the period. From the end of July through to October, four more major storms hit the country, leading to nearly all of the country's dams reaching full capacity, including the Bhumibol and Sirikit dams. The spillways for the Sirikit Dam had to be opened from the end of August until early September, while spillways at the Bhumibol Dam opened in October.

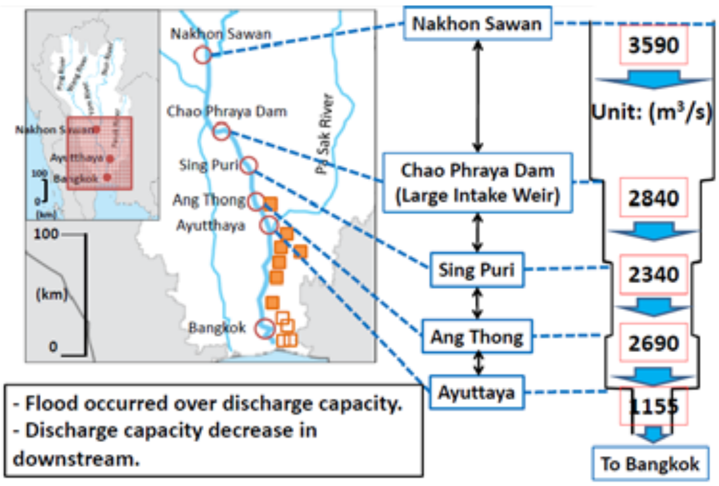
There was simply too much water for the system to manage. However, it may be possible that the late discharge of water exacerbated the floods because it led to too much water needing to be discharged from August onwards. The Bhumibol and Sirikit dams contribute about 22% of the discharge in the Chao Phraya basin. Flooding in Thailand in 2011 could not have been avoided due to the high amount of rainfall, which was highest in more than 60 years, but better management of dams could have resulted in lower discharges (by about 2 billion m^3) in the Chao Phraya river between September and October and consequently lower flood heights.

2011 FLOOD EVENT

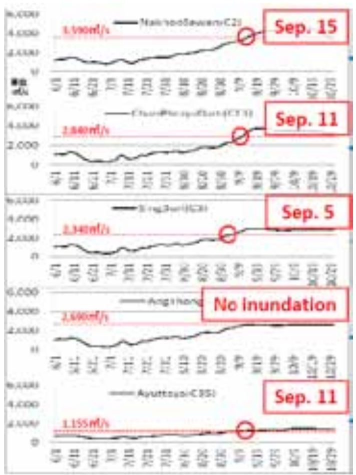
Flooding occurred at the confluence of the Yom River lower watershed and the Nan River downstream from the Sirikit Dam starting July. In August, flooding had begun in the area near Nakhon Sawan, and it was no longer possible to increase preliminary water releases to prevent flooding downstream from both reservoirs.

By September, the Sirikit Dam reservoir was almost full and the Chao Phraya River exceeded its discharge capacity between Nakhon Sawan and Ayutthaya, and began to overflow. In the middle of the month, water gates on the right bank were destroyed by the flood, and massive flooding occurred. At the end of the month, levees on the left bank broke one after another, and there was flooding of around 5 billion m^3 which was estimated from the difference in the hydrograph between the upstream and downstream parts at the levee failure locations.

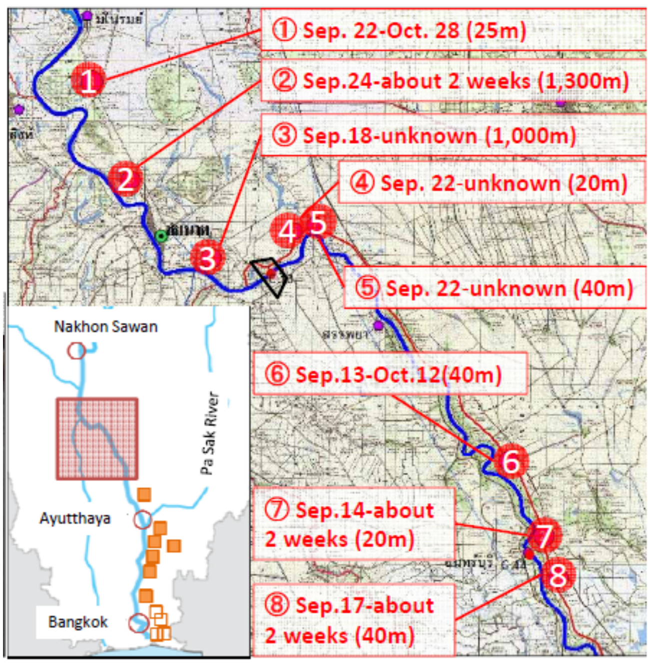
By the beginning of October, the Bhumibol Dam reservoir was almost full. The flooding of the left bank in late September moved to the South, inundating a series of industrial estates on the left bank.



Discharge capacity of Chao Phraya river (Source: Komori, 2011)



Time line for flooding (Source: Komori, 2011)



Points of levee crevasse between Chao Phraya Dam and Ayutthaya (Source: Komori, 2011)

There were eight levee breaks on the left bank of the Chao Phraya river from the middle to the end of September between Nakhon Sawan and Ayutthaya. It took the water two weeks to travel from the levee break points to Saha Rattananakorn Industrial park which was fully inundated on October 6 (first breach October 4).A total of seven Industrial parks were inundated in the month of October.

Floodwaters reached Bangkok in late October and the flood situation in the city remained grim until end November. The flooding situation was exacerbated by higher tide levels in the Bay of Thailand in November which prevented the flood waters from quickly flowing out to the sea threatening Bangkok.

The flooding in Thailand lasted until December and was described as the world's fourth costliest disaster as of 2011 according to the World Bank. It is also the world's worst flood disaster in terms of losses.

CONCENTRATION OF INSURED VALUE IN INDUSTRIAL PARKS

Industrial Estate Authority of Thailand (IEAT) is a state enterprise established in 1972 under the Ministry of Industry. IEAT is chartered to develop and operate industrial estates in order to promote systematic industrial growth. Currently, there are 28 estates of which 9 are owned and operated by the IEAT. Others are joint ventures between the IEAT and private developers.

The industrial estate market in Thailand can be divided into five main zones according to Colliers International Thailand. These are:

Eastern Seaboard area – This is the industrial powerhouse due to its location near Thailand's main container port, Laem Chabang and its proximity to Bangkok. Further growth has come about due to suppliers clustering around large manufacturers.

North Eastern area – The remoteness of this area and poor transport means that the area has a minor share of industrial activity although the border with Cambodia and Laos (leading to Vietnam) could provide some potential for the future.

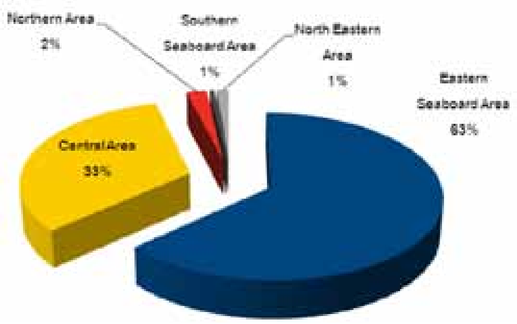
Northern area – Limited industrial activity has taken place here so far due to its remote location, its predominantly agricultural environment, and its unfavourable topography. Its proximity to China has potential as trade between the two countries increases.

Central Area – Another key industrial area due to its proximity to Bangkok and use as a distribution center.

Southern Seaboard area – An underdeveloped industrial area catering mainly to the Malaysian market with halal food produce as well as heavy industrial projects based on oil and frozen seafood products.

A considerable number of stand-alone factories exist outside the industrial estates in Thailand.

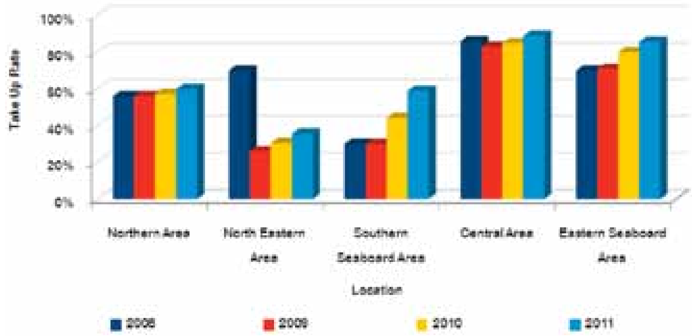
The total supply in 2011 was around 200 million m^2 (20,000 hectares). Supply in the Eastern Seaboard area dominates the Thai industrial estate market, accounting for nearly two-thirds of the total supply. The Eastern Seaboard and Central areas account for more than 90% of the total supply. Most industrial estates in the Central area were damaged by the floods in the fourth quarter of 2011 and this is the main concern for new industrial estate development and the expansion of the existing industrial estates. Most industrial estates planned for development in 2012 will be more focused on non-flood areas, such as the North Eastern and Eastern Seaboard areas.



Supply by Zone (Source: IEAT and Colliers)

The take-up rate for industries increased in every zone in 2011, even in the flood-affected Central area, due to the increase in demand in the first half of the year. Many investors from flooded areas are planning to move to the Eastern Seaboard Area or other locations in 2012 or beyond.

The Japanese remain the largest investors in Thailand with approximately 50% of the total invested, followed by East Asia with 13%. While European and ASEAN have some share, other parts of the world have very limited manufacturing facilities here.



Take up Rate for industries during 2008-2011 (Source: Colliers)

Proportion of Investors in Industrial Estates
(Source: IEAT and Colliers)

PROPERTY AND RELATED SUPPLY CHAIN LOSSES WITH INDUSTRIAL PARKS

Five industrial estates (Bang-Pa-in, Hi-Tech, Factory Land, Rojana and Saha Rattana Nakorn) in the badly-affected province of Ayutthaya were flooded. At Hi-Tech, all 130 factories were inundated by floodwaters of up to 3.4 metres. The Nava Nakorn industrial estate in Pathum Thani Province, one of Thailand's oldest and largest industrial estates with a high concentration of Japanese manufacturers, was evacuated after floodwaters submerged several factories. A seventh big industrial estate was overwhelmed when flood defences were breached at the Bangkadi estate in Pathum Thani Province. The industrial estates of Lat Krabang, Bang Chan, Bang Phli and Bang Poo remained at risk of being flooded.

Industrial Park (Year of Estb.)	Region	Number of companies	Companies impacted (examples)	Date on which inundated	Reported flood height
Bang Pa-in (1994)	Bang Pa-In, Ayutthaya	98	Western Digital	Oct 15	1.8m
Bangkadi (1989)	Mueang Pathum Thani, Pathum Thani	50	Nidec, Nissan, Sony, Toshiba Semiconductor	Oct 20	3.0m
Factory Land	Wang Noi, Ayutthaya	99	Canon Engineering, HDK, Sony	Oct 16	1.5m
Hi-Tech (1992)	Bang Pa-In, Ayutthaya	143	Canon Engineering, HDK, Sony	Oct 13	3.4m
Nava Nakorn (1972)	Khlong Luang, Pathum Thani	227	Western Digital, Toshiba, Casio, Fujitsu, JVC, Seiko	Oct 17	2.0-3.0m
Rojana (1989)	Uthai, Ayutthaya	198	Honda, Furukawa, TDK, Nidec, Canon, Nikon, Panasonic, Sanyo Semiconductor	Oct 9	3.0m
Saha Rattana Nakorn (1993)	Nakhon Luang, Ayutthaya	46	Yamamoto	Oct 6	3.0-4.0m

Affected Industrial Parks (Source: Bangkok Post etc)

Japanese car manufacturers Honda, Nissan and Toyota had to suspend production for several weeks because of flood damage and component shortages. All nine of the Japanese car manufacturers with operations in Thailand were forced to suspend production. According to the Japan Automobile Manufacturers Association, production of 6,000 units was affected on a daily basis. Several Japanese companies were increasingly moving production to Thailand to negate the strong yen and the power shortages that continue to affect Japan following the Tohoku earthquake. In total, around 450 Japanese manufacturers were affected by the floods in Thailand.

Flooding in Rojana Industrial estate

Honda halted operations at its factory in Rojana, Ayutthaya Province, on October 4. The factory is the company's largest in Southeast Asia, annually producing 240,000 cars. Output at a second Honda plant in Thailand was halted due to part supply shortages. The impact on Honda's production was also felt outside of Thailand. On October 31 Honda said a shortage of electronic parts caused by the floods in Thailand forced it to scale back its North American production in November.

In December, Honda destroyed 1,055 cars that were damaged in the floods at the plant. Honda opened it's plant in early April with production back to normal by the middle of the month. Honda plans to export 40,000 units in 2012 from Thailand.

Bang Pa-in industrial park before breach

Cars at Honda factory in Rojana industrial park after flooding (Source: Reuters)

Although the floods caused no physical impact to the plants, Toyota suspended production at its Thai factories on October 10 due to supply shortages caused by submerged roads and factories. The situation was a serious blow for Toyota, whose production in Thailand is its third-largest outside of Japan. In 2010, it produced about 630,000 vehicles in Thailand. The floods also affected the company's output outside the country, with Toyota having to cancel overtime at all its Japanese vehicle plants, causing a production loss of 7,000 vehicles a week. Toyota had to also cut back work in Indonesia, Vietnam and the Philippines and in the United States, Canada and South Africa. Toyota Motors restarted production lines at its plants in Thailand on November 21. Toyota estimated it lost production of 87,000 vehicles in Thailand and 40,000 in Japan between October 10 to November 12.

Nissan, meanwhile, halted its production in Thailand on October 17 after the floods inundated about 120 of its suppliers with the floods sparing its factories in the region. Nissan started work partially from 14 November by procuring substitute parts through its global supply network in an effort to limit output losses to 40,000 vehicles in Thailand. Nissan prevented any impact from Thailand's floods on production in North America, Europe and China due to a more robust supply chain strengthened after the Tohoku earthquake.

Mitsubishi Motors Corporation had to halt production lines in Laem Chabang industrial estate on October 13 as its auto-part suppliers in industrial estates were earlier shut down by the flooding. It restarted production on November 14.

Mazda Motor Corporation resumed production of passenger cars at its factory in Thailand on November 14 after parts supply partially recovered.

Several electronics firms and chipmakers suspended output at factories in the region because of the flood damage (two Toshiba factories in the industrial parks of Bangkadi and Nava Nakorn were inundated by floodwater of up to 1.5m). Other companies were also affected by supply shortages.

The impact on electronic companies in the region was severe. Sony, who manufactured all of its digital single lens reflex (SLR) cameras in the industrial area of Ayutthaya slashed its full-year operating profit outlook by 90% on November 2 as the floods disrupted its camera production.

Nikon's Thailand plant, which produced low to mid range SLR cameras and accounted for 90% of the company's SLR camera production, was damaged by the floodwaters. The company reported that the first floor of the plant was submerged by floodwaters of up to 2m. Production at the factory was suspended on October 6 and partially opened in January 2012.

Canon was also affected by the floods, and it's factory reopened on December 15.

Elsewhere, Nidec suspended production of hard disk motors at its factory in Thailand on October 10, causing concerns about supplies to other companies. Research by IHS iSuppli suggested the floods are set to cause a slump of up to 30% in hard disk production in the last three months of this year compared to the same period last year and warned supply shortages may continue throughout the first half of 2012.

Denmark-based Ecco, the world's leading footwear company, expects its revenue generated from the Thai unit in 2012 will be halved from the pre-flood period on uncertainty over future inundations and the bankruptcy of the industrial estate where it is located. Partial production has resumed at Ecco's factory in Saha Rattana Nakorn Industrial Estate in Ayutthaya in mid-January. In the fourth quarter of 2011, Ecco moved its machinery from the Ayutthaya factory to a temporary site in Lop Buri after Saha Rattana Nakorn estate was inundated.

Damage to machinery and stock in a factory

Damage to machinery due to flooding

A levee breach leading to flooding

Flooding in Bangkadi Industrial estate (Source: Bangkadi IP)

THREAT TO BANGKOK

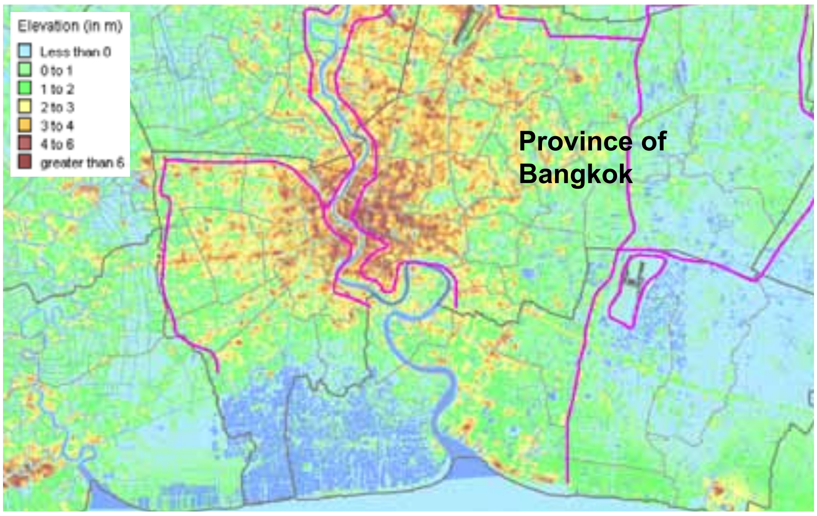
Thailand has taken advantage of the river characteristics of gentle slope to control flooding of the Chao Phraya River. Flooding is controlled by storing water in the dam reservoirs in the upper watershed of the Chao Phraya River, and by expanding the flood area to decrease the floodwater level in the lower watershed. Since the flood flow is slow, due to the gentle gradient of the Chao Phraya River watershed, flooding seldom causes real damage to human life if the inundation level is below the knee. In addition, floodwaters can also be effectively evaporated by widely expanding the flood area.

The still expanding city boundary rests about 1m to 1.5m above the nearby gulf, although some areas already lie below sea level. The gulf's waters have been rising by about 25mm a year, about the same as the world average. But the city, built on clay rather than bedrock, has also been sinking at a pace of up to 3cm annually as its teeming population and factories pump some 2.5 million cubic tons of water out of its aquifers. This compacts the layers of clay and causes the land to sink.

Once known as the "Venice of the East," Bangkok was founded 225 years ago on a swampy floodplain along the Chao Phraya River. Apart from the main river which cuts the city in two, Bangkok was once criss-crossed by canals, or khlongs, that cover the river basin and the city's transportation system was built around water travel.

But beginning in the 1950s, on the advice of international development agencies, most of the canals were filled in to combat malaria and construct roads as car use increased. This fractured the natural drainage system that had helped control Bangkok's annual monsoon season flooding. The system of canals had served to drain the waterlogged Chao Phraya Delta, so as the khlongs were turned into roads flooding became an increasing problem in low-lying parts of the city.

According to a flood survey report by the Japan International Cooperation Agency (JICA) released in 1999, the discharge capacity of the Chao Phraya River at Bangkok is only about a 3-year probability river discharge if there is no flooding from the Chao Phraya Dam to Bangkok. However, floods have not occurred frequently in Bangkok because most of the excess water is stored upstream in floodplains of the Chao Phraya River lower watershed.



Bangkok elevation map together with approximate location of existing and proposed dykes (Source: NASA SRTM and BMA)

Old picture of a khlong in Bangkok

SUMMARY OF INSURED LOSSES

Company	4Q 2011 Thai Flood Net Loss Estimate
ACE	117
ACR	55
Allied World	43
Alterra Capital	30
Amlin	86
Arch	61
Argo	35
Ariel	22
Asian Re	60
Aspen	59
AXIS	48
Beazley	42
Best Re	20
CCR	194
Chubb	12
Endurance	77
Everest Re	218
Fairfax	202
Flagstone	15
Hannover	254
Hardy	39
HCC Ins Hldgs	10
IAG	50
Korean Re	135
Labuan Re	33
Lancashire	25
Lloyd's	2,200
Markel	19
Montpelier Re	40
MRB	11
MS&AD	3,000
Munich Re	680
NKSJ	1,290
Novae	15
PartnerRe	120
Platinum	28
QBE	261
RenaissanceRe	45
SCOR	186
Swiss Re	680
Taiping Re	62
Thai Re	94
Toa Re	956
Tokio Marine	1,417
Transatlantic	72
Travelers	102
Validus	56
White Mountains	34
XL Group	185
Total	13,494

After the floods, Thailand's General Insurance Association (GIA), confirmed that large businesses in the industrial estates had insurance coverage for floods and business interruption. Most multinational firms bought coverage with foreign insurers rather than Thai companies. Meanwhile, Residential losses were limited as less than 1% of households in Thailand have insurance that covers flooding. Japanese non-life insurers registered in Thailand were more exposed to the flooding than local insurers given their high exposure to industrial all risk and business disruption coverage for Japanese manufacturers in the affected industrial estates. It was estimated that the seven flooded industrial estates had insurance coverage of around THB 600 billion (USD 19.5 billion) with major part of the losses being ceded to foreign reinsurers.

The World Bank has estimated THB 1,425 billion (USD 45.7 billion) in economic damages and losses due to flooding, as of December 1, 2011. Most of this was to the manufacturing industry, as seven major industrial estates were inundated by as much 3m during the floods.

The estimate of insured losses from last years flood are reproduced in the table on the left. The claims payments are still being made in 2012.

Insured losses for 2011 Thailand flood in USD millions (Source: Company disclosure; highest or "worst case" estimate where a range of probable losses is provided)

WHY ARE THE DAMAGES SO SIGNIFICANT?

Hydrologic and geomorphological changes – while heavy rainfall may have contributed, other underlying factors can be also be pointed out including sea level rise in the Gulf of Thailand (19 to 29 cm until 2050) and subsidence among others due to groundwater extraction. In the 1970s, Bangkok was sinking 10 cm per year but is currently "only" subsiding 1 to 3 cm per year.

Increase of exposure – during the past decades, the region has undertaken rapid 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.

The flood waters stayed around in the Industrial parks for weeks, which led to the growth of mould (like Hurricane Katrina in New Orleans) given the high humidity. Also, specialised equipments for semiconductors, cameras, drives etc were completely ruined due to flooding and had to be replaced. This escalated the economic/insured losses.

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 prolonged flood period in many areas including the ancient city of Ayutthaya, and some Industrial Estates. For example, part of the embankment of the Hi Tech Industrial Estate located north of Bangkok broke as leakage weakened its structure and emergency reinforcement failed.

GUY CARPENTER THAILAND FLOOD MODEL

The Guy Carpenter Thailand flood model was developed in 2008 in conjunction with DHI, an independent research and consultancy organization specializing in hydraulic flood modeling software, and covers the main flood risk areas in Thailand's lower Chao Phraya basin enabling clients to better estimate their probable maximum losses at different return periods based on their commercial and industrial exposures. The model allows for analysis from 5-year to 1,000-year return periods.

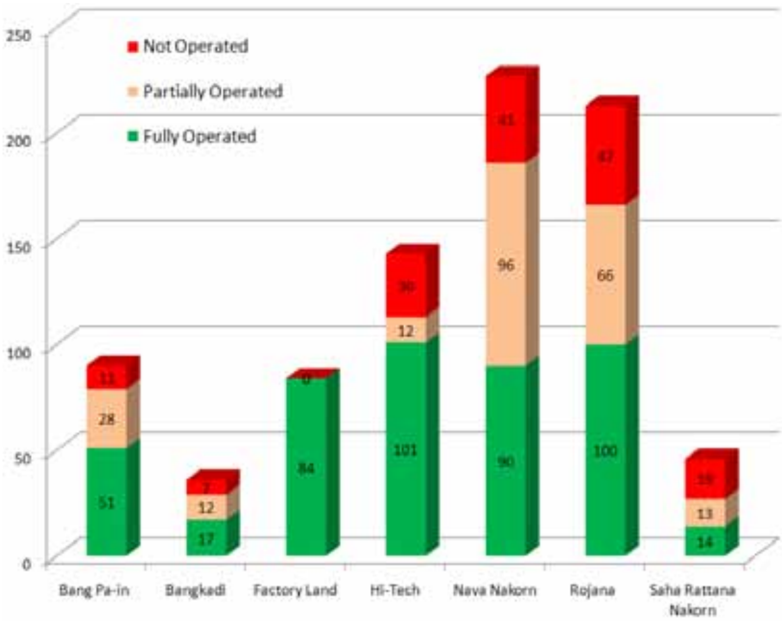
Guy Carpenter has been providing analysis results to clients for flood in Thailand and also embarked on a detailed study to determine the model behaviour in light of the floods of 2011. It was found that the model gave satisfactory results and had rightly predicted that the area including and surrounding Don Mueang airport could be submerged.

The model analyses risk at high resolution (less than 100m grid) and works for all lines of business.

Guy Carpenter is planning to update the model to incorporate the flooding event of 2011 and is in consultation with our clients and various consultants.

100yr flood map near Don Mueang airport (Source: GC Thailand flood model)

CURRENT STATUS OF RECOVERY EFFORTS



No.	Site	Cost (MB)	Started	Planned Finish
1	Saharatananakorn Industrial Estate	535.123	Temporary Dike Construction	
2	Hi-Tech Industrial Estate	558.061	1 Feb. 2012	31 Aug. 2012
3	Bang Pa-In Industrial Estate	704.374	1 Feb. 2012	31 Aug. 2012
4	Rojana Industrial Zone	2,030.000	20 Feb. 2012	31 Aug. 2012
5	Navanakorn Industrial Zone	1,102.100	15 Feb. 2012	31 Aug. 2012
6	Bangkadi Industrial Zone	583.280	2 Mar. 2012	31 Aug. 2012
	Total	5,512.911		

(Source: IEAT, September 2012)

According to Industrial Estate Authority of Thailand, as at September 21 2012, more than 684 (>80%) of the factories in the seven flooded Industrial estates have either fully or partially opened. The dewatering and cleanup of the Industrial estates started in mid-November with Factoryland; Bangpa-in and Rojana in early December; Bangkadi, Navanakorn and Hi-Tech in mid-December and lastly Saha Rattananakorn in late December.

There is work ongoing at the Industrial estates for construction of new dykes with the government directly subsidising two-thirds of the cost to construct flood barriers at industrial estates.

The floodwalls are being built to the standards set by the Japan International Cooperation Agency and the Thai Industry Ministry with the maintenance costs being borne by the private industrial operators. The government has instructed the Government Savings Bank to provide 15-year loans worth THB 15 billion at an annual interest rate of only 0.01 per cent for flood projects.

IEAT has provided revised design criteria for dykes,

1. Provide retention pond and dewatering station for drainage with spare pumps
    a) Within two hours drainage capacity
    b) Capacity and efficiency of spare pumps not less than working pumps
    c) Provide service road surrounding retention pond

2. Flood protection dyke
    a) Must be higher than 70 years period maximum flood level (+ 0.5m free board)
    b) Strong structure and resist hydro-pressure
    c) Width of road not less than 2.5m
    d) Not disturb water way including quantity and direction

3. In case fill earth covers the entire area, allow 0.5m higher than 70 years period maximum flood level

4. Designing of dewatering system must be considered and concerned with the capacity and direction of outer water way

5. Provide periodic maintenance

6. Provide water monitoring system, early warning system and emergency response plan for flood protection

7. Annual inspection and report

RECOVERY PROGRESS BY INDUSTRIAL PARK

The actual recovery efforts being undertaken by each Industrial park are presented below.

No.	Site	Cumulative Planed Progress (%)	Cum. Existing Progress (%) at 17 Sep 2012	Compare to Plan	Cum. Existing Progress (%) at 30 Aug 2012	Compare to Last Update
1	**Saharatananakorn Industrial Estate**	41.00%	29.33%	- 11.67%	3.00%	+26.33%
2	**Hi-Tech Industrial Estate**	94.50%	90.19%	- 4.86%	85.02%	+5.17%
3	**Bang Pa-In Industrial Estate**	66.96%	75.00%	+7.39%	72.00%	+3.00%
4	**Rojana Industrial Zone**	100.00%	98.00%	-3.00%	94.00%	+4.00%
5	**Navanakorn Industrial Zone**	100.00%	97.83%	-3.00%	95.00%	+2.83%
6	**Bangkadi Industrial Zone**	93.97%	84.08%	-3.99%	77.92%	+6.16%

Progress of Dyke construction for Industrial estates (Source: IEAT, Sep 2012)

JAPANESE FIRMS RECOVERING

A year after floods in Thailand struck about 450 Japanese firms, more than 80 per cent of factories in seven submerged industrial parks have resumed operations. But restoration progress has varied according to sector and size. By the first anniversary of the floods, small and midsize manufacturers of electronic components for home appliances restored most of their production equipment to pre-flooding levels. Yet operations stand at only about 40 per cent of capacity, and lights remain off at half of these factories.

Meanwhile, firms in automobile-related sectors have been recovering steadily and automakers have also increased production in the country. In January 2012, Toyota Motor Corporation announced plans to build its fourth factory in Thailand.

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