

Short term floods mitigation measures after Thailand Floods 2011

By Assoc. Prof. Dr. Sucharit Koontanakulvong

Faculty of Engineering

Chulalongkorn University

Abstract

During July-November 2011, Chao Phraya Plain of Thailand suffered from the serious flooding started in July in the northern area and the flood went downward to midstream area in September and reached Bangkok area in October. It was the first time that flood water reached the inner part of the capital city, Bangkok, and also caused flash flood to many main industrial estates in the suburb of Bangkok. The damages of this flooding was estimated to be more than ten times of the previous major past flooding especially to the industrial sector and were in the ranking number four of disaster damages in the world. The floods also induced huge impacts to the world's insurance industry and industrial logistic supply chain system.

After the floods, Thai Government increased particular concern over floods mitigation measures including both immediate and sustainable measures. The Strategic Formulation Committee on Water Management Resources (SFCWMR) was set up to draft the mitigation measures. This paper summarized the directions and plans for short term flood mitigation measures by which some plans had been implemented in the passing years. The effectiveness and some concerns for further improvement were also commented for future flood planning.

Keyword: Thailand, floods, short term, mitigation plan, Chao Phraya, Bangkok

1. Introduction

During July-November 2011, Chao Phraya Plain of Thailand suffered from the serious flooding started in July in the northern area and the flood went downward to midstream area in September and reached Bangkok area in October. It was the first time that flood water reached the inner part of the capital city, Bangkok, and also caused flash flood to many main industrial estates in the suburb of Bangkok. The damages of this flooding were estimated to be more than ten times of the previous major past flooding especially to the industrial sector and were in the ranking number four of disaster damages in the world. As of Dec 1, 2011, World Bank estimated the total loss to be 45.7 billion US dollars (World Bank, 2011) which exceeded the fourth loss in the world, i.e. California Earthquake (42.0 billion US dollars, Bo Zhang, 2011). The floods also induced huge impacts to the world's insurance and industrial supply chain system, e.g. hard disk, automotive, and electronics industries.

After the floods, Thai Government increased particular concern over floods mitigation measures including both immediate and sustainable measures. The Strategic Formulation Committee on Water Resources Management (SFCWRM) was set up to draft the mitigation measures. The committee had set two subcommittees, i.e. for short and long term measures, to collect and draft the measures and projects proposed from the concerned authorities to the Government.

This paper summarized the directions and plans for short term flood mitigation measures which had been implemented in the passing years. The effectiveness and some improvement were also commented for future planning.

2. Flood events

Floods 2011 induced a lot of damage to water control structures along the Chao Phraya River and more than 30 water control structures were damaged by high river level (Fig. 1). The overflow floodwater flowed through paddy field in the form of flood sheet flow and finally overflowed the flood protection dyke into the industrial estate area in the rapid time. The flood water caused huge damages to high technology machines in the main seven industrial estates in the vicinity of Bangkok area. The flood area can be estimated from satellite images and the flood area in September 2011 and 2012 in the Chao Phraya basin are 10,375 and 3,070.28 sq km (Fig. 2) respectively. One of the main causes was the long duration and high amount of rainfall that also induced correspondingly long duration and high runoff volume during August-October.

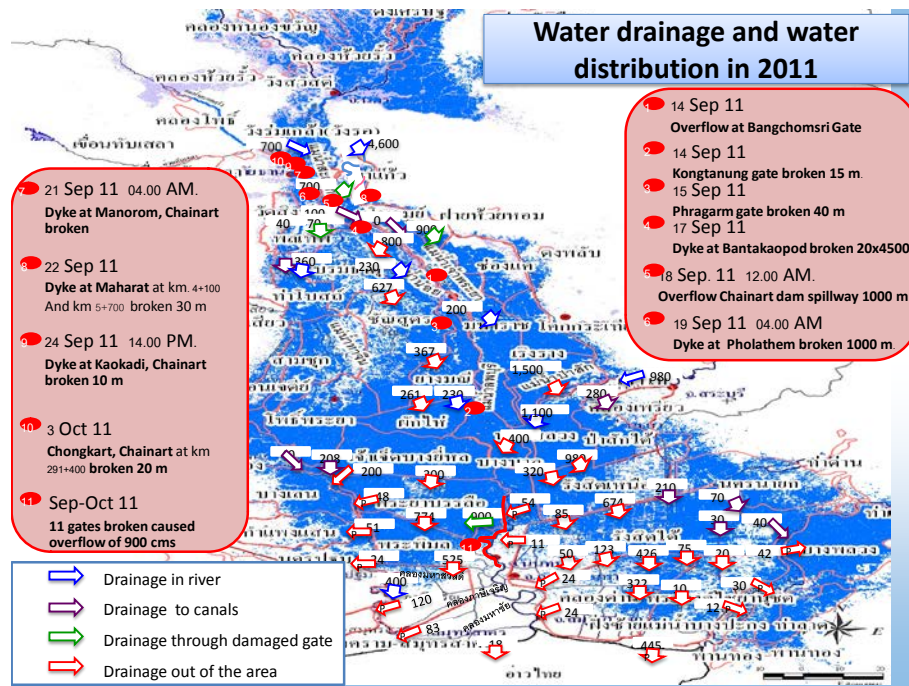


Figure 1 Floods water movement during September – October 2011 (SFCWRM, 2012)

Flood area in September

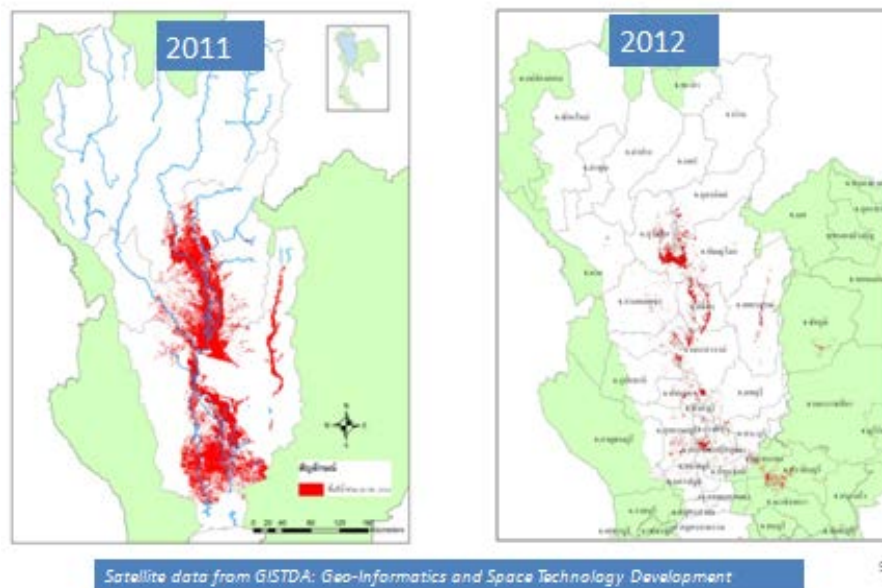


Figure 2 Comparisons of flood area in September 2011 and 2012

Table 1 and 2 show water balance of floods 2011 in the upper and lower central plains of the Chao Phraya Plain. Water storage in the area equals to inflow minus outflow volume. The flood volume in the area can be estimated from the water storage volume minus water retention volume (if any) in the area.

Table 1 shows the water balance of the upper central plain which covers the area downstream of two big dams, i.e. Bhumipol and Sirikit Dams, to Nakornsawan Province (at C2 station, upstream of Chao Phraya Delta) and Table 2 shows the water balance of the lower central plain which covers the downstream of Nakornsawan Province to Chao Phraya River Mouth. The analysis of water balance is based on the data from May to November 2011. With the inflow, outflow and storage of the upper and lower Chao Phraya River basins in monthly basis, the amount of net water storage, which indicated the flood volume, can be estimated. The net flood storages are estimated to be 6180 and 14818 MCM in the upper (Table 1) and lower zones respectively (Table 2) resulting in 20,998 MCM of the total flood volume that needed to be considered for future flood mitigation planning.

Table 1 Flood water sources- Upper zone (May-Oct 2011)

	Volume (MCM)	Percentage (%)
Total Inflow	40928	100
Release from Bhumipol Dam	3776	9
Inflow Wang River (W 4 A)	3520	9
Inflow from Yom River (Y	11124	27
Release from Sirikit Dam	5209	13
Estimated runoff from rainfall	17298	42
Outflow through C2	34748	85
Net accumulated flood storage	6180	15

Table 2 Flood water sources- Lower zone (May-Oct 2011)

	Volume (MC)	Percentage (%)
Total inflow	57696	100
Inflow (through C2)	37545	65
Inflow from Dams (Pasak etc.)	4227	7
Estimated runoff from rainfall	15924	28
Total outflow	42879	74
Out flow (through West:Tachin)	1799	3
Out flow (through Chao Phraya)	38324	66
Out flow (through East zone)	2757	5
Net accumulated flood storage	14818	26

3. Mitigation principles

The Strategic Formulation Committee on Water Resources Management (SFCWRM), set up by the Government, had set the flood mitigation principle into eight schemes to cope with various aspects of flood planning as follows:

- (1) Reforestation scheme,
- (2) Annual water management scheme,
- (3) Structural rehabilitation scheme,
- (4) Flood data, prediction and warning system,
- (5) Flood fighting scheme
- (6) Retention and compensation scheme
- (7) Organization and regulations improvement scheme
(water, land use, forest, retention),
- (8) Social participation, recognition scheme.

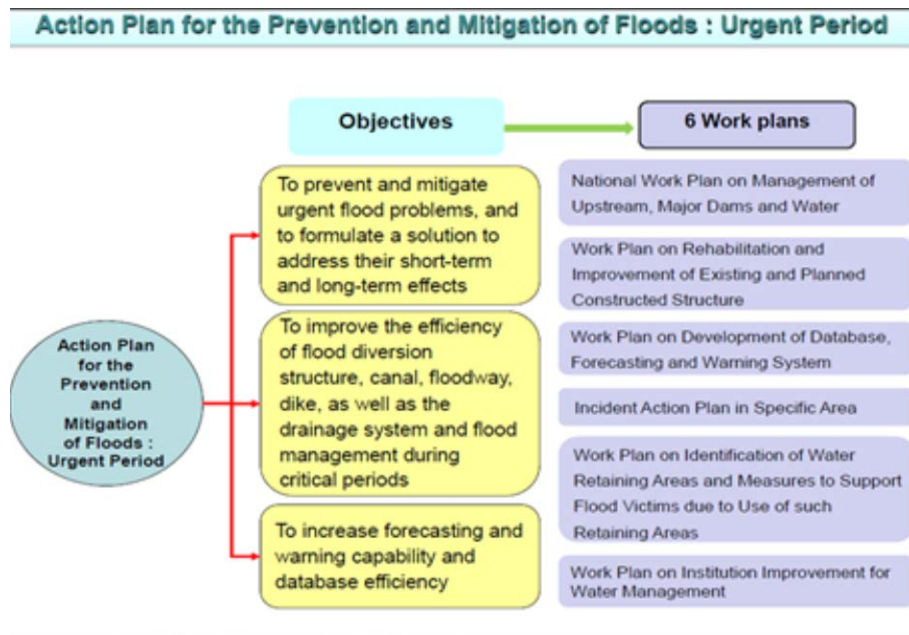
The principles cover both hard (structure, facilities) and soft (organization, system) measures. Flood mitigation and planning should integrated many of hard and soft measures together. However, this may take time for implementation. Since the situations were serious for both recovery works and future planning, the Committee decided to set up two subcommittee; one of which is to take care of immediate term measures (immediate repair and short term improvement works) and the other is to responsible for long term measures (sustainable (medium and long) planning). The immediate term subcommittee took care the repair works and immediate measures including water management related projects in order to be able to handle 2012 flood mitigation works with lessen impacts if the same flood water volume would come. To handle the water related projects, the working group was set to consider the prevention and mitigation guidelines and to propose mitigation projects for immediate/short term measures that should be able to implement (immediately) within one or two years. The guidelines are as follows:

- (1) Make use of the existing structures with the consideration of local characteristics in each area,
- (2) Enhance storage and drainage capacity,
- (3) Prevent floods in community and economic zones,
- (4) Implement supportive measures (if needed).

The long term subcommittee took care the drafting of sustainable water resources development plan in the future which can sustain future floods. The implementation of the long term measures will be supported by the special flood relief budget under special loan act.

4. Immediate/short term framework

Based on the in-depth discussions among agencies concerned, the action plan for immediate/short term measure projects had been drafted and the main objectives are to prevent and mitigate urgent floods (SFCWRM, 2012), improve drainage capacity, and increase water management capacity. The action plan for the flood prevention and mitigation of floods in the short term was set as shown in the following figure.



In the upstream area, more water retention mechanisms, e.g. dam control, retention area etc., were considered. In the middle area, the repair of main structures to control excess flood water (which means flow above the defined discharge which may cause overflow in some downstream areas) and improvement work for emergency retention area were considered. In the downstream area, the improvement of drainage capacity toward the sea, e.g. dredging, installation of more pumps, dyke repair etc., were considered. There are 1043 projects under six work plans and the budget of 42,973 M baht is set for implementation. The SFCWRM agreed with the proposed work plan in January 2012 and the cabinet approved the budget framework in February 2012. The main immediate/short term activities can be categorized into six groups as follows.

(1) Structural Repair works with effective solution

As mentioned earlier that the floods 2011 caused huge damages to water control structures especially in the main Chao Phraya River and within the limited time constraint, the focused repair works had been chosen to better the flood operation in the coming floods 2012. The repair works comprised of water gates, dykes, and roads. Besides, the additional flood protection

scheme with permanent dyke structures for special zone such as industrial estate (Fig. 3) was also planned.

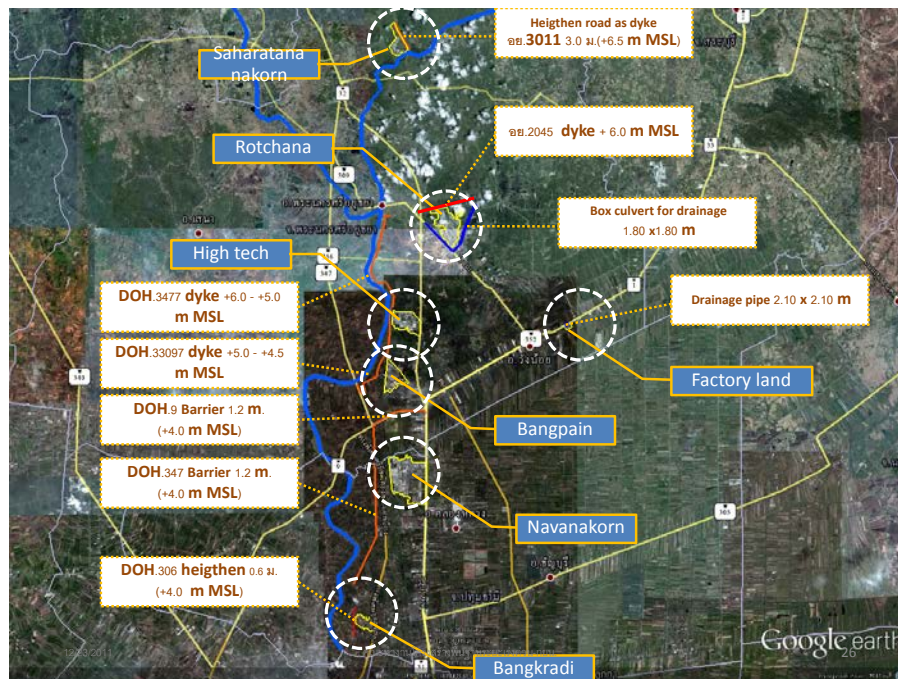


Figure 3 Embankment in the industrial estate and road heightening (SFCWRM, 2012)

(2) *Upstream area works*

Water level in the Chao Phraya River normally reaches its peak in September every year and if the peak is sufficiently high, it will cause floods and induce damages. The review on reservoir water release was done by another working group to lessen the peak flow during September. A guideline for reservoir release of the main dams was drafted (Fig. 4) so that water will be released before August and minimum or zero release in September and October can be controlled with increased efficiency. Based on this measure, it is estimated that about 5000 MCM can be stored in the upstream dam and the peak at C2 (Nakornsawan) can be reduced about 600 cms during the flood event.

Dam Operation Adjustment

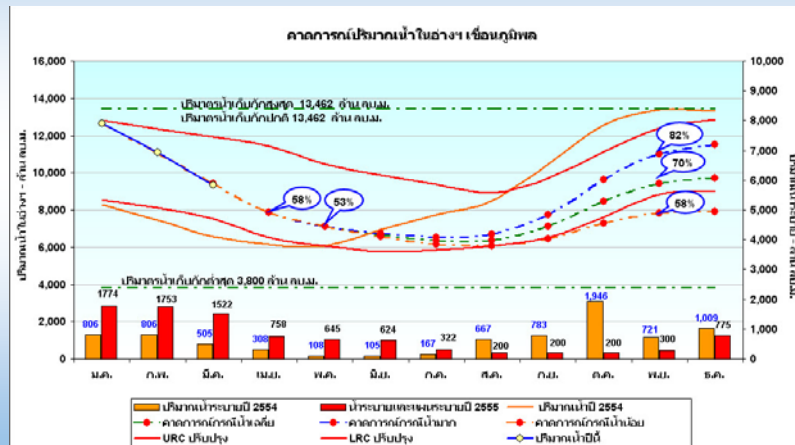


Figure 4 Dam operation adjustment (RID, 2012)

(3) Midstream area works

In case of emergency, the retention area was prepared to divert excess flood water to be stored for a certain period of time to refrain the high flood peak both from rainfall and runoff from the upstream. Detail investigations on the appropriate site for retention use were explored and the improvement work such as dredging, dyking and pumping facilities, were planned to better the control of inflow-outflow-storage in the retention area. The area of about 2.1 M rai (about 336,000 hectares) in the north area covering the area of Phitsanulok, Phichit and Nakornsawan Province and the south area covering the area of Nakornsawan, Chainart, Singburi Province, had been prepared to cut flood peak for this emergency situation and the sample of the retention area is shown in Fig. 5. With these measures, the flood storage of about 5000 MCM can be stored in the retention area if needed.

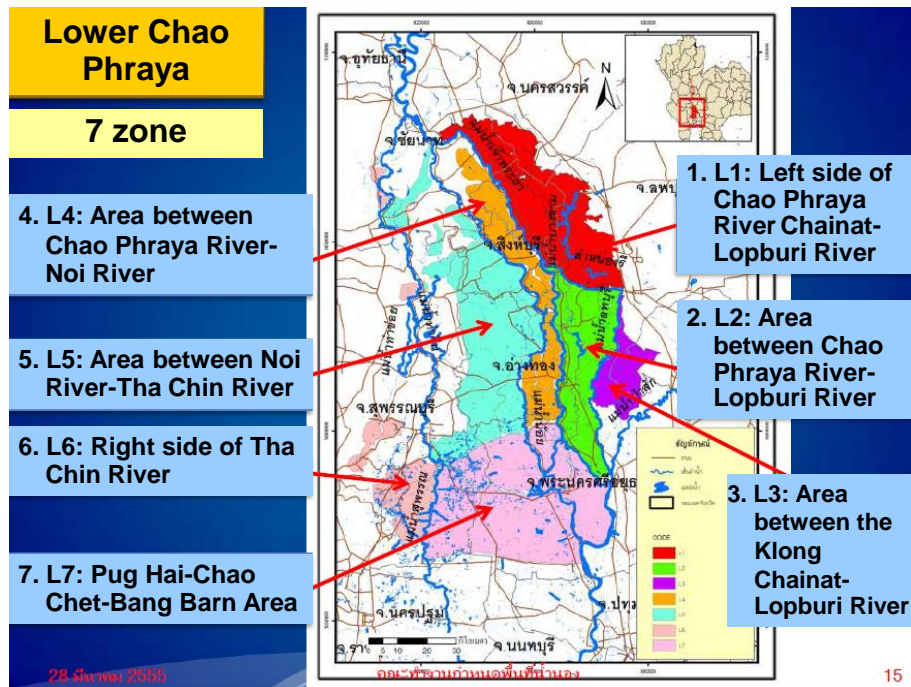


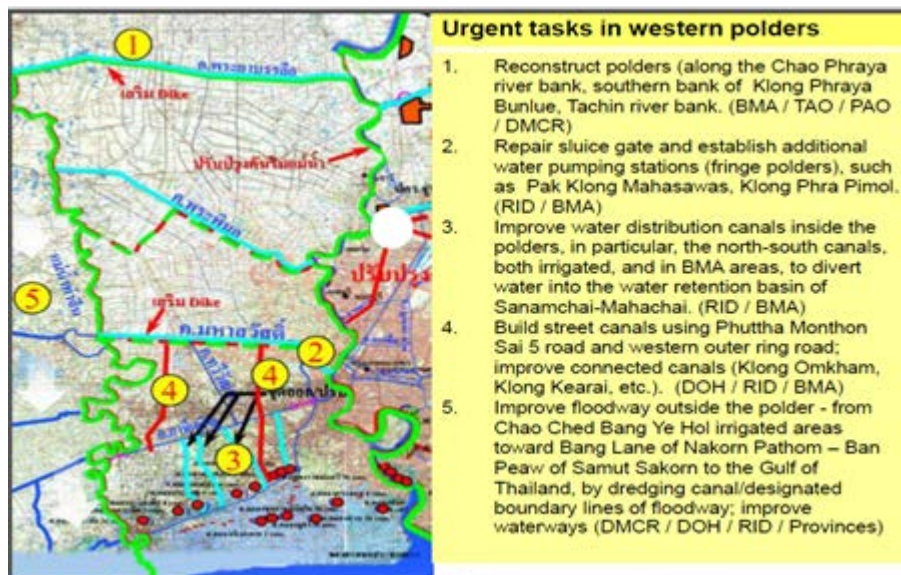
Figure 5 Retention area preparation (RID, 2012)

(4) *Downstream area works*

In the downstream area (south of Ayuthaya Province to the sea) the water drainage route improvements were set to drain flood water through Tha Chin, Chao Phraya, Bangpakong Rivers and through small canal networks to the Gulf of Thailand as urgent works. Massive dredging activities were planned to improve the drainage capacity with the installation of pumping and heightening low dykes along the river. The drainage capacity improvement works in the Bangkok East were planned, in case of necessity, to drain flood water from Khlong 1-7 of the Chao Phraya River east. While the flood water from Khlong 8-14 of the Chao Phraya River east will drain through Khlong 13 and 14 through Phraya Chaiyanuchit canal to the pumping stations along the shoreline of the Gulf of Thailand. Some flood water may also pass through Bangkok area, if necessary and available, for emergency purpose (about 300 cms). The locations of improvement project are shown in Fig 6-1 with five main projects as below (Supot, 2012).



The drainage capacity improvement works in the Bangkok west were also planned to receive excessive flood water from the north of the Chao Phraya River west. Again, if necessary and available, some flood water from the north area may pass through Taweewatana canal to Pasicharoen canal (about 75 cms) to Tachin River or down to Mahachai canal and finally to the sea. The locations of improvement project are shown in Fig 6-2 with five main projects as below (Supot, 2012).



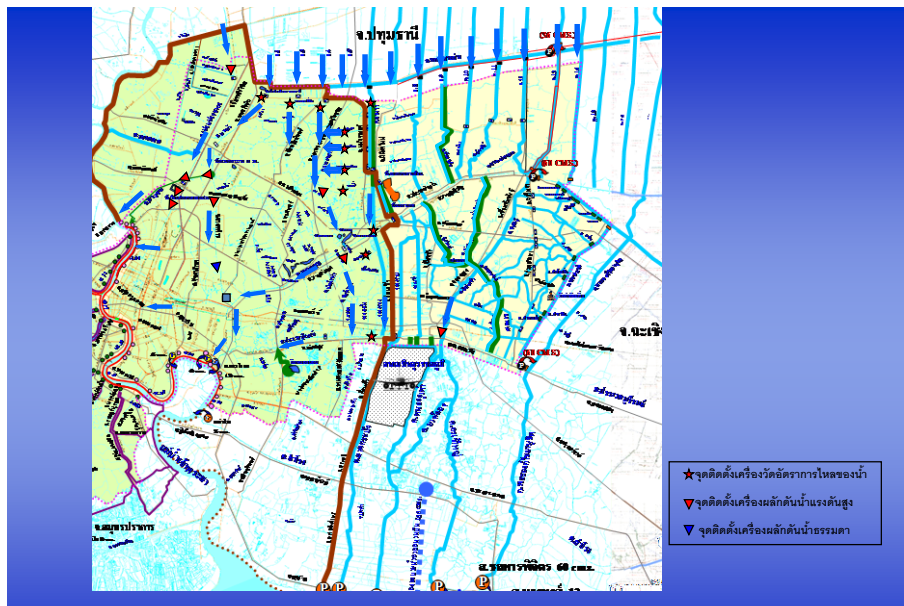


Figure 6-1 Drainage capacity improvement in East BKK (SFCWRM, 2012)

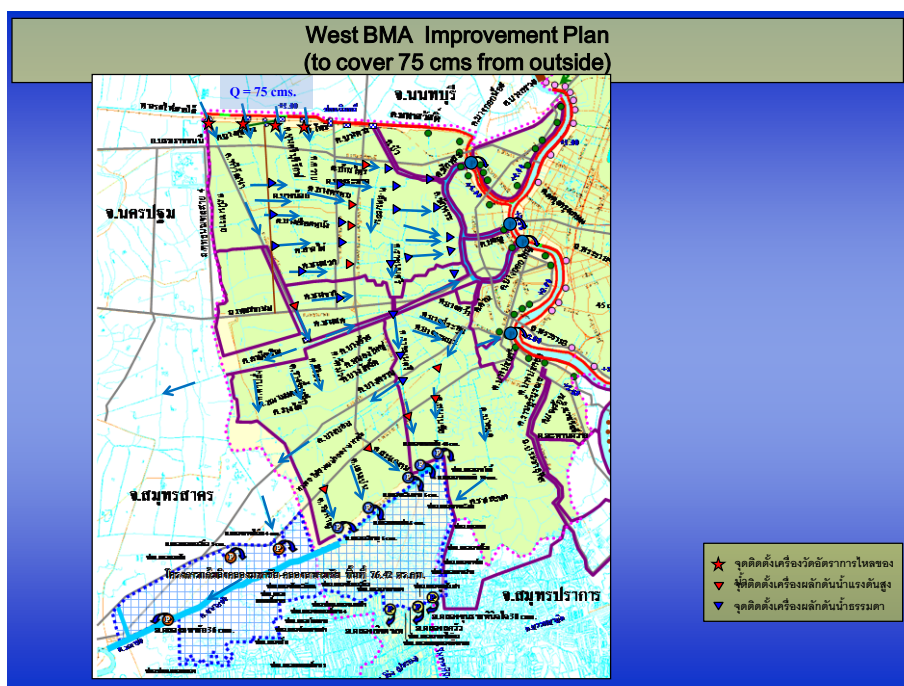


Figure 6-2 Drainage capacity improvement in West BKK (SFCWRM, 2012)

(5) Flood fighting system

Central warehouse system is set up to register the stock list of necessary equipment (central equipment: mobile pumps, cars, relief life bags etc.) to share among agencies during emergency operation under a single command unit. New scheme of water jet pump in the canal for the low land area is also prepared to improve the drainage capacity.

(6) Single command management system

During the flood event, the Flood Relief Operation Center (FROC) was established as a task force in early October 2011 to guide the flood fighting operation of all concerned agencies, after that the Flood Recovery and Restoration Committee was set up to plan for the relief and restoration works. In the early November the Strategic Formulation Committee for Water Resources Management (SCFWRM) was established to prepare for short and long term water management planning. Under the prime minister office, the National Water Policy and Flood (NWPFC) was established in February 2012 as recommended by SCWRM with the Water and Flood Management committee (WFMC) as an operational unit to gather flood situations and decide on water operation and as a single command unit to guide the water operation to the concerned agencies. The integrated information system (Fig. 7) with facilities of data monitoring, transfer, display, computing, and weather forecasting is also planned to be installed for operational decision making. This single command unit will monitor, guide the operation of water management and also will be a main body for long term project implementation.



Figure 7 Information system (NWOC) under single command (Supot, 2012)

5. Short term implementation progress

For the short term remedial measures, the Government had approved the budget for social assistance to the affected people, upstream plantation and infrastructure improvement. The budget for infrastructure improvement was also divided into the immediate and short term infrastructure improvement projects. The immediate improvement projects included 624 projects with the approved budget of 13343 M baht and the short term improvement projects included 419 projects with the

approved budget of 25,637 M baht. The main improvement activities are structural repair, dyke improvement, road heightening, dredging, pump installation, retention area preparation etc.

Based on the WFMC progress report, the overall implementation progress is 43% while the immediate projects finished 87% and the short term projects finished 14% based on the reported figures as of November 9, 2012 (as shown in Table 3, there are some project groups that have already been implemented but some projects need more detailed document for budget approval and caused report delay). The projects are also classified into east, west Chao Phraya region and central equipment and the progress in each type is 25%, 7% and unknown respectively. The project implementation will be proceeded for further construction during the summer period (April-May) of 2013.

The main obstacles are budget approval process (some projects need more detailed document for approval), meteorological effect and negotiations with communities for land entering.

Table 3 Immediate and short term flood improvement project progress (as of Nov. 9, 12)

Title	Budget (M฿)	No. of Project	Progress (%)	Remark
a) Immediate Term Project				
1 Ministry of Transport	2491	44	92	
2 Ministry of Agriculture	6251	129	96	
3 Ministry of Science and Technology	1985	24	68	
4 Ministry of Interior	1846	150	62	
5 Ministry of Defense	770	277	100	
Subtotal	13343	624	87%	
b) Short term Project				
b1 East Chao Phraya				
1 Ministry of Transport	15716 ¹	140	n.a.	
2 Ministry of Agriculture	2027	98	32	
3 Ministry of Interior	1220	2	93	
4 Ministry of Industry	3237	6	90	Ind. Estate
5 Ministry of Education	171	1	n.a.	
Subtotal	22371 ²	247	25%	
b2 West Chao Phraya				
6 Ministry of Transport	6008 ³	49	n.a.	
7 Ministry of Agriculture	488	25	95	
Subtotal	6496 ⁴	74	7%	
b3 Central Equipments				
8 Ministry of Defense	20	1	n.a.	water jet pumps
9 Ministry of Interior	129	1	n.a.	for BMA
Subtotal	149	2	n.a.	
C) Retention Pond Improvement				
1 Ministry of Agriculture	614 ⁵	96	n.a.	
total	42973	1043	43%	

Remark:

1: approved only 11898 M฿

2: approved only 18553 M฿

3: approved only 5823 M฿

4: approved only 6311 M฿

5: approved only 519 M฿

n.a. : some projects in the group waiting for final approval,
then, no progress reporting

6. Short term mitigation system effectiveness

With the planned immediate/short term mitigation plan, many improvement works had been implemented from March to September 2012, e.g. dyke repair/improvement dredging dyke and road as flood dyke protection (Fig. 8), installation of water jet pump, dam release rule adjustment (Fig. 4), retention area preparedness. With the measures, it is expected that the excessive flood water like 2011 can be better controlled via dam operation adjustment (about 5000 mcm), emergency retention area (about 5000 mcm) and drainage capacity improvement (about 2000 mcm). The control peak flow at C2 is set to be 3600 cms and if the peak exceeds 3600 cms, it may cause floods or overbank at downstream. During floods 2011, the peak flow at C2 station exceeded 3600 cms for more than a month. With rough estimation, the short term plan can handle about 60 % of control flood peak of 2011 and can reduce the runoff peak in the main Chao Phraya River and flood damage considerably if the same volume of flood water (like 2011) comes. Besides, the Prime Minister herself also paid an intention and followed up the plan and implementation via site visit and meeting with Governors via teleconference periodically.

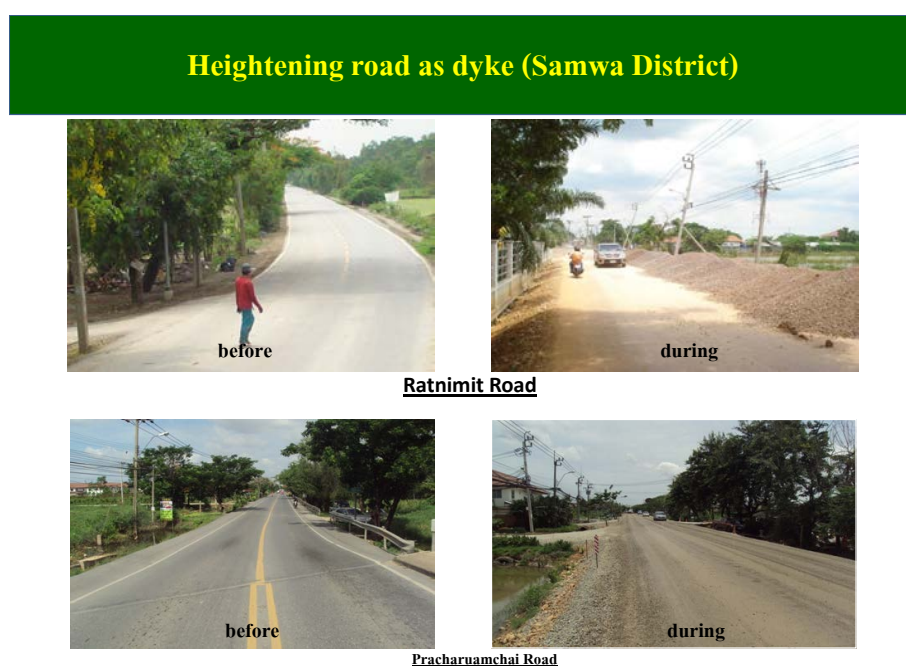


Figure 8 Heightening the road to be used as flood protection dyke (BMA, 2012)

Table 4 showed the comparison of the monthly hydrological data during rainy season in the year 2011 and 2012. The input of water into the Central Plain can be divided into three major sources, i.e. runoff induced from the rainfall in the area, dam release, natural runoff (from the Yom and Wang Rivers).

If we considered by area, rainfall during rainy season in the year 2012 (upper central plain: 1074 mm, lower central plain: 973 mm) decreased from the year 2011 (upper: 1421, lower: 1127 mm) by 24 % in the upper, 14 % in the lower or 20 % in average. The dam release during rainy season in the year 2012 (4820 mcm) also decreased from the year 2011 (13163 mcm) or 63 %. The natural inflow (no big dam upstream) from the Yom and Wang River in the rainy season also decreased from 14576 mcm (2011) to 4521 mcm (2012) or 69 % (as shown in Table 5). The effect of the dam release adjustment can be seen clearly from the water situation in 2012 while water flow in the Chao Phraya River was better managed with the 30 % of peak decrease in September at Nakornsawan (station C 2) and with the 59 % of peak decrease in October at Ayuthaya (station C 29). For short term measures, RID will control normal flow limit at Nakornsawan (C2 station) to be not more than 2700 cms and prepare the downstream facilities to cover the flow condition. Hence, in 2012, the peak flow was at 1838 cms (September 11, 6.00 AM) and much below the normal control limit. In case there is much rain and runoff, and the flow at C2 is over 2700 cms, various emergency measures such as dam release control, utilization of upstream and downstream retention area (north of Bansai Station, C29) will be adopted to control the flow at Nakornsawan (C2) not to be over 3600 cms (SFCWRM, 2012).

Table 4 Comparison of hydrological data of rainy season in the year 2011 and 2012

Zone	Item	year	Month						Total
			May	Jun	Jul	Aug	Sep	Oct	
Upper	1 Release / inflow								
	1.1 Bhumipol Dam	2011	112	98	176	626	776	1988	3776
		2012	908	334	326	255	78	58	1959
	1.2 Sirikit Dam	2011	212	187	473	1559	1830	946	5207
		2012	701	685	492	365	125	171	2539
	1.3 Wang River (W4A)	2011	389	160	124	1028	948	802	3451
		2012	113	114	60	82	58	233	660
	1.4 Yom River (Y10)	2011	664	845	1077	2378	3080	3081	11125
		2012	107	624	411	499	1107	1111	3859
	Total Inflow	2011	1378	1290	1921	5591	6634	6816	23630
		2012	1829	1704	3001	1203	1892	1573	11202
Lower	2 Rainfall (mm)	2011	231	156	244	253	379	158	1421
		2012	240	113	162	185	318	56	1074
	3 In flow								
	3.1 From upper zone (at C2)	2011	2246	2899	5484	9286	12164	9119	41198
		2012	1696	1835	1430	1471	3742	2841	13015
	3.2 Pasak	2011	39	277	496	555	1093	1356	3816
		2012	57	65	38	28	212	72	472
	3.3 Kra-siao	2011	45	60	72	46	39	57	319
		2012	45	30	15	36	10	26	162
	3.4 Tab Salao	2011	0	7	6	0	0	32	45
		2012	1	1	0	1	0	0	3
	4 total Inflow	2011	3319	4800	6778	9012	14979	16145	55033
		2012	1799	1930	1484	1535	3963	2940	13651
	5 Rainfall (mm)	2011	213	122	174	177	281	160	1127
		2012	161	100	136	156	333	87	973
	6 Out flow (at C29)	2011	3098	4606	6036	7500	9101	9674	40015
		2012	1850	2112	1941	1777	4340	4013	16033

Tabl 5 Comparison of total input of rainfall and inflows during rainy season in 2011 and 2012

Item	2011	2012	Difference (%)
Rainfall in the Upper zone (mm)	1421	1074	-24
Rainfall in the Lower zone (mm)	1127	973	-14
Dams release (mcm)	13163	4820	-63
Flows from Yom and Wang River (mcm)	14576	4521	-69

The water situation in 2012 was lessened, compared with flood in 2011, due to less rainfall. The rainfall peak occurred only in September but with better control on dam release, the peak runoff reduced significantly. Table 5 showed the input of water into the Chao Phraya River system during rainy season (May-October) in 2011 and 2012. It can be noticed that the rainfall in the rainy season (May to October) decreased by 14 % in the lower zone and decreased by 24 % in the upper zone while the dam total release and total runoff from the Yom and Wang River in the rainy season decreased by 63 % and 69 % respectively. The effect from dam control adjustment can be noticed from this information. The floods in 2012 happened only in specific area locally like in low land area, i.e. Bang Rakam, Phitsanulok, Ayuthaya, and in the cities, i.e. Sukhothai, Bangkok due to the high intensified rainfall within the area in September (318 mm in the upper and 333 mm in the lower zone). Rapid floods in Bangkok urban area caused by the limited drainage capacity compared with high intensified rainfall in the short period of time. Besides floods in the Ladkrabang Industrial Estate, Bangkok area happened due to the broken dyke also happened but with immediate counter actions.

Overall water situations in the year 2012 were under control due to less rainfall and better dam release control via the newly setup single command with better coordination and responses. The water information through the center called NWOC (website called Water4Thai) also gave better operation decision and communication to the publics. Flood fighting system also could provide necessary assistance to local authorities when needed.

7. Issues left

The construction works regarding the immediate/short term mitigation plan are implemented about 50 % in terms of budget spent due to many delay factors, i.e. budget approval process, bidding, contracting, site readiness etc. Further monitoring on the construction progress is still needed.

More communication for flood system planning of each agencies concerned is necessary for better coordination for improvement works and flood operation.

The process of participation in the stages of planning, operation, review among local and government, and within government agencies should be carefully taken into account for smooth project implementation especially for the long term planning.

At the moment, Thai Government decided to use the tendering approach using local/international consultant services for long term plan (concept, goals, approach, implementations). Many remarks in the selection process and implementation works are still questionable, e.g. design and build scheme, design and EIA process, contract administration process etc., that if any obstacles happened, this may cause implementation delay or project termination and needed further follow up of the progress.

8. Concluding remarks

Floods 2011 was due to high and long rainfall pattern, besides the coordination for flood fighting was also ineffective. To counter with flood issue, eight principles and implementation guides were drafted as a framework for planning of both immediate and long terms.

Short term plan was drafted and implemented to counter the flood volume like 2011 and comprised of eight work plans. The measures helped lessen the water load in 2012 from the upstream especially from the dam release and the measure of retention area utilization to lower the flood peak was also prepared as backup measures if necessary.

Thai Government decided to tender the long term plan for international bidding so that the implementation process can be done faster and gain international acceptance at the same time. Some concerned on long term planning, implementation, coordination within the implementation stages and agencies concerned and consultancy contract administration are still left as questions and need close monitoring on how the progress will be developed.

9. Acknowledgement

The authors would like to thank to the authorities involved in immediate/short term planning within the working committee that provide all valuable comments and document. During the manuscript preparation, data from authorities website and some power points were also kindly provided. Special thanks to Chulalongkorn University who support our research unit and the Thailand Research Fund who supports our financial research fund.

10. References

- BMA, Construction progress pictures of the Flood Protection Projects, 2012.
(DDS website: http://dds.bangkok.go.th/dds_now/index.php)
- Bo Zhang 2011. "Top 5 Most Expensive Natural Disasters in History," AccuWeather.com.
(<http://www.accuweather.com/en/weather-news/top-5-most-expensive-natural-d/474659>)
- Chulalongkorn, 2007. Flood 2006 Assessment Report, jointly with the Royal Irrigation Department, Bangkok: September . (in Thai).
- Chulalongkorn 2001. Flood 2011 Situation, Technical Report, Faculty of Engineering, November. (in Thai).
- Chulalongkorn 2013. Water Situation in 2012 compared with 2011, Technical Report, Faculty of Engineering, May (in Thai).
- DOH 2012. "Short term construction progress report."
(http://www.doh.go.th/project_uncon.aspx?c_id=23&sc_id=6322)
- EGAT 2012. Bhimipol and Sirikit Dam data, (<http://water.egat.co.th/waternew/>).
- GISTDA 2011. Flood area from satellite images.
([http://flood.gistda.or.th/tiled/radarsat2/y2011 & y2012/](http://flood.gistda.or.th/tiled/radarsat2/y2011&y2012/))

- Kanwarn Deesuwan 2012. Why floods in BMA, Faculty Talk Seminar, Faculty of Engineering, Chulalongkorn University, held on Oct 3, 2012 (in Thai).
- Lertviroj Kowatana 2012. Thailand Flood Management, PAWEES 2012, Thailand, Nov 27.
- Piyatida H. 2012. Water Situation in the Chao Phraya Basin in 2012, Faculty Talk Seminar, Faculty of Engineering, Chulalongkorn University, Oct 3. (in Thai).
- RID, Daily water report and short term construction progress report, (RID website).
(Now changed to ONWFMC instead).
- RID 2012. Rainfall, river and dam discharge and river water level.
(<http://water.rid.go.th/flood/flood/daily.pdf>)
- RID 2012. Dam release adjustment guideline, study report under working team, March. (in Thai).
- RID 2012. Proposed flood retention area, study report under working team, March. (in Thai).
- SCWRM 2012. Budget for Flood Remediation in the year 2012
(<http://www.waterforthai.go.th/managewater-13/>)
- SFCWRM 2012. Immediate Term Flood Mitigation Report, Jan. (in Thai).
- SFCWRM 2012. Long Term Strategy for Flood Prevention and Mitigation in Chao Phraya Basin, Jan 14,.
- Sucharit Koontanakulvong 2012. Lessons learned from Bangkok Floods 2011 and what's next ? , presented at the 10th Kyoto University Southeast Asia Forum 2012, Thailand, March 17.
- Sucharit Koontanakulvong 2012. Thailand Floods 2011 – Causes and Future Management System, Proc. SSMS2012, TAIWAN, MAY.
- Sucharit Koontanakulvong 2012. Thailand Floods 2011 – Causes and Long Term Measures - With CC Consideration, Presented at Workshop on Natural Disaster And Climate Change in ASIA, NOV 5-7, Equatorial Hotel, Bangi, Malaysia.
- Supot T. 2012, Thailand Water Resources Management and Single Command, ONWF, 2012.
- TMD 2012. Rainfall data. (<http://hydromet.tmd.go.th/Monitor/Forecast.aspx>)
- WFMC 2012. Progress Report on Floods Relief and Improvement Projects, November 9.
- WFMC 2012. Budget for Flood Remediation in the year 2012.
(<http://www.waterforthai.go.th/managewater-13/>) (reference for Table 3)
- World Bank 2011. “The World Bank Supports Thailand's Post-Floods Recovery Effect”, December 13. (Retrieved 25 January 2012).
(<http://www.worldbank.org/en/news/feature/2011/12/13/world-bank-supports-thailands-post-floods-recovery-effort>)
- (Remarks: This article was translated from my article published in Japanese version in the report no 22 on “Major Thailand Floods 2011”, published by IDE-JETRO, September 23, 2013)