Proposal for enhancing flood retarding capacity in the Chao Phraya Delta

Naritaka Kubo and Chikayo Hotta[1]

Abstract: *Floating rice areas spreading north of Ayutthaya have been playing important roles for downstream areas of the Chao Phraya River until now. During the rainy season, they received flooding water to decrease the flow rate of the Chao Phraya River, which mitigated flood damage against Bangkok metropolitan area. During the dry season, they released stored water, which irrigated vast downstream paddy field areas. However, nowadays the area used for high yield rice's cultivation is rapidly increasing instead of the floating rice area. As the results, in these areas, an excessive water that was not recognized as a flood when people grew floating rice became considered as a flood. Moreover, because of the increase of vehicles and road networks, flood mitigation becomes more and more important even in rural areas. Considering these situations, we proposed following several development projects, which may be beneficial to floating rice areas and also may contribute to the downstream rural and urban areas. (1) Constructing regulating reservoirs for rice cultivation during the rainy season. (2) Raising roads and residential sites to avoid submergence. (3) Releasing water to increase retarding capacity during rainy season. Concerning to these projects, we examined their effectiveness for the water resource's development and for the flood mitigation.*

1 Introduction

More than thirty years has passed since two big reservoirs (the Phumiphol dam and the Sirikit dam) were constructed in two major tributaries of the Chao Phraya River. They have greatly contributed to the Thai society in the fields of irrigation, municipal water supply, power generation, and flood control. Recently, however, water shortage becomes tangible in several areas because of rapid economic development, increase of irrigated area, and the change of hydrological conditions in the upper regions. As two reservoirs have vast downstream areas often hit by heavy rainfalls, two reservoirs cannot control floods perfectly. Moreover, flood damages become more and more serious than ever before, because the Bangkok outskirts' areas have been urbanized and industrialized.

Vast paddy field areas over the Chao Phraya Delta have high productivity, and play an important role to mitigate floods by storing rainfall water and releasing it slowly. Especially,

[1] Dept. of Environmental & Agricultural Engineering, Faculty of Agriculture, Tokyo University of Agriculture & Technology

floating/deep water rice can tolerate deep water, and paddy field for which shows high retarding capacity. The released water after floods can be also used to irrigate downstream areas during the dry season. However, this retarding capacity is now decreasing gradually due to the spread of high yield varieties and the urbanization. The high yield varieties are replacing the floating rice, and require proper water management. It means that excessive water must be drained directly to the outside canals or rivers, which leads to water shortage during the dry season.

After the big flood in 1995, the King Phumipol proposed the "Monkey Cheek Project", where a part of flooded water should be stored temporarily in numerous small reservoirs or ponds to cut down the peak discharge. With accordance to this idea, we will propose "Enhancing Retarding Capacity Project". In this project we will show the way to strengthen the retarding and reserving water functions inherent to the floating rice paddy fields, without constructing huge dams or release canals that are commonly used to prevent floods.

2 Flood retarding function of paddy fields in old delta

Agricultures, in the Southeast Asian countries, have developed since old times adapting themselves to surrounding water environments. It means that crop varieties and the timing for seeding or harvesting are subject to the environment. It is also quite different from the concept of the large-scale land improvement project, in which environment is tried to change suitable to modern agriculture. As water environment became controllable to some extent by such projects, many farmers in the Chao Phraya Delta are replacing the floating rice to the high yield varieties. As the result, the area of floating rice reduced half during this decade.

TABLE 1 CHANGE OF FLOATING RICE AREAS IN THE DELTA

Year	1976	1986	1995	1996
Area (1000ha)	180	228	173	114

The floating rice can grow following the ponding depth, and becomes sometimes more than several meters. Paddy field area of the floating rice is usually surrounded by high dikes, which are usually used as roads. It can store a considerable amount of water, and this function is called "retarding function" of the floating rice area. Assuming that the average ponding depth is 2 meters, we can estimate that about 2.28 billions m^3 of retarding capacity was lost during this decade. In other words, if the high yield varieties take the place of the floating rice and its allowable depth is 30 cm, 1.9 billions m^3 of water is released without being reused during the rainy season. This may be one of the reasons why drought becomes serious in recent years.

Floating rice cultivation is as follows. Paddy soil is plowed during April and May. Seeding follows the plowing after half month. At that time, paddy field is not flooded but the soil is a little bit softened. Because the yield is subject to the amount of seed, 20 to 30 kg of seeds are sowed per rai. Ponding begins at the end of August or at the beginning of September, when flooded water flows into the floating rice area. According to the increase of water depth after September, the rice crop also grows rapidly becoming 2 to 3 meters long. Farmers cannot do anything while the deep water, because the fertilizer application and weeding have no meanings. Harvest time is around December when all water flows out, and only ears of lying rice plants are reaped with a sickle. The yield is about 2 kg/ha, which is one third of that of the high yield variety.

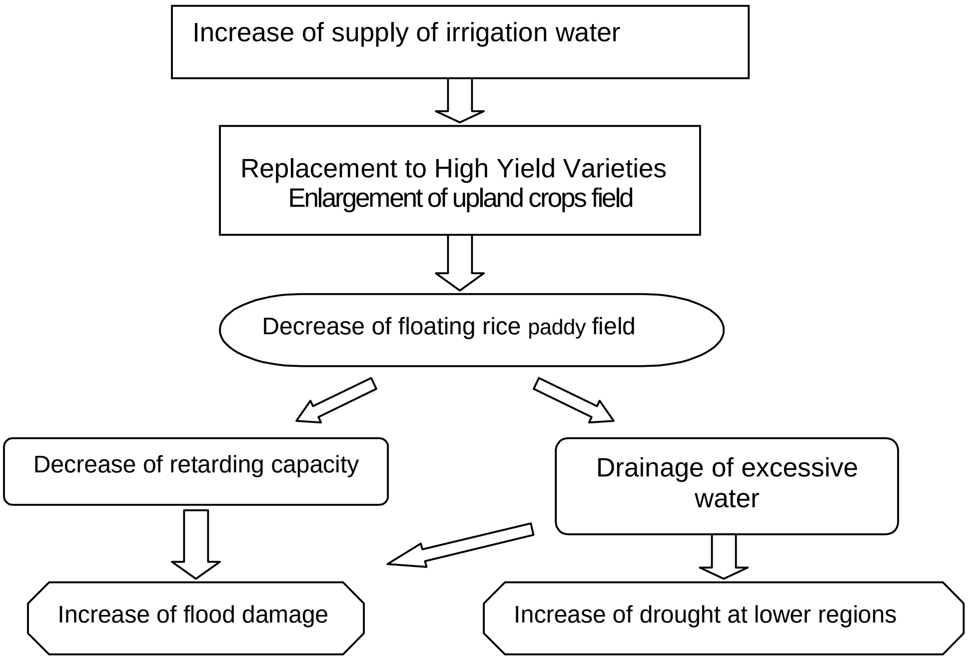

FIG. 1 PROCESS OF PROBLEMS CAUSED BY DECREASE OF FLOATING RICE AREAS

Paddy field cultivation in the old Delta and its hydrological conditions are as follows. The Great Chao Phraya project aimed at a major water resources' development to supply irrigation water during rainy season, and both irrigation and drainage channels were arranged at that time. This project also enabled farmers to grow paddy crops during the dry season. Many farmers came to grow the high yield varieties, and the high yield varieties are now planted around 66% of the total area in the old Delta. On the other hand, the floating rice and the deep water rice are naturally driven away in the changing environment, and their planted area is decreasing rapidly.

TABLE 2 PROJECTION OF AREA AND SHARE OF RICE VARIETIES IN THE OLD DELTA

Land Use	Annual Growth (%)	Present (1998)		Future (2005)		Future (2018)	
		Area (km^2)	Share (%)	Area (km^2)	Share (%)	Area (km^2)	Share (%)
Rice	-0.4	9,133	100.0	8,684	100.0	8,336	100.0
1) HYV	0.3	6,038	66.1	6,183	71.2	6,703	80.4
2) General	0.0	0	0.0	0	0.0	0	0.0
3) Deep Water	-3.0	2,539	27.8	2,051	23.6	1,339	16.1
4) Floating	-3.0	556	6.1	449	5.2	293	3.5

TABLE 3 COMPARISON BETWEEN LOCAL VARIETIES AND HIGH YIELD VARIETIES

	Local varieties	High yield varieties
Yield	Deep water rice:300-400 kg/rai Floating rice:200-300 kg/rai	About 600kg/rai
Water supply	Rain fed, gravity irrigation	Irrigation
Growing season	Deep water rice: 7,8-12 Floating rice: 5,6-12,1	6-11(rainy season) 12-5(dry season)
Fertilizer, chemicals, Herbicide	No need	Need large quantities
Growing speed	Fast	Slow
Photosensitivity	Sensitive	No-sensitive
Stem length	Deep water rice: 1,2m Floating rice: 2,3m	40,50cm

3 Enhancing retarding capacity project

We propose our project under following three assumptions. The first assumption is that they will not construct a large-scale release canal in future, which washes flood away directly to the sea, because it may cause a severe water shortage during the dry season. We also assume that a large part of flooded water must be stored within the Delta at the end of the rainy season consequently. The second assumption is that high yield varieties will replace floating rice in almost all areas, and that the floating rice cultivation will continue in a very limited area. Table 2 shows the projection of the rice cultivation areas in future. We can see that the area of the floating rice will reduce rapidly, and its share will be only 3.5% of the total paddy field area after 18 years. The reasons may be that the yield of the floating rice is low and agricultural mechanization is difficult for the floating rice cultivation. The third assumption is that the living standard will be improved more in future and the importance of protecting houses, buildings and roads from floods will increase remarkably. Namely, rural living styles are urbanized, and the submergence of houses and roads is recognized as a disaster. People are requiring counter measures to prevent damages by a flood having the same scale with that in 1995. Above three assumptions seem to be realistic at least in future in many areas in the Delta.

We expect following four effects by this project. The first effect is that farmers can mechanize their farming, and that they can grow high yield varieties three times in two years through drainage improvement and acquirement of irrigation water. The second effect is that houses and roads are free from floods, and floods do not disturb daily lives of people. Floods are not avoidable, but damages by floods are expected to be avoidable. The third effect is that damages against downstream urban areas of the Chao Phraya River, especially Bangkok metropolitan area, are mitigated in the flood season. The fourth effect is that much irrigation water is supplied to the downstream agricultural areas in the dry season.

Above four effects of our project may look too admirable. Our project, however, is not such that as produces something from nothing, but it merely changes water distribution temporally and spatially. You can see that this project is feasible by checking the annual water budget in the Delta, which will be shown later. Advantage of this project, we expect, is that results come out in accordance with the rate of the project achievement. In such a project as construction of a dam, the result comes out when the project is fully accomplished.

The outline of this project is as follows. This project consists of two parts. One is concerned in construction, and another is in the practice. First, the construction part is explained.

Surrounding dike and dividing dike: A former floating rice area, which is a unit of the retarding area, is divided into two parts with same conditions by a surrounding dike and a dividing dike. As dikes are also sites for houses and roads, they must be raised and not to be inundated against a big flood. From the worst record of the past floods, the height of dikes is decided.

Regulating reservoir: Several regulating reservoirs are constructed within the former floating rice area. Several swamps may exist in the area. In such a case, sites for ponds may be acquired from such swamps. The regulating reservoir should be big enough to store water for the paddy rice in the rainy season, and to provide soil material for the dike construction.

Channel networks: Irrigation and drainage channels are also arranged properly.

Pumping station: Pumping station is constructed to lift water in the regulating reservoir for the irrigation or for the drainage.

Water gates: Several gates are constructed to regulate the inflow from outside, the outflow from inside, and the water exchange between two parts divided by dividing dike.

Next, the practice is explained.

(1). The unit consists of two blocks, i.e., A block and B block, and two blocks exchange their roles each other every year. The paddy rice is grown three times in two years. When the A block is used for the rice cultivation twice (rainy and dry) in a year, the B block is used only one time (rainy), and vice versa.

(2). When the A block is used for the dry season paddy rice (from December to March), the B block reserves flood water and supply irrigation water to the A block.

(3). In the B block the rainy season cultivation (from April to September) begins when remaining water is fully drained before the end of February. On the other hand, in the A block the rainy season cultivation (from May to August) also begins after harvesting the dry season crops. Irrigation water for the both blocks is supplied from regulating reservoirs, rainfall, and drained water from the upper regions.

(4). During the flood season, flooded water is stored in both blocks. However, if a flood comes earlier and the harvesting is not completed in the A block, the B block exclusively stores flooded water.

(5). At the end of the flood season, the B block is drained actively and the dry season cultivation begins in December.

The above cultivation cycle is applied to an average-sized flood. However, if a small-sized or large-sized flood comes, the practice may be modified as follows.

In case of the small-sized flood, the B block reserves a small amount of water and cropping area in the A block is reduced. In case of the large-sized flood, the A block is flooded for longer time. As the result, the dry season cultivation delays in the A block and no crops can be grown in the rainy season. If next flood comes earlier, the A block guards the B block where rainy season rice is grown.

4 Feasibility of the project

The above project will not work effectively if it is practiced only in one project, because a flood occurs in a large area. Not a small number of this kind of projects can multiply their individual effects. However, if the project is applied for many areas, it will lose concreteness and may become very abstractive because each area has its own properties. Therefore, we choose one floating rice area for which this project is considered most suitable, and examine the feasibility of this project.

Table 4 shows deep water and floating rice cultivation areas, and Figures 3 and 4 show flooded areas and floating rice areas, respectively. We can find several overlapping areas from above two figures. They are Ayuttaya, Ang Thong, Lop Buri, and etc. Among them, we select Lop Buri area as the site for the pilot project.

The proposed site is a floating rice area of about 3,000 ha located northwest of Lop Buri city and surrounded by Lop Buri River and Chai Nat-Pasak Canal. North of this area, there are three irrigation districts irrigated by three secondary canals of Chai Nat-Pasak Canal. They are CPK16, 17, and 18, and about 7 mm/day of water is supplied to their command districts in the rainy season. Table 5 shows commanded areas and supplied flows by three canals.

TABLE 4 CULTIVATED AREAS OF DEEP WATER RICE AND FLOATING RICE (1992/1993)

Provinces	Cultivated Area(ha)		Total
	WD<100cm	WD>100cm	
Ayutthaya	33,328	64,123	97,451
Nakorn Sawan	59,527	11,593	71,120
Phichit	52,136	13,859	65,995
Nakorn Nayok	17,686	25,875	43,561
Ang Thong	12,326	29,037	41,363
Lop Buri	12,793	21,325	34,118
Phitsanulok	21,049	8,598	29,647
Prachin Buri	5,796	16,243	22,039

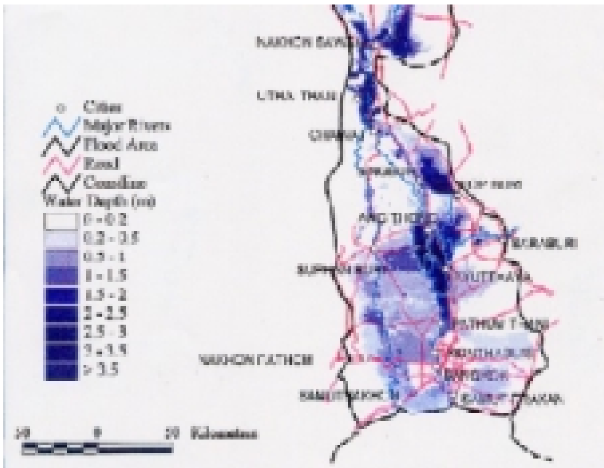

FIG. 2 INUNDATION MAP OF FLOOD IN1995

FIG. 3 DEEP WATER/FLOATING RICE CULTIVATION IN 1989

TABLE 5 AREAS AND FLOWS OF THREE SECONDARY CANALS

Secondary canal	Area (ha)	Flow (m^3/s) in rainy season
CPK 16R	10,920	8.873
CPK 17R	2,440	1.983
CPK 18R	6,740	5.551

Figure 4 shows precipitation data for average, flood, and drought years. The average year's precipitation is calculated by averaging precipitation data of 11 years, i.e., '80-'87, '89, '90, and '93. The flood and drought years are 1983 and 1993, respectively.

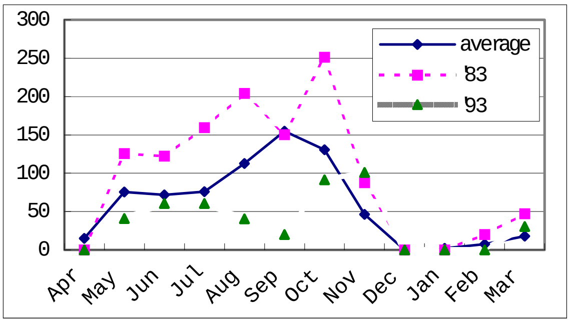

FIG.4 PRECIPITATION AT LOPBURI (MM/MONTH)

In this report, we show only a rough estimate of soil and water budgets when this project is practiced. Detailed simulations of soil and water budgets are now being calculated, but their results are not yet matured to report. As for the soil budget, 15,000,000 m^3 volume of soil is produced if regulating reservoirs are constructed, of which the area is 300 ha and the depth is 5 m. The area of 300 ha is 10 percent of the project area. When this volume of soil is used for the dike construction, the length of the dike becomes 150 km if the cross sectional area of the dike is 100 m^2 (5 m*20 m). As the total length of the surrounding dike and dividing dike is about 50km, the remaining soil may be used to raise the ground level of houses and buildings. From the viewpoint of the soil budget, the volume of 15,000,000 m^3 is large enough to enforce the dikes.

As for the water budget, we estimate the water requirement for the dry and rainy seasons. In the dry season, only the A block is used for cropping and the B block supplies irrigation water. If the total water requirement is 2,000 mm in the A block, the B block can supply water if its ponding depth is more than 2m. The depth of 2m is not so deep because floating rice areas are usually inundated by 2 to 3 m depth. Therefore, irrigation water will be fully supplied in the dry season.

During the rainy season both blocks must be irrigated. The irrigation water is available from regulating reservoirs, rainfall, and unused and drained water coming from northern areas irrigated by Chai Nat-Pasak canal. The regulating reservoirs can supply about 15,000,000 m^3 of water because reservoirs are not used during the dry season. The rainfall also supply about 7,000,000 m^3, because the total rainfall from April to September is about 240 mm from Fig.4 and the catchment area is 3,000 ha. The unused and drained water from the irrigated area having 20,000 ha is estimated about 12,000,000 m^3. This amount of water is derived from irrigation water plus rainfall minus evapotranspiration. As the Chai Nat-Pasak canal supplies irrigation water about 7mm/day during June and July, the total supplied water is 84,000,000 m^3. The total rainfall from April to July is estimated about 48,000,000 m^3, and the evapotranspiration during the same period is 120,000,000 m^3 if the daily evapotranspiration is 5 mm/day. As the result, the total available water is about 34,000,000 m^3. If the total water requirement during the rainy season is 1,550 mm, about 2,200 ha, i.e., 70 percent of the project area, can be irrigated.

Above examination of soil and water budgets indicates that this project is feasible if small amount of supplemental water is supplied from the Chai Nat-Pasak canal. However, we cannot conclude whether this project is economically feasible or not because we did not calculate the BC ratio of this project. It may not be so difficult to calculate the costs for land purchase, for construction of dikes, regulating reservoirs and pumping stations, and for pump operation. However, it will be very difficult to estimate the benefits of flood mitigation in downstream areas or no inundation of the project site.

5 Conclusion

The rice cultivation and water management in the Delta are now changing rapidly requiring an adequate water resource's distribution and suitable land use. At the same time, life styles in rural areas are also changed, and came to show discrepancy with the hydrological environment. In the proposed project, considering the hydrological properties in the Delta, we sought the way people and agriculture in the Delta can adapt themselves to the new water environment. Through the examination of this time, we could get the conclusion that the project is physically feasible, but there remain many problems to be solved and examined until its realization. We are now making more detailed analysis by use of hydrological simulations.