

Appropriate Flood-Protection Measures under Rapid Urbanization

- Applicability of Japan's Comprehensive Flood Control Measures to Bangkok -

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Abstract: The comprehensive flood-control measures, which consist of structural measures and non-structural measures including on-site run-off retention systems, were evaluated to be highly workable for urgent flood-protection under rapid urbanization during high economic growth in 1960s-70s in Japan. Out of various non-structural measures, on-site rainwater retardation systems based on developer-pay-principle were most effective when tax-generation and governance were particularly weak.

This paper aims to verify the applicability of the above-mentioned measures to the rapidly urbanized river basins in Asian countries. Based on such notion, Japan International Cooperation Agency (JICA) laid a flood-protection master plan in early 1980s to answer for the request from Bangkok Metropolitan Administration (BMA).

Herein the authors have made a survey to know how BMA translated the master plan into action so far taking socio-economic and political conditions into due consideration. Plus the authors have tried to discuss with graduate students of Asian Institute of Technology (AIT) to know the applicability of the comprehensive flood-control measures to Asian countries.

Keywords: Comprehensive Flood-control Measures, Structural Measures, Non-structural Measures, Rapidly Urbanized River Basin, Weak Governance, Developer-Pay-Principle

1. Introduction

Rapid urbanization is under way in Asia in line with high economic growth. **Fig. 1** shows on-going urbanization process in Bangkok since 1980s. Various problems including frequent floods were caused due to the lack of proper governance on infrastructure making.

In early 1980s, BMA requested Japan International Cooperation Agency (JICA) for laying flood-protection master plan. The proposal was made based on the comprehensive

2. Development of Measures in 2-1 Flood-Protection

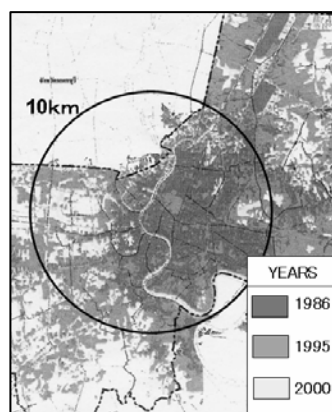


Fig.-1 Urbanization in Bangkok

flood-control measures which had been workable on rapidly urbanized river basins in Japan. In this scheme, the private sector or developers should take responsibilities for on-site rainwater retarding systems to make-up for the insufficient flood-protection works done by public sectors.

Fig. 2 shows one of such storage ponds introduced in down town of Tokyo, where the developer-pay-principle was stipulated by municipal regulations. During recent two decades, BMA has assimilated the Japan's previous way of basin management. Thus this paper shows how BMA has done it and why BMA could do it for the reference to other Asian countries.



Fig.-2 Typical On-site Rainwater Storage Pond in Tokyo

Flood-Protection Measures proposed by JICA in 1980s

As Fig. 3 suggests, cut-and-bank methods had been commonly utilized for land reclamation in Bangkok until 1970s. There had been little flood damages during rainy seasons, because the canals created through such land reclamation process had had enough capacity for rainwater retardation. Traditional lifestyle of Thai people had been supported by by-boat transportation systems and stable, when they had had heavy rain.

However, the situation was completely changed, when mechanical carry-in-and-bank methods were introduced at the early stage of rapid urbanization beginning in 1980s. Rainwater retarding function of the low-lying flood plain disappeared in line with progress of such way of the land reclamation.

Thus reduced rainwater retarding function resulted in flood damages to accompany heavy traffic jam due to on-going motorization as shown in Fig. 4.

Fig. 5 shows composition of total flood-protection measures in Bangkok, which was originally planned in 1980s, and has been assimilated to the socio-economic and political conditions in years to come.

In principle, BMA should take responsibilities for structural measures such as construction of dykes, water gates and pumping stations in principle. However, it was found that adopting standardized structural measures cost 30 million baht (100 million yen) per 1 km² in the inner city area. Plus, it became difficult to purchase the land required to install water gates and/or pumping stations in densely populated city areas. Without any particular supplemental schemes, BMA should be caught in a vicious cycle: occurrence of floods → shortages of financial resources → lack of drainage capacity → more frequent occurrence of floods.

In 1980s, JICA proposed

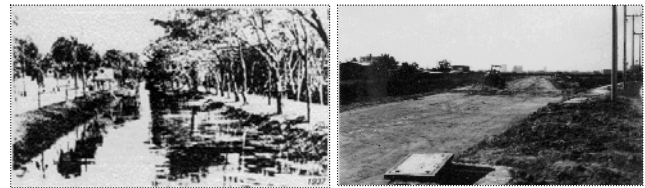


Fig. 3 Change of Land Reclamation Methods

Left: traditional cut-and-bank method with rainwater retention function

Right: newly introduced carry-in-and-bank method

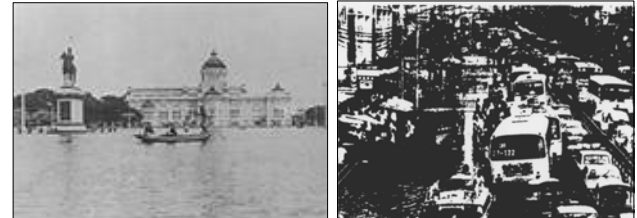


Fig. 4 Change of Flood Aspect from 1940s to 1980s

Left: ever-strict flood causing few disturbances in the city

Right: newly-born flood causing heavy traffic jam

cost-cutting schemes for flood-protection in newly urbanized middle areas in Bangkok based on the notion of Japan's comprehensive flood-control measures in rapidly urbanized river basins. The schemes mainly consisted of (1) rainwater retarding pond to reduce floodwater run-off and (2) greenbelt to contain rapid urbanization where any development projects would not be allowed.

In another word, the schemes aimed at introducing public-private partnership to shift part of the burden from BMA to developers which should cause the roots of floods. And the most interesting was whether BMA would be successful or not in making consensus with business-first mind developers.

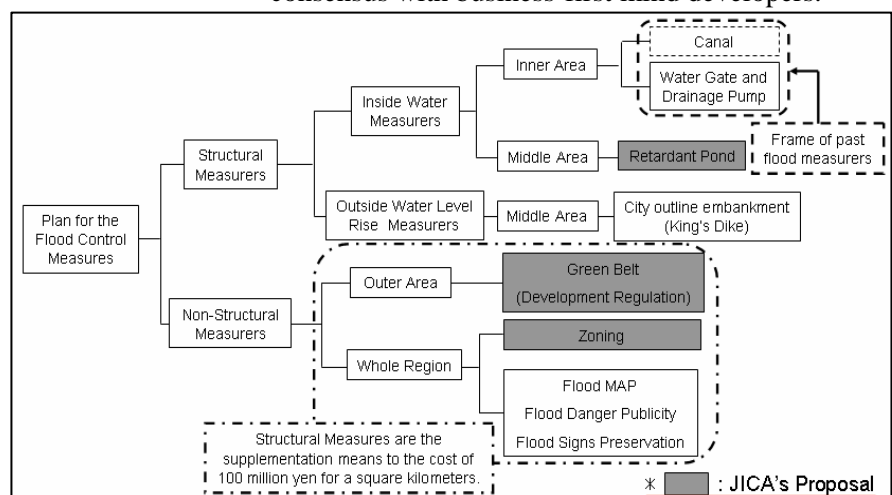


Fig. 5 Composition of Total Flood-Protection Measures in Bangkok

2-2 Flood-protection Measures implemented by BMA

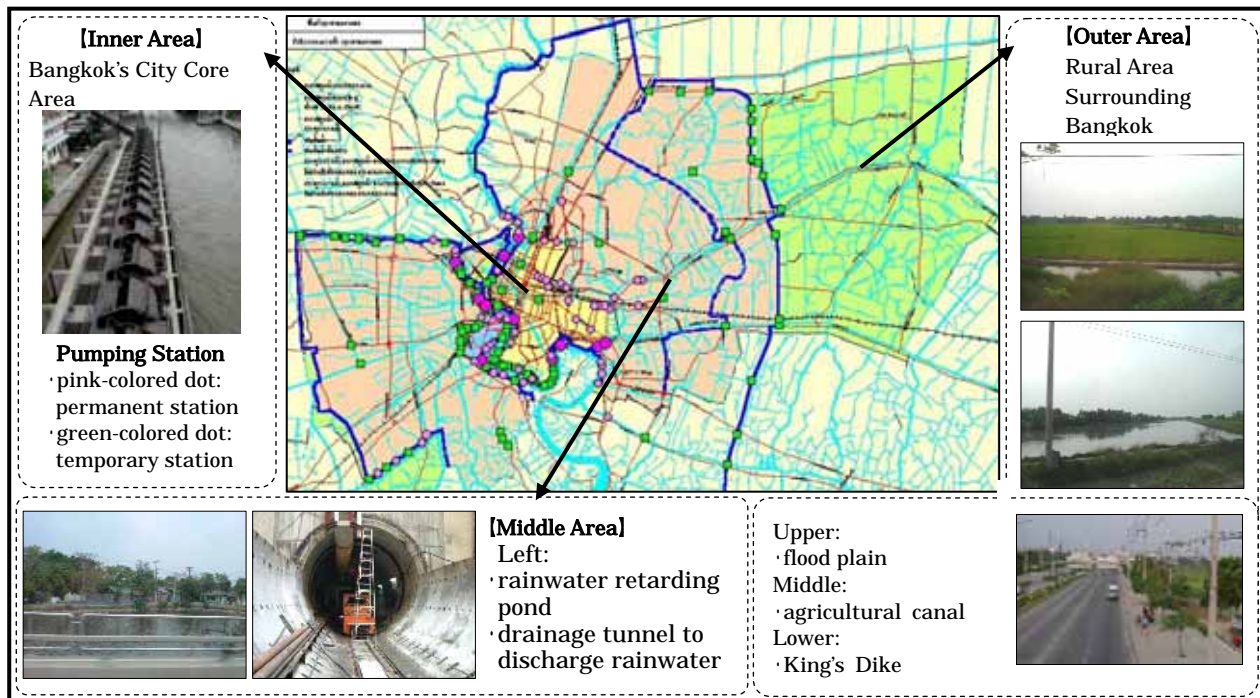


Fig. 6 Map on Major Flood-Protection Measures Implemented by BMA (2000s)

Fig.-6 shows map on flood-protection measures based on the zoning concept in Bangkok in 2000s.

Inner City Area:

Rainwater retarding function was well maintained, because cut-and-bank method had been applied previously to land reclamation in this city's old core area.

BMA has so far completed construction of water gates and pumping stations along the River Chao-phraya (hereinafter called the river) to meet the design criteria based on 5-year frequency rainfall intensity.

Middle City Area:

In this newly urbanized area, carry-in-and-bank method was applied for land reclamation. Therefore the due loss of previous retarding function in low-lying alluvial plain caused flood damages during rainy seasons.

However, it seemed unfeasible for BMA to expand the structural measures standardized in the inner city area to the middle area, because construction of new canals from here to the river should be urgent but very costly.

Taking such condition into consideration, JICA proposed rainwater retarding pond systems to reduce floodwater outflow into the river to reduce the total cost.

2-3 Significance of Japan's Comprehensive Flood-Control Measures in Asian Countries

Capacity of the proposed rainwater retardation ponds was estimated at 2 million m³, or 25 mm, if expressed in rainfall depth. BMA has constructed 1-million-m³ retardation ponds so far, supposedly because of the difficulty of land acquisition.

To make-up for the insufficiency, the administration has implemented construction of underground tunnel to discharge excess floodwater out to the river.

Outer Area:

This area was called 'Green Belt' in the 1980s master plan: complete ban on new building was desired initially.

However, BMA has been facing strong opposition from land owners in this area. As a result, BMA has decided to introduce 'a carrot-and-stick' policy in 1990s.

New building should be allowed with condition of installing on-site rainwater storage ponds to reduce floodwater run-off to 60% under the developer-pay-principle.

In addition, BMA has constructed the King's Dike enclosing Bangkok city areas in order to prevent floodwater inflow from outer area into middle city area. Plus BMA will construct new diversion channel to discharge floodwater to the Thai Gulf directly.

The proposal by JICA based on comprehensive flood-control measures, combined with structural

measures and non-structural measures, has added workability plus elasticity to the flood-protection operations of BMA during two decades.

In particular, it is clarified that the total cost which public sector should be used to pay for structural measures has become reduced.

The following examples are verified and indicated in evidence:

- (1) standardization of structural measures in the inner city area or old core city where retarding function had been maintained due to previous cut-and-bank type land reclamation
- (2) construction of underground tunnel to cover the insufficiency of rainwater retarding ponds in the middle area where retarding function has been lost due to recent carry-in-and-bank type land reclamation
- (3) introduction of the developer-pay-principle for on-site rainwater storage ponds in the outer city area where complete ban on new buildings has been desired

These evidences suggest that Japan's comprehensive flood-control measures could be applicable to other Asian countries where rapid urbanization is commonly under way.

3. Efficiency of Japan's Technological Experience to Asian Countries through Discussion at AIT

3-1 Method

Nine graduate students of AIT from 6 countries joined in the discussion after the authors called for participation.

And the procedure of the international discussion was as follows:

- (1) Pre-presentation questionnaire on their ideas about flood-protection under rapid urbanization
- (2) Presentation on Japan's comprehensive flood-control measures by the authors
- (3) Presentation on how BMA has translated the flood-protection master plan proposed by JICA into workable action during recent two decades
- (4) Post-presentation questionnaire on their new ideas about applicability of Japan's comprehensive flood-control measures to rapidly urbanized cities in each countries

Table 1 shows contents of the two questionnaire types: the answering forms to these two questionnaire types are as follows:

- (1) Pre-presentation questionnaire:
Herein, description-style form was applied to stimulate free discussion.
- (2) Post-presentation questionnaire
Herein, selection-style form was applied to expect more concentrated discussion.

Table 1 Questioning Items and Answering Form for Pre-Presentation/Post-Presentation Questionnaire

	Questioning Items	Pre-Presentation	Post-Presentation
Q1	If you were a director of the department in charge of flood-protection projects in your country, will you introduce the Japan's comprehensive flood protection measures?	A: Free answer B: I don't know	a: will introduce b: will not introduce c: will introduce conditionally d: No idea
Q2	Can you figure out any measures to properly manage rapid urbanization in your country?	A: Free answer B: I don't know	a: Zoning such as green belt b: Regulation to stop discordant development c: Planning of self-sustaining satellite cities d: Other idea
Q3	What do you think are rainwater storage and infiltration facilities available for?	A: Free answer B: I don't know	a: Available for reducing rainwater run-off b: Available for recharging of ground water c: Available for increase of drinking water d: Other idea
Q4	Which way do you think is more applicable to your country to improve weak governance on infrastructure making under rapid urbanization?	A: Free answer B: I don't know	a: Up-grading of present taxation system b: Up-grading of institutional organization c: Introduction of urbanization restrain policy d: Other idea

3-2 Analysis of the Answers obtained at AIT

3-2-1 Overall Analysis

Answers to Pre-Presentation Questionnaire:

In Q1 and Q2, most of graduate students selected A to describe their ideas on flood-protection and urbanization-control measures.

On the contrary, in Q3 and Q4, a good few of them selected B saying they have no idea on rainwater storage/infiltration systems and proper management of rapid urbanization.

Answers to Post-Presentation Questionnaires

In Q1, all students showed positive response to Japan's comprehensive flood-control measures. In Q2, most of them selected (a) zoning and (c) satellite cities.

In Q3, all of them selected (a) reducing rainwater run-off control and (b) recharging ground water. In Q4, most of them selected (b) up-grading of institutional organization.



Fig. 7 Discussion at AIT

3-2-2 Individual Analysis

(1) Q1 on applicability of Japan's comprehensive

Table 2 Total Number of the Answers for Pre-Presentation/Post-Presentation Questionnaire

	Pre-Presentation		Post-Presentation			
	A	B	a	b	c	d
Q1	9	0	7	0	2	0
Q2	8	1	4	1	4	0
Q3	3	6	6	3	0	0
Q4	4	5	1	7	1	0

flood-control measures to each country

Answers to Pre-Presentation Questionnaire:

The answers varied from typical flood-control measures such as construction of drainage channels and dams to installation of infiltration/storage systems and planting of the forest.

Answers to Post-Presentation Questionnaire:

One graduate student had a doubt over financial aspects due to introduction of Japan's system. According to him, Japan's way of flood-control measures in Japan cost expensive to both of public and private sectors: therefore public sectors result in paying more in Bangkok. It is also true in wastewater treatment to which people pay nothing and public sectors pay all in Bangkok.

However, we could deepen mutual understanding through tense discussions on the availability of developer-pay-principle to solve financial shortages in public sectors in principle.

(2) Q2 on proper urbanization control measures in each country

Answers to Pre-Presentation Questionnaire:

The answers varied from construction of satellite cities to introduction of population restraint policy and taxation systems on new buildings.

Answers to Post-Presentation Questionnaire:

Most of them supported introduction of zoning and ideas of satellite cities.

They showed not so strong interest to regulating discordant development: some of them were rather hesitant toward such regulating.

Although the authors explained zoning and satellite cities were not so effective in Japan, why they answered as mentioned-above was not clear. They might have their own confidence in managing rapid urbanization the other way. We must have another discussion to know of their detailed reason and background.

(3) Q3 on availability of rainwater storage/infiltration facilities in each country

Answers to Pre-Presentation Questionnaire:

Most of the graduate students probably have had not enough knowledge on these facilities.

Answers to Post-Presentation Questionnaire:

The ideas on availability rainwater storage/infiltration facilities varied in accordance with climate condition, dry or wet, of each country. Annual amount of rainfall of each country is shown in **Table 3** for your reference.

**Table 3 Nationality of the Participants
And Rainfall of each Countries**

Countries	number of students	Rainfall [mm/year]
Sri Lanka	1	1,313
Vietnam	2	1,704
Japan	2	1,720
Bangladesh	1	2,144
Uzbekistan	1	424
Myanmar	1	2,262
Thailand	1	1,420
Total	9	-

Five out of seven graduate students considered these facilities to be available for rainwater run-off reduction. They came from a monsoonal wet region. On the contrary, remaining two students, including Thai ones indicated that these facilities were available for ground water recharging. They came from a relatively rainless region or wet-and-dry region.

Since Japan is included in the monsoonal wet region, flood-control is the biggest concern of the nation. As mentioned formerly, we have had to develop non-structural measures including on-site rainwater storage ponds to reduce floodwater run-off.

With regard to the answer from Thai student, his concern was rather on the excessive ground water up-take due to rapid industrialization and urban development. Land subsidence has been continued as such water use mode has become common in Bangkok since 1980s.

His particular concern on this problem was probably connected to the idea of utilizing rainwater for ground water recharging in this discussion. (In Japan, in-factory recycling of treated wastewater had been effective to reduce ground water up-take and control due land subsidence.)

(4) Q4 on applicable way to improve weak governance on infrastructure-making in each country

Answers to Pre-Presentation Questionnaire:

The authors realized that we could have common understanding that discordant development should be regulated to reduce financial burden imposed to public sectors through intense discussions.

3.3 Summary of the Discussion with Graduate Students of AIT

Although discussion hours were very short, mutual understanding could be reached on the necessity on proper management systems of rapid urbanization and flood-protection measures.

It was verified that information was very effective for mutual understanding on how Japan's comprehensive flood-control measures could be workable in rapidly urbanized river basins like Bangkok.

The authors realized deeper discussion was desired in the future in every country in Asia to prevent discordant development and enhance long-standing prosperity on the basis of public-private-partner ship.

4. Conclusion

In this paper, the effect of technological cooperation was clarified in the field of flood-protection in Bangkok.

In addition, the importance of non-structural measures supported by due cooperation between public sectors and private sectors was recognized.

Many years have passed, since the cooperation between Japan and Thailand was commenced in 1980s and BMA have assimilated and translated the proposal into action.

We may not have enough time to have effective solutions in Asian cities under very rapid urbanization.

The authors strongly hope that this paper would be helpful to the well-balanced and sustainable development in Asian countries.

Acknowledgment:

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