Flood mitigation and the '*monkey cheek*' policy in Thailand: does it hold water?

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1 Introduction

The Chao Phraya basin has witnessed dramatic changes in its rice cultivation patterns, from rainfed or floating rice varieties to instances of triple-cropping of High Yield Varieties (HYV) (Hanks, 1972; Takaya, 1987; Kasetsart University and ORSTOM, 1996). Generally speaking, the modes of rice cultivation are shaped by the type of soil, topography, the exposure to flooding, the presence of irrigation canals, drains, dykes, pumping stations and other infrastructures, the availability of water, farming technology, etc. One particular agro-ecosystem is that of flood plains where deep-water and floating rice varieties, with specific cycle duration, straw length and elongation capacity, have been attuned to local conditions. In the late 1980s, around 500,000 ha of so-called 'traditional' deep-water rice varieties were cultivated in the Chao Phraya delta (Puckridge et al., 2000), an area that had dropped to around 300,000 ha 10 years later (Molle et al., 1999) and is, in present days, residual. Farmers have always endeavored to intensify cultivation, that is, to derive a growing production and income from a given plot of land, a feature of agriculture in general and deltas in particular (Catling, 1992; Molle and The Tuan, 2005).

But flood plains, as their name indicates, are flood-prone low-lying areas where water control is uneasy and which have a key buffer role in times of flood. The 1995, 2002, 2006 and finally 2011 floods forced the realization that the buffer capacity in the basin/delta had been severely reduced by diking/poldering, road construction, encroachment on wetland, and urbanization (Roachanakanan, 2013; Mehl and Mekvichai, 2017). After the 1995 flood, the King Rama IX famously emphasized that this buffer capacity should be maintained and managed, a policy that came to be known as the "monkey cheek" (*kaem ling*) policy, after the image used by His Majesty:[1]

> *Monkeys store chewed up food it in their cheeks. Likewise, when there is a flood, if we do not go forward with the Monkey Cheek Project, the effect would be tremendous. This year the central region of Thailand got destroyed by flooding. We need to carry out the Monkey Cheek project to hold the flood water and prevent future flood damage.*

King Bhumibol Adulyadej stated in 2003 that *"Monkey Cheek reservoirs are needed in order to retain water when the sea water rises and water excess cannot be drained. During the flooding season between September and November, the seawater will push water in rivers until it reaches Ayutthaya province, which will make it impossible to drain excessive rain water into the sea. As a result, the areas along the Chao Phraya river in the lower Central Plains will remain flooded. Therefore, we need Monkey Cheek reservoirs to receive excessive water during the flooding season*" (Suppaisarn, 2011). Urbanization is the main cause that leads to decreasing flood retention areas, which can lead to rising flood damages.

[1] http://www.satapornbooks.co.th/imgadmins/product_pdf/20170515_SardPraracha_kamLing.pdf

Early application of the idea in the upper central plain was limited to the dredging of some low-lying areas turned into reservoirs but this faced opposition from locals who were expropriated (Trakuldit, 2018) and the volumes stored remained extremely limited, with a negligible impact on flooding. Conspicuous among these reservoirs is the 'Thale Luang' reservoir near Sukhothai (Figure 1).

Figure 1. Thung Thap Nai2 (Nakhon Si Tammarat); Thale Luang (Sukhothai); Bueng Ram, Bueng Takrong (Phitsanulok) (from left to right and top to down)

A first model developed in 2011 and dubbed the Bang Rakam Model 54[3] consisted in the building of three reservoirs in Bang Rakam sub-district: These three ponds are located outside the irrigation scheme area and are supposed to store 32 million m^3 (Mm^3) of water (Boonwanno, 2017), a small amount compared with the estimated need to store approximately 400 Mm^3 of flood water (Trakuldit, 2018). These shallow reservoirs need to be excavated, maintained through dredging, and a temporary road system was developed around the reservoirs. This prevented farmers to pump water to their field and RID then created a canal around the reservoirs and constructed a sluice gate for a drainage system (ibid). An attempt to fill the reservoirs from the Yom river failed because they are located at a higher elevation. Eventually the reservoirs are chiefly filled by rainfall, that is, not to their full capacity. All these investments made, added to expropriation costs, are probably disproportionate with regard to the benefits generated.

[2] https://www.nationmultimedia.com/detail/breakingnews/30371463

[3] 54 refers to the year 2554 in thai calendar, which corresponds to the year of the great flood, 2011.

In 2016 the government initiated a *'keam ling*' policy, as proposed by the Ministry of Agriculture and Cooperatives (MOAC), applied to the Bang Rakam area (near Sukhothai) and 12 low-lying areas in the Chao Phraya Delta. This report investigates the effectiveness of this policy by reviewing four different 'flood retarding basins': Bang Rakam in the upper Central Plain, and Bang Kum, Chao Chet-Bang Yihon project, and Mahachai Canal in the Chao Phraya Delta. Flood management in the delta is a complex issue that is intimately linked to cropping patterns and irrigation scheduling. To understand what the government's policy has changed and how, it is first necessary to recall key elements of flood management in the delta as well as recent evolutions.

2 The management of the flood plain in the 2000s

The Chao Phraya flood plain is divided in 20 main low-lying areas described by Molle et al. (1999)[4] (In the late 1980s and the 1990s, the management target levels were gradually modified in several boxes. The overall decrease in the magnitude of the flood was due to upstream development in the basin (see below), but also to the addition of intermediate regulators segmenting the box in successive steps, which allowed for a reduction in target water levels. In Wat Ulom box, for example, the regulation level was around 5.20 m in the late 1980s and it was later decreased to 4.50 and then 4.00 m. In the Bang Kum box, the regulation level was reduced from 4.80 m to 4.50 m. As a result, several areas shifted from floating rice to deep-water rice, and from deep-water rice to HYVs. The target water level in the dry season, on the contrary, was raised in some boxes where, instead of fully draining the box, some water was kept in the lower drains, often transformed in reservoirs by diking them on both sides. Data point to changes in regulation in Lam Chuad (from 4.00 to 5.50 m), Wat Manee (2.30 m to 4.50 m), or Saladeng (2.50 to 3.00 m).

). They form a set of 'drainage boxes' isolated from the river system by dikes fitted with gated outlets that allow the exchange of water between the rivers and these low lands. Drainage boxes are mainly filled with the return flows from those fields, local runoff, sideflows from rainfed areas on both sides of the delta, and possible releases from main canals directly to the drainage system by the RID. The area cropped with Traditional Varieties (TVs) decreased and, around 2000, was confined to a "flood-prone" area of around 300,000 ha (In the late 1980s and the 1990s, the management target levels were gradually modified in several boxes. The overall decrease in the magnitude of the flood was due to upstream development in the basin (see below), but also to the addition of intermediate regulators segmenting the box in successive steps, which allowed for a reduction in target water levels. In Wat Ulom box, for example, the regulation level was around 5.20 m in the late 1980s and it was later decreased to 4.50 and then 4.00 m. In the Bang Kum box, the regulation level was reduced from 4.80 m to 4.50 m. As a result, several areas shifted from floating rice to deep-water rice, and from deep-water rice to HYVs. The target water level in the dry season, on the contrary, was raised in some boxes where, instead of fully draining the box, some water was kept in the lower drains, often transformed in

[4] http://horizon.documentation.ird.fr/exl-doc/pleins_textes/divers19-02/010074692.pdf

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), in which the water regime is partly controlled by means of dikes and regulators.

According to the survey carried out by Molle et al. (1999), the management of these boxes around 2000 followed the same pattern: in each 'drainage *box*' water was stored during the rainy season up to a specific height (that depended on topography and governed the type of rice planted) and maintained at this level *until* the rice was ripe, after which water was drained to allow harvesting. Depending on the box, this was to happen in December or January, at a time when the water level in the river system, outside the boxes, had subsided, allowing water to be drained by gravity. But risk was not fully eliminated: high inflow might exceed the drainage capacity of the boxes, with the water raising above normal heights and some deep-water rice being submerged; or the water level could rise too slowly or not enough; it could also be too long and a delay in the draining out of the box might force farmers to harvest their rice by boat.

As shown in In the late 1980s and the 1990s, the management target levels were gradually modified in several boxes. The overall decrease in the magnitude of the flood was due to upstream development in the basin (see below), but also to the addition of intermediate regulators segmenting the box in successive steps, which allowed for a reduction in target water levels. In Wat Ulom box, for example, the regulation level was around 5.20 m in the late 1980s and it was later decreased to 4.50 and then 4.00 m. In the Bang Kum box, the regulation level was reduced from 4.80 m to 4.50 m. As a result, several areas shifted from floating rice to deep-water rice, and from deep-water rice to HYVs. The target water level in the dry season, on the contrary, was raised in some boxes where, instead of fully draining the box, some water was kept in the lower drains, often transformed in reservoirs by diking them on both sides. Data point to changes in regulation in Lam Chuad (from 4.00 to 5.50 m), Wat Manee (2.30 m to 4.50 m), or Saladeng (2.50 to 3.00 m).

Figure 3, a box would generally include floating rice in the lower parts, deep-water rice in the middle yet flooded elevation, and HYVs on the higher parts. These higher lands would be supplied by irrigation canals, provided with on-farm infrastructures (tertiary canals and drains), and – water supply allowing – be in a position to double-crop HYVs (see details in Molle et al. 1999). Deep water and floating rice would be grown on (rough) natural terrain and be flooded 'from below', as water accumulates and rises in the box.

Figure 2: Main 'drainage boxes' and deep-water rice areas in the Chao Phraya delta (late 1990s) (Molle et al. 1999)

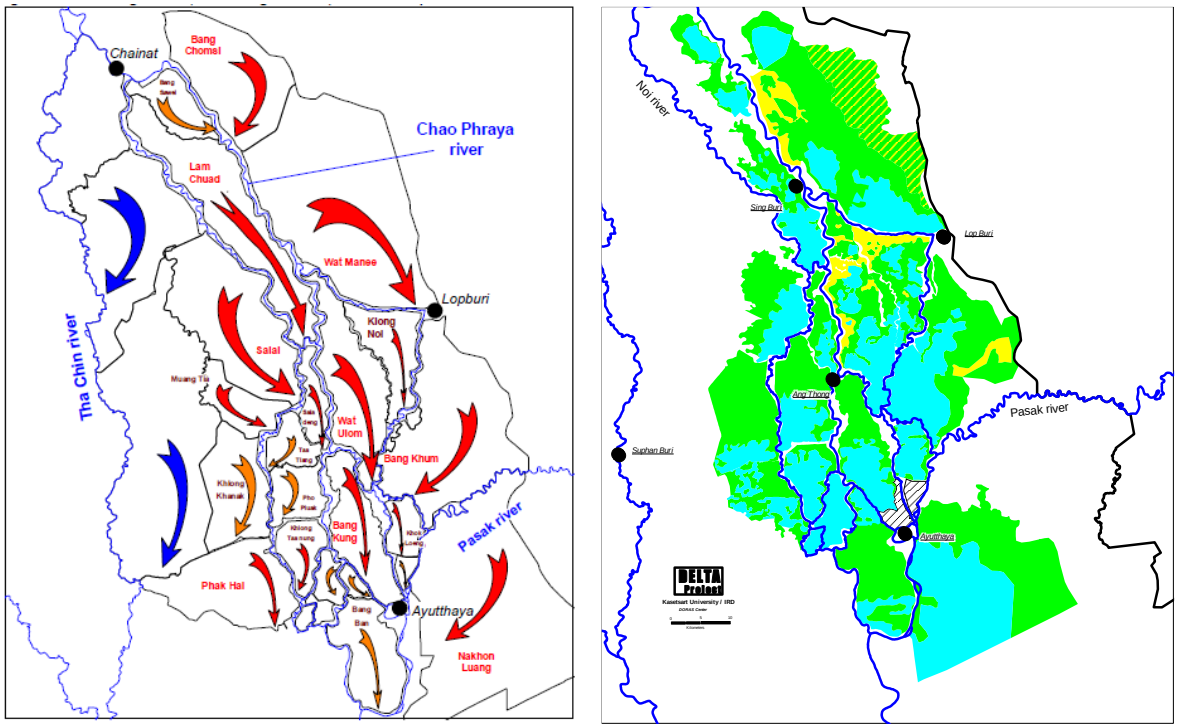

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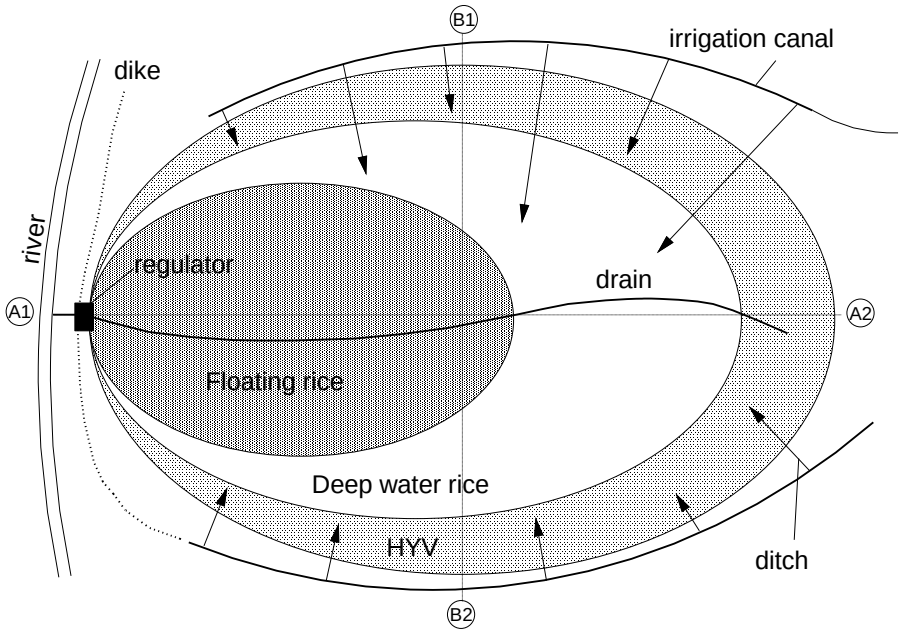
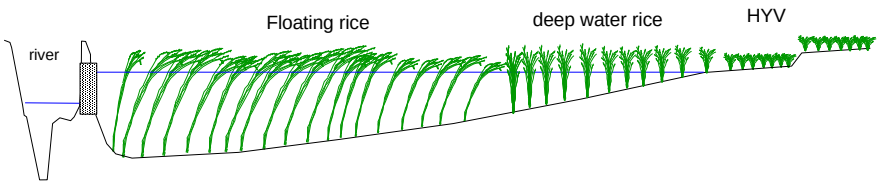
Figure 3: General layout of a drainage box

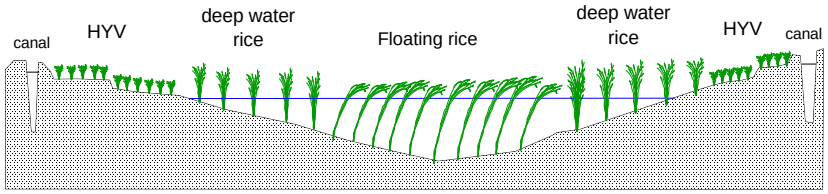


Schematic representation of a drainage unit

Cross-section A1-A2



Cross-section B1-B2



3 The full shift to HYV rice

The construction of the Bhumipol (1964) and Sirikit (1974) dams resulted in an overall gradual decrease in the intensity of flooding (Tebkari et al., 2003). But this trend was also continuously enhanced by the development of smaller dams and diversion works in the upper and middle sections of the Chao Phraya basin (see Molle et al. 2001). This reduction first manifested itself in the lower delta, where flooding was on average much milder. The upper half of the West bank (Chao Chet-Bang Yihon and Phraya Banlue projects) found that they could, in most years, protect themselves from flooding by protecting their fields at a cost that became accessible to farmers. Raised road embankments also contributed to poldering fields from the many waterways that criss-cross the West bank (Roachanakanan, 2013). Similar changes occurred in the East Bank and

along the Song Phi Nong River (Phophya project), that marks the divide between the Mae Klong alluvial fan and the paddy fields of Suphan Buri, and in smaller low-lying areas, such as in the Boromathad Project, in the upper part of the delta, as documented by Molle and Keawkulaya (1998). Finally, in the late 1990s, the lower part of Phak Hai Project followed the transformations witnessed earlier in the neighboring West Bank (Molle et al., 1999).

But shifting from TVs to the double-cropping of HYV on the higher land of drainage boxes that is no longer flooded comes with two *sine qua non*: first the terrain must be levelled and supplied by a water distribution network where, initially, flood water was just spread onto uneven land. This on-farm investment – shouldered by farmers – has been facilitated by the ever-cheaper cost of earth-moving machinery and service. Second, irrigation water must be provided by RID, especially for the second (post-flood) crop that will be grown in the dry-season, with hardly any rainfall, although in some boxes farmers primarily resort to local resources, including rivers. Water supply depends on the capacity/willingness of RID to provide water but farmers have understood that by starting cultivation as soon as possible after the flood (even sometimes draining their individual plot by pumping in order to start land preparation early), they 1) benefit from the residual soil wetness and the water stored in canals[5], 2) force RID to supply them with water in the later part of the cultivation, as drying paddy fields in media releases are considered as unpalatable.

Despite the instances of transformation discussed above and the overall decrease in the regulated water level in the boxes, by the turn of the century it was hardly envisioned that the remaining~300,000 ha of flooded land would be able to convert to HYV double-cropping: on the one hand excess water (from local rainfall, lateral drains entering the delta, return flows from irrigated areas) 'had to go somewhere' and, in times of high river levels, could not be drained out of the boxes (in the absence of pump stations); on the other, RID was loath to see the demand for dry-season water increase in a situation where, on average, the available supply can only irrigate half of the delta (Molle et al., 2001a).

Yet, despite these constraints, all the boxes have seen their rice cultivation patterns dramatically transformed around 2010. In a nutshell, the traditional photosensitive TVs cultivated during the rainy season were replaced by (ideally) two HYVs (short-term varieties), one grown before the flood and another after it, emulating the transformation witnessed earlier in the lower part of the delta and the Phophya area. The change had a dramatic, yet partly diffuse or non-visible, impact on both irrigation and flood management, as will be discussed in Section 5.

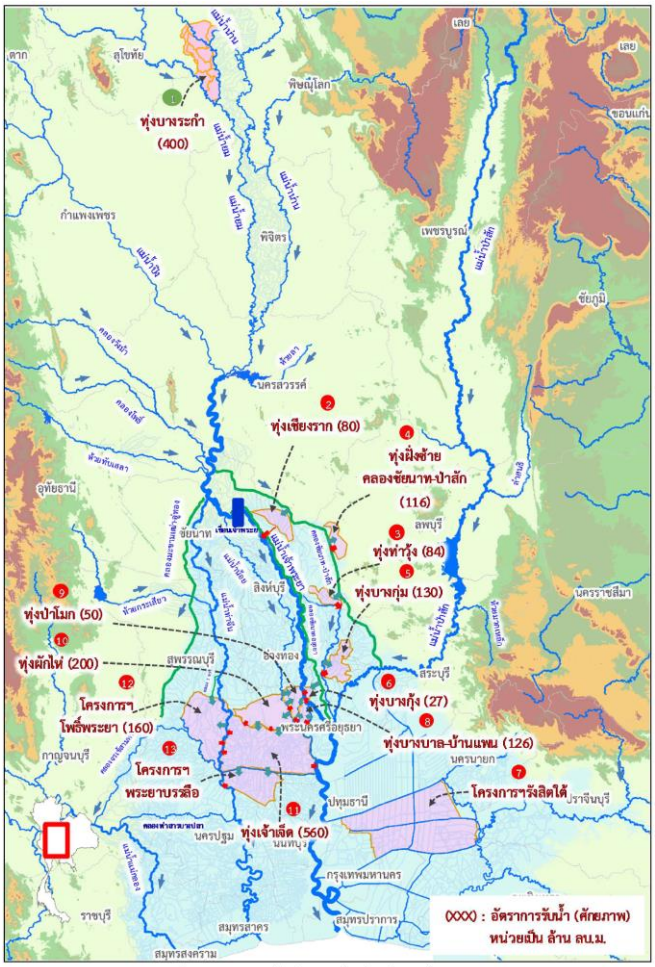
[5] This saves around 300 mm of water, as compared with a dry soil.

4 The 'monkey cheek' project and the requalification of flood management

4.1 The *kaem ling* policy is back

The 20th September 2016, Deputy Prime Minister, also Minister of the MOAC, Gen. Chatchai, like earlier government administrations[6], endorsed the 'monkey cheek' (*kaem ling*) policy to use low-lying land as buffers in times of flooding. Largely triggered by the very late harvest of rice in the boxes (as a consequence of late planting due to insufficient rainfall at the start of the season), and the flooding that this generated for people outside the dike system in Ayutthaya, Gen. Chatchai subsequently issued a policy to rearrange the cropping calendar in order to accelerate crop establishment and harvesting in thirteen areas designated as 'monkey cheeks' in the Chao Phraya River basin (see Figure 4). Twelve of them are situated in the delta, the Bang Rakam low-lying land being the only one situated in the upper central plain.

Figure 4: The 13 main 'monkey cheeks' advertised by the government in 2017



ภาพที่ 1-2 ภาพรวมพื้นที่ศึกษาพื้นที่ลุ่มต่ำลุ่มน้ำเจ้าพระยา

[6] A 'Bang Rakam' model is mentioned in March 2012 in a journal article "Residents pin hopes on govt's Bang Rakam model" In March 2012 (www.bangkokpost.com/thailand/politics/284935/residents-pin-hopes-on-govt-bang-rakam-model).

The policy brings a number of changes to the management regime of the early 2010s. It still supports the cultivation of two crops of rice but aims at filling the boxes at their full capacity each year, with a no-cultivation period of 2.5 months devoted to developing fishing activities. 2017 was the pilot year for this new cropping pattern and RID was to distribute water for rice cultivation in Bang Rakam (265,000 rai) on the 1st of April, and to the twelve remaining 'monkey cheeks' (1.15 million rai) on the 1st of May[7]. These calendars – starting on average a few weeks earlier than usual – were designed to ensure that plots would be harvested during August and early September, before the flooding of the land, with a deadline for harvesting set up at September 15. After having been filled, the drainage boxes would later be drained, starting on the 1st of November 2017.

To elicit buy-in of the policy by farmers, the plan also included several incentives: first, RID committed itself to deliver water to the selected areas as a priority, both in early May and after the flood, at the beginning of the dry season. In addition, farmers would be compensated if their crops were damaged by an early flood in August. Finally, to help accompany this shift, farmers in those areas (1.41 million rai) also received help from provincial agricultural extension services working under the Rice Department in the form of improved seeds for the rainy season crop (5kg/rai).

This policy of artificially filling these flood retention buffer areas according to a uniform and rigid calendar, without considering the actual hydrologic situation, has resulted in a loss in flexibility and resilience and a few contradictory effects that are detailed in what follows through the examination of four *monkey cheeks*: Bang Rakam, Bang Kum, Chao Chet-Bang Yihon project and Mahachai Canal.

4.2 Bang Rakam

To avoid the Yom River discharge exceeding 400 m^3/s at a bottleneck upstream of Sukhothai, which would affect the city, managers have to divert part of the river flow at the Sawankhalok regulator into the Bang Rakam flood plain (and also to the Nan River) (Figure 5). In August or early September, this often conflicts with the end of rice cultivation which runs the risk of being damaged. In 2016, General Chatchai instructed the RID and relevant agencies of the MOAC to coordinate with the Army to plan a change in cropping patterns in Bang Rakam, located between the Yom and the Nan rivers and to be considered as a 'monkey cheek' during the 2017 (2560) flood season.

This project came to be known as the "Bang Rakam Model 60" (BRM60) and included four main points (Trakuldit, 2018): 1) fields should be harvested before the flood, which requires rice to be established in April (and not in May) and harvested at the end of July; 2) the water level should not affect the main road at Klong Pla-kray village, and should therefore be raised at around 41

[7] During 2017, under the integrated rice production policy (*nayobai phalit khao khrob wongjon*), 15.95 million *rai* were planned to be used nationwide for rain season rice crops, of which 7.6 million rai are within the Chao Phraya basin. Within these 7.6 million rai, 1.415 are lowlying lands (*phuen thi loom*) whereas 6.19 are higher hills (*phuen thi don*) (RID, 2018: 3).

MASL[8] at a maximum; 3) The flood period should be kept short (3-4 months); 4) water will be available for irrigation in the dry season, both in terms of quantity and early enough for farmers to grow a second crop in April and harvest it by the end of July.

Figure 5: Sketch of Bang Rakam 'monkey cheek' area (RID)

The main benefits expected from Bang Rakam Model 60 were 1) the mitigation of flooding in Sukhothai province and downstream regions (Bangkok being often referred to, see Voogd, 2019), 2) avoiding flood damage and costs to the government budget in terms of compensation to farmers and repair of irrigation infrastructure, 3) creating job opportunities in fishing for farmers during the flood period, and 4) storing water for later use in downstream regions (Trakuldit, 2018).

Farmers, however, did not want to change their cropping patterns and accepted the project somewhat reluctantly (Trakuldit, 2018): the fact that the army was involved, the understanding that they would not get compensation in case of flood damage if they did not adhere to the project, and the hope that they would get good water supply in the dry season contributed to convincing them. Farmers in concerned areas had to register at the agricultural office of the district, and had to start rice cultivation during the 1-30 April period, using HYV such as Gor-Kor61 (90 days) or Gor-Kor41 (105 days), that are short-term rice varieties. They would also have to agree not to farm until November 1, 2017. In case of a natural flood occurring before August

[8] Meters Above Sea Level

20, 2017 and farmers not having harvested yet, they would be compensated at the level of 1,113 baht per rai (ibid).

The model started with the early planting of a rice crop on the 1st of April 2017 and the 42,400 hectares (twenty sub-districts and ninety-three villages) of the project area received 228 Mm^3 during the whole cropping period. The beginning of the season, in May, witnessed frequent and substantial precipitations that affected the BRM60 area. In the last day of July, two storms (Sonca and Talas) later also affected the area and 1,664 hectares were lost to floods. Many roads were also submerged[9]. On August 6, "People living in the Bang Rakam Model 60 area were warned on Monday to move their belongings to higher ground ahead of likely flooding (…) Local farmers, meanwhile, should harvest their crops" (The Nation, 2017). The Yom River burst its banks to inundate rice fields in Phitsanulok's Bang Rakam district, about two weeks before the Royal Irrigation Department's plan to use the area for floodwater retention (The Nation, 2017b).

Although on July 21, only 12,800 hectares had been harvested, RID later assessed that 97.5 percent of the rice area in BRM60 had been harvested before the flood. While RID officers argued that this was out of their control because of excessive water in the system (due to early rain and storms), this first season served to show there remained substantial risk that could undermine the BRM60 model, and make farmers unhappy with it (fifteen villages of Bank Rakam District that were not part of the project were affected by the flood). The model's lack of robustness is also shown by the fact that, according to RID officials, it was finalized since 2015 but could not be implemented because of the drought in that year. In May 2018, by contrast, many reservoirs were "already brimming with water prior to the predicted 'wetter than average' rainy season", and therefore had a lower flood mitigation capacity (The Nation, 2018), signaling that monkey cheeks might receive water earlier than planned. This again illustrates how hydrologic conditions may vary from one year to the other, showing the inadequacy of the proposed rigid model (more discussion later).

Most farmers in BRM60 were unsatisfied for a number of reasons with what happened in 2017 (Trakuldit, 2018; Boonwanno, 2017): 1) the flood damaged the road system and houses, and even some fields; 2) the lack of access to water once the box was drained for those farmers in higher land (for lack of infrastructure to retain water locally); 3) farmers had to grow short-term rice varieties and sometimes to harvest before the rice was fully ripe, resulting in a lower income; 4) the artificial flooding of the area for 4 months, while naturally the duration would have been less; 5) the emphasis put on fish production did not resonate with all local farmers, since most do not have the skills and/or the equipment to catch fish.[10]

Despite all these shortcomings, in December 23, 2017, the head of the district and representatives of RID and of the Army announced the success of the model on the National Council for Peace and Order (NCPO) television program. The Headman of Tha Nang Ngam sub-

[9] RID has presented a funding request to the GCF.

[10] Fishing was presented as an alternative income-generating activity. The slogan of Bang Rakam model is that "*Change the green land (rice field) to the white (inundated areas), reduce floods in the field and increase water for fishing*" (RID, 2017) (Trakuldit, 2018).

district also stated that the public was satisfied with the result of the model (Trakuldit, 2018). In December, the Director of RID declared that "the success of the floodwater retention fields under the Bang Rakam Model project this year proved that it could significantly reduce flooding problems in the lower Chao Phraya River Basin, and also reduce the severe flooding in Sukhothai… [and the] government's burden to compensate for damage caused by flooding". The test resulted in the storing of 400 Mm^3 until December, when 300 Mm^3 were drained to the river and 100 Mm^3 kept in the drainage system for use in the dry season. The cabinet view this success as warranting the expansion of the Bang Rakam Model floodwater retention fields to a total of 382,000 rai (with a capacity to hold 550 Mm^3), and gave its approval for it (The Nation, 2017c).

However, as a result of the perceived failure by farmers of the RID policy, the government also agreed to invest in flood mitigation works, including raising roads and fitting a pumping station at the outlet of Bang Rakam box[11], so that water could be drained if flood threatened crops. Early diversions at Sawankhalok regulator draining into Bang Rakam could be pumped out to the Yom River. However, the flow capacity of the Yom River at this location is extremely low, so this added volume would all likely contribute to more flooding on the right bank.

A later study carried out in 2019 (Voogd, 2019) found out that the change in cropping calendars (Figure 6) brought some benefits to farmers in terms of accessing water earlier in April, reducing flood risk at the time of harvest, and receiving state infrastructures in some parts (raised roads and excavation of reservoirs to store water for the ensuing dry season crop). Drawbacks included the reduced number of farmers who can cultivate three crops of rice (for those 10% farmers who could do this because of a relatively high land) and the lengthening of the flood period, which brings hardship for farmers who have to use boats for transportation.

Figure 6: Cropping calendars in Bang Rakam (Voogd, 2019)

<table>
<tr><td colspan="13">Rice period</td><td>% of farmers</td></tr>
<tr><td></td><td>Apr</td><td>May</td><td>Jun</td><td>Jul</td><td>Aug</td><td>Sep</td><td>Oct</td><td>Nov</td><td>Dec</td><td>Jan</td><td>Feb</td><td>Mar</td><td></td></tr>
<tr><td>3x harvest before BRM 60</td><td colspan="4">2nd rice cultivation</td><td colspan="4">3rd rice cultivation</td><td colspan="4">1st rice cultivation</td><td>10%</td></tr>
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<tr><td>2x harvest with BRM 60</td><td colspan="4">1st rice cultivation</td><td colspan="4"></td><td colspan="4">2nd rice cultivation</td><td>95%</td></tr>
<tr><td>3x harvest with BRM 60</td><td colspan="4">2nd rice cultivation</td><td colspan="4">3rd rice cultivation</td><td colspan="4">1st rice cultivation</td><td>5%</td></tr>
</table>

[11] This station does not seem to have been constructed.

If, on balance, the Bang Rakam model can be considered to be instrumental in partially reducing cultivation risk, it does not seem that the other benefits claimed are indeed forthcoming. Firstly, RID has to provide water in late March/early April, at a time when storage in the Sirikit dam is often very low. In 2015 this was not possible and delayed the implementation of the idea. Secondly, 2017 served as a reminder that the risk of damage by flood occurrence between May and August remained unchanged. Thirdly, claims that flooding in Sukhothai is reduced are unpersuasive because diverting water to Bang Rakam was already practiced before. Fourthly, the statement that Bang Rakam mitigates flood risk for Bangkok/downstream areas is unconvincing since the box is filled early (August/September), at a time when the delta is not yet threatened by flooding. Fifthly, for a similar reason, the idea that these 400 Mm^3 can be reused downstream when released does not match reality because this happens in November, at a time when there is still excess water in the delta and demand is lower than natural runoff.

Finally, and most importantly, RID has committed to enforce a fixed and rigid cropping calendar that it will often not be able to respect (when storage is low in April) and that does not do away with the risk of flooding. But because of the announced commitment, farmers now take as a government failure what, in the past, was seen as a hydrologic risk that was left to each farmer to manage according to his own means and situation. This did not prevent failure or losses but made flexibility and adaptivity the key responses to hydrologic vagaries.

In any case Bang Rakam was already a 'monkey cheek' long before being considered as such and the new policy does *not* enhance its buffering capacity nor its alleged impact on downstream areas. The lengthening of the flooding period works against the principle and the interest of starting dry-season cultivation as soon as the water stored can be allowed to drain, and the expected added benefits in terms of fisheries seem to be more *ad hoc* than forthcoming, not compensating the hardships of those having to use boats. Whether the shift is overall beneficial or not is debatable but it clearly does not add anything to the pre-existing 'monkey cheek' management of the area. The objective to shift calendars to reduce risk at the end of the cycle is laudable but it is not sure that a fixed calendar can be sustained. It must also be noted that this measure is an attempt to correct a problem which has been created by allowing farmers to shift from a TV to double-cropping of HYV in an environment that may not allow two crops to be grown each year.

4.3 Bang Kum[12]

Bang Kum box (BKB) covers 83,000 *rai* of which 38,000 *rai* belong to the Roeng Rang project and 45,000 to the Khok Katiem project, and administratively comprises 22 *tambon* (sub-districts) belonging to the three provinces of Lop Buri, Ayutthaya and Saraburi (RID, 2018). 90% of the land is used for rice and the rest for taro, other crops, fish ponds, small-scale factories, government buildings, temples and residential areas (RID, 2014). The land elevation average in the Bang Kum box is 2.90 MASL, varying between +2.70 m and +3.20 m (RID, 2014: 4-23). It is

[12] For a more detailed description of the changes in the water regime and rice cultivation, see Molle, F.; Chompadist, C. and Bremard, T. 2020. Intensification of rice cultivation in the flood plain of the Chao Phraya Delta. Forthcoming.

nested in a depression bordered by the levees of the Lop Buri River, Pasak River and Khlong Bang Phra Khru canal (Farmers in the Bang Kum box, at least in its lower parts, have been constrained by the flood water regime. Although this regime was regulated, as described above, and therefore afforded a degree of predictability and stabilization of production, yields remained low, at an average of 35 *thang* (0.35 t) per *rai* (Molle et al., 1999). Farming system analysis in Ban Nong Mon village in 2000 (Molle et al., 2001c), in the heart of the box, revealed 1) a low rice productivity and limited diversification, 2) that many absent villagers were renting out their land to relatives or other villagers, 3) a lower average fertility (induced by the lack of economic perspectives), 4) a high rate of emigration, and 5) the importance of off-farm income from factory work, handicrafts, remittances, etc.

In the 2008-2013 period, the average farm gate price of rice reached 9.6 baht/kilo, against 6-7 baht, making rice cultivation extremely attractive. In 2010 farmers formed a group consisting of 84 members and invited government agencies from varying sectors to discuss a change whereby flood-season traditional rice cropping would be abandoned and replaced by double-cropping of HYVs, one crop before the flood and the second one after it. RID accompanied and supported the move and the group's initiative. The shift was gradual, leaving the time for developing on-farm infrastructures, levelling the land, raising the water regulation level in the dry season to reach more land without flooding the lower ones (from +3.00 to +3.20 m), developing ditches to connect with the different sources of water: the main drain, the irrigation canal, the Khlong Bang Phra Khru and Lop Buri River (through pumping), or local excavated reservoirs, until the whole Bang Kum box (around 71 500 rai) could convert to growing one or two HYVs, with eventually most of the farmers being able to grow two crops. The first (post-flood) crop is largely grown based on local resources and higher lands near the canal; if they cannot access other resources, they have to wait for deliveries by RID to irrigation canals.

This change entailed a redefinition of the flood management practiced in the past decades: During the flood period, the Bang Kum box would now be drained as long as the water level in the downstream Bang Phra Khru canal allowed this. In case of water rising in that canal (which connects the Lop Buri and Pasak rivers and therefore reflects their respective water levels and flow conditions), the gates would be closed and water would accumulate in the box. There would be no particular attempt to store water but, if need be, water could be stored up to 4.50-4.80 m without disrupting local life, as in previous conditions. As soon as downstream river levels would allow it, the gates would be opened again and water in the box drained out. In some years this could be done as early as late November, allowing the post-flood crop to be established early, thus maximizing chances to cultivate a second crop in the following spring.

Figure 7).

Farmers in the Bang Kum box, at least in its lower parts, have been constrained by the flood water regime. Although this regime was regulated, as described above, and therefore afforded a degree of predictability and stabilization of production, yields remained low, at an average of 35 *thang* (0.35 t) per *rai* (Molle et al., 1999). Farming system analysis in Ban Nong Mon village in 2000 (Molle et al., 2001c), in the heart of the box, revealed 1) a low rice productivity and limited

diversification, 2) that many absent villagers were renting out their land to relatives or other villagers, 3) a lower average fertility (induced by the lack of economic perspectives), 4) a high rate of emigration, and 5) the importance of off-farm income from factory work, handicrafts, remittances, etc.

In the 2008-2013 period, the average farm gate price of rice reached 9.6 baht/kilo, against 6-7 baht[13], making rice cultivation extremely attractive. In 2010 farmers formed a group consisting of 84 members and invited government agencies from varying sectors[14] to discuss a change whereby flood-season traditional rice cropping would be abandoned and replaced by double-cropping of HYVs, one crop before the flood and the second one after it. RID accompanied and supported the move and the group's initiative. The shift was gradual, leaving the time for developing on-farm infrastructures, levelling the land, raising the water regulation level in the dry season to reach more land without flooding the lower ones (from +3.00 to +3.20 m), developing ditches to connect with the different sources of water: the main drain[15], the irrigation canal, the Khlong Bang Phra Khru and Lop Buri River (through pumping), or local excavated reservoirs, until the whole Bang Kum box (around 71 500 rai) could convert to growing one or two HYVs, with eventually most of the farmers being able to grow two crops. The first (post-flood) crop is largely grown based on local resources and higher lands near the canal; if they cannot access other resources, they have to wait for deliveries by RID to irrigation canals.

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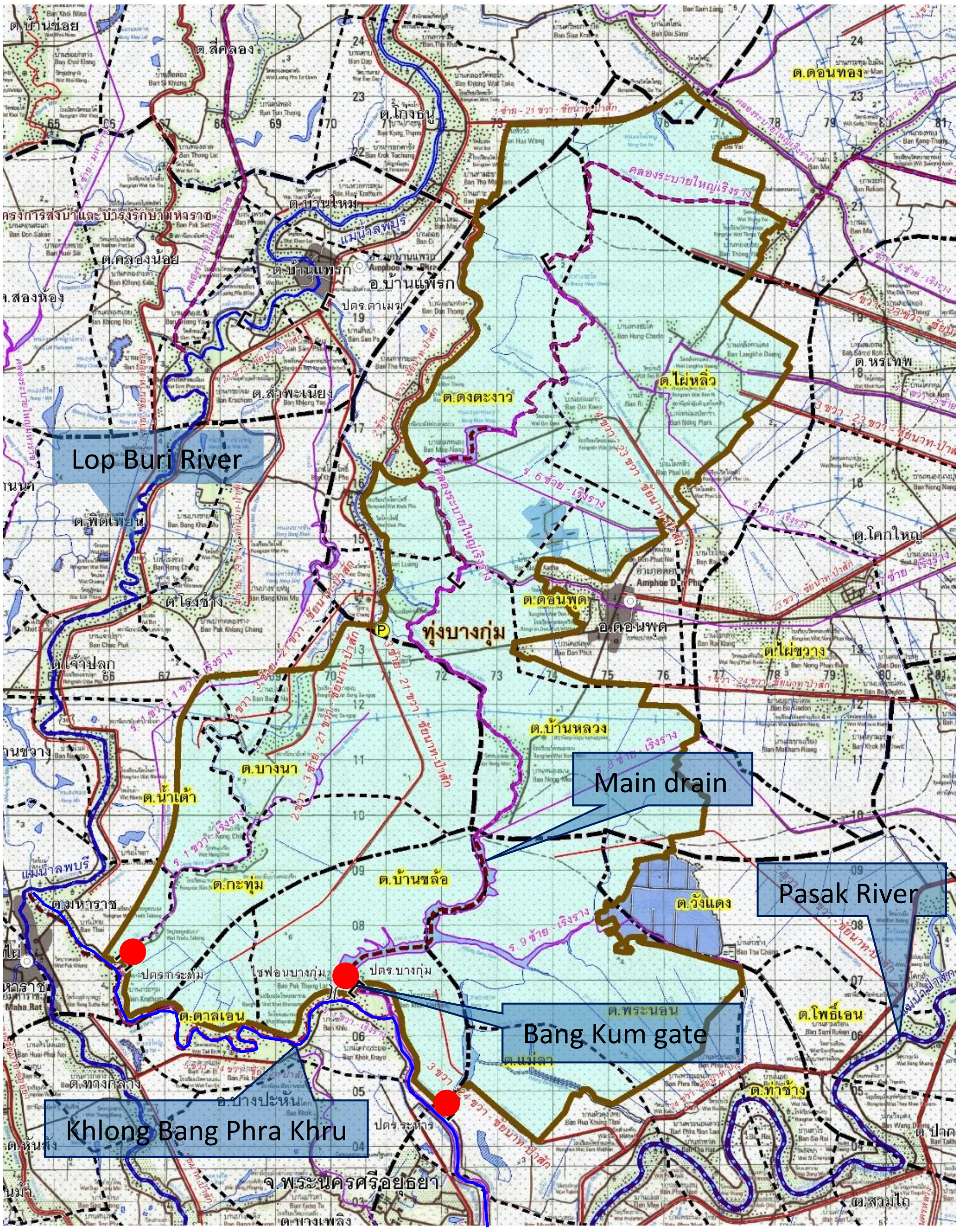
[13] National Statistical Office (NSO) website data.

[14] The persons who helped mediate the process include a former DG of the Department of agricultural extension and a head of district with political support.

[15] However, with a terrain gently sloping towards the central drain, higher plots were hard to reach. Farmers would have to build two or more successive reaches, with water pumped from the lower one to the higher one in a step-wise fashion.

Figure 7: Bang Kum drainage box (Bang Kum box)



While the new farm and water management system allowed for a spectacular increase in land productivity and farmer's income, and also in water use efficiency at the project level, it also had less obvious negative impacts. First, it substantially increased water demand in the dry-season, compounding the overall difficulty of RID to meet this demand. Second the staggering of farm operations to allow the cultivation of two crops between December and September meant that a large part of Bang Kum box is still under cultivation when excess or flood water already have to be diverted. At the project level, managers thus have to close siphons[16] to prevent sideflows from the highlands, on the eastern side of the delta, from crossing the Chainat-Pasak canal and

[16] As a result, water accumulates on the left bank of that canal and has to be allowed in by gravity or pumping into the canal.

accumulating in the Bang Kum box. It thus reduces the flood mitigation capacity of the box until crops are harvested.

The new *kaem ling* policy formalized in 2017 did not try to radically change the established management system. It introduced dates for starting to fill in the boxes and draining them, and promises about delivering canal water as a priority to the Bang Kum box. Bang Kum box lies at the frontier of Ayutthaya Province and may be seen as less important in dampening the flood between the dikes of the Chao Phraya River than the boxes located around Ayutthaya itself. It is also shared by Ayutthaya and Lop Buri provinces and therefore escapes the authority of the sole Ayutthaya governor. This may explain why the timing instructions seem to have been loosely adhered to. Priority delivery to lowlands in the dry season is also not fully happening, farmers mainly relying on local water resources for a start.

If strictly implemented, the new calendar would help manage sideflows and let them in, but it would decrease the flood mitigation capacity by 1) filling in the boxes at a time where there is no excess water in the system, 2) fully filling the boxes instead of keeping as much storage capacity as possible to absorb possible future floods. This also possibly reduces the time available for growing two crops after the flood.

4.4 Chao Chet-Bang Yihon

The Chao Chet-Bang Yihon project, together with the neighbouring Phraya Banlue project, form the upper West Bank area of the delta. Subject to moderate flooding, the area has been one of the first to undergo a shift from traditional varieties to double cropping of HYVs (Takaya, 1987; JICA, 1992). Gradual poldering, a reduced average inflow coming from the north, pumping stations allowing to pump water out to the Tha Chin River at any time, have reduced flood risk and intensity dramatically. Although seemingly rather flat, the area slopes to the north-west, where low-lying parts can be found. The project is crisscrossed with dual-purpose channels from which farmers can source water and to which they can also pump water out, depending on the hydrological situation and the cultivation stage. The good availability of water and diking/poldering at the plot level has led some farmers to engage in continuous rice farming (2.5 to 3 crops per year): in case of flooding, farmers discontinue cultivation for some time (typically a couple of months) and start again when conditions allow. They can also play with rice varieties of different cycle duration (from 90 to 120 days) to better adjust to constraints. Depending on their plot and specific assessment of risk farmers may try to avoid the risky October-November period, while starting as soon as they believe the risk of flood to be low. Although some feel they are secured with a high probability, in exceptional years the whole area may end up covered with water (and also the roads, as seen in particular in 1995-6). In summary, farmers are responsive to changes in the water regime in a flexible and site-specific way and while they do ask for the RID to pump water in and out of the project to enhance their water (supply/drainage) situation, there is no assurance nor commitment from the government that this will happen.

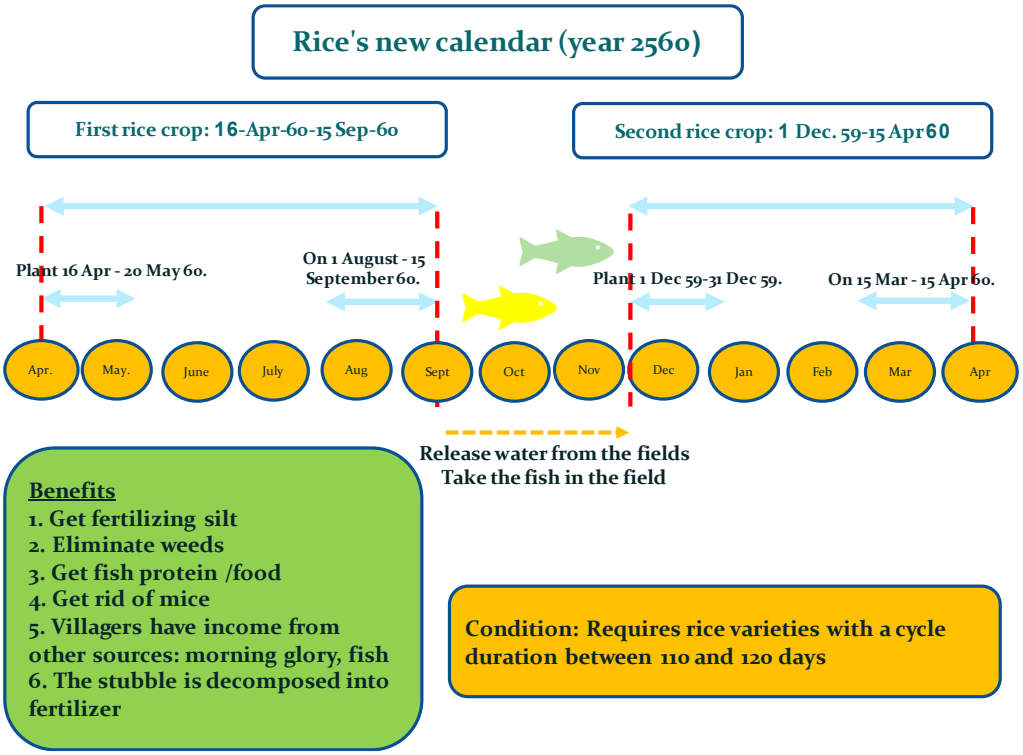
Figure 8: Flooded fields in the West Bank, showing some poldered raised beds (F.Molle)

The heterogeneity of land, farming and water conditions is actually quite high, as the very diverse stages of rice that can be observed when crossing the area suggest. In such a situation, flexibility in adjusting to changing and site-specific hydrologic conditions remains key at the farm level, and it is not easy for RID to plan water supply. Heterogeneity is also well illustrated by the western quarter of the Chao Chet-Bang Yihon project. This lower land enjoys better water supply in the dry season (as water tends to flow towards it) but is more susceptible to flood and, because it is low, has higher costs of plot poldering. Some farmers have therefore shifted to aquaculture[17], that generates a higher income than rice and pays for poldering, or to intensive vegetable growing with short cycles that can be better attuned to conditions (and which can also be partly poldered).

With the new *kaem ling* policy pushed by the Governor of Ayutthaya and the government, a calendar has been defined and formalized (Figure 9). Farmers should have harvested their fields on the 15th of September so that water can be allowed in (i.e. the *monkey cheek* can be filled). A 2.5 month flooding period is planned during which cultivation should be stopped and water is supposed to cover fields with a height of 30 cm (which corresponds to a *monkey cheek* storage of 560 Mm^3). Farmers do see the benefit of flooding in terms of weed control and natural fertilization by silt, and for some of them in terms of fishing potential, but many complain that the flooding period is too long.

[17] Images show that ponds tend to be concentrated along main waterways, showing the importance of accessing freshwater.

Figure 9: The new calendar imposed in Ayutthaya Province



RID project managers in the Ayutthaya province are under pressure from the governor of Ayutthaya and the government to enforce this calendar. In particular, the governor wants RID to start storing water on September 15, to avoid the discharge and the water level in the Chao Phraya River to rise and disrupt the life of local villagers whose house is located outside of the main river dikes. But, in 2017, after the governor insisted to have all the gates of the neighboring Bang Kung box open to store water after September 15, the box was already full when excess flow arrived in mid-October (and at the end of the month even RID office got flooded). In Chao Chet-Bang Yihon project too, the flooding found no room for expansion and water rose to levels much higher than planned, submerging many local roads and even threatening the main highway to Suphan Buri. Where a genuine *kaem ling* policy would dictate to keep the water levels in the canals as low as possible during the rainy season in order to preserve the buffering capacity, this storage is now artificially filled *before* the period in which the flood risk is higher.

In addition, RID has committed to ensure conditions allowing farmers to start dry season cropping in the first half of December (the 5th in 2017 and the 15th in 2018), and therefore needs to start releasing water in the middle of November. But this is normally a slow and gradual process and in order to fulfill its commitment RID has to switch on its pump stations in order to pump water out to the Tha Chin River[18] (it still takes around one month to release the 560 Mm^3). In 2017, for example, the dry season was supposed to start in the province on December 5, but a good part of it was still fully under water, making RID unable to fulfill the agreed-upon calendar and engaging in very costly pumping action to drain the water out as soon as possible. While

[18] Drainage is also possible by gravity, at low tide, on the eastern Noi River/Chao Phraya River side, but too slow to empty the area on time. The overall pumping capacity is 150 m^3/s.

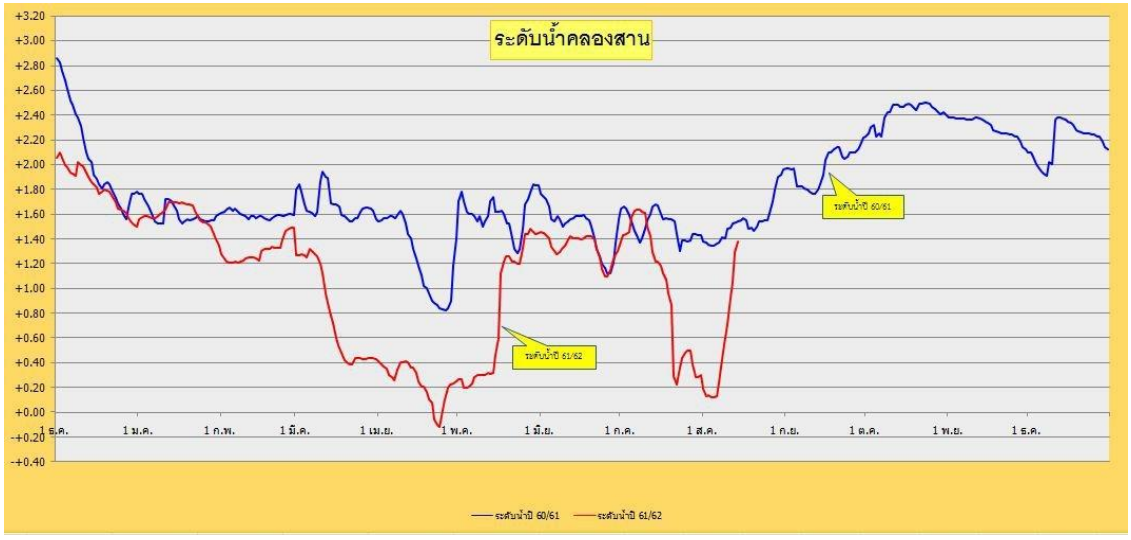
farmers were used to a gradual process they now demand water conditions to be, on the expected date, what they have been promised to be[19]… This situation is even more serious in the Phak Hai project, which is located upstream and normally has to wait one month for Chao Chet-Bang Yihon to empty before it can fully drain its waters, and where people also demand the calendar agreed upon to be respected. The policy has also generated complaints in the downstream Phraya Banlue project, because it affects its inflow and prevents farmers from growing three crops of rice, leading them to ask for compensation…

The following year, in 2018, the opposite situation occurred, and RID was not able to fill up the paddy fields up to 30 cm above ground level, as designed. Figure 10 shows the evolution of the water level in two locations of the Chao Chet-Bang Yihon project in both 2017 and 2018.

Figure 10: Evolution of water levels in Chao Chet-Bang Yihon project in 2017 (blue) and 2018 (red). The graph starts on the 1st day of December.

Khlong Bang Sai water level

Khlong San water level



[19] In 2018, the planned date was December 15; on the 16th angry farmers dropped by the manager's office to complain…

Similar difficulties are created with the early start of the rainy season crop, which according to the policy should be on May the first: the West Bank is the most downstream area supplied by water from the Noi River: this means that upstream projects (Boromathad, Chanasutr, Yangmanee and Phak Hai projects) will help themselves first, and that the West Bank will only get sufficient flow quite late[20]. If farmers haven't started cultivation before the end of May then they may not be in a position to harvest and clean their fields before the imposed deadline of September 15.

As a means of gaining the acceptation of local people, the 12 'monkey cheeks' boxes actually have 100% priority for dry-season water allocation (and even more so when the planned conditions have not been fulfilled during the rainy season, like in 2017). But this also creates its own problem in different ways. First the uniform calendar is conducive to inefficient use of water since the water released when draining Phak Hai (sequentially, after the West Bank) that was used downstream in the latter is now, with the new policy of uniform calendar, lost to the Chao Phraya river, thus reducing the quota of Chao Chet-Bang Yihon for the dry season. Second, ensuring such supply in the dry season is made difficult by the same upstream-downstream problems mentioned above for the rainy season crop. Coordination between the two regional offices (north and south delta) remains difficult. Despite central command orders, individual projects still tend to divert their excess water to other projects and to maximize their share in the dry season to the detriment of others. Third, when similar situations where dry-season allocation is promised add up at the level of the delta, this may lead to a (too) high level of dam releases in the dry season that increases the risk of water scarcity for the rest of the season (especially for non-priority areas), and even for the forthcoming wet season crop.

Although the promotion of double cropping in monkey cheek areas is problematic because of the increase in dry season water allocation that it implies, in the Chao Chet-Bang Yihon project the objective is, on the contrary, to *reduce* triple cropping through the imposition of a rigid calendar. Triple or continuous cropping in the West bank generates problems for RID because the main supply of the West Bank from the north, through Phak Hai project, quickly declines during the first months of the year. Water from Tha Chin River can be admitted in the project (by gravity at high tide and pumping at low tide) but this is costly and is hampered by the salinity of water in the Tha Chin (at high tide): this salinity is controlled by releases at the Phophya regulator[21] that would need to be increased if the West Bank abstracted too much water, which explains that a pumping quota is given to the four West bank projects[22]. Chao Chet-Bang Yihon project (or the regional office) can also request the regional office No 13 in charge of the Mae Klong Basin to transfer more water (than planned) from the Mae Klong River to the Tha Chin River, if they need water in the dry season. However, this only happens in years when the Mae Klong Basin has abundant storage, while in other years Mae Klong managers are reluctant to

[20] In theory upstream projects should let enough water flow downstream but it is an open secret that practice differs, and that even the data communicated do not necessarily reflect the reality of actual water abstraction.

[21] The last cross-regulator on the Tha Chin River, located south of Suphan Buri City.

[22] But the provinces have also installed mobile pumps in a number of places and it is unclear whether their use is controlled or not.

increase risk in their own basin. Phraya Banlue and Phrapimol projects also pump water from the Tha Chin River water in the dry season and can grow up to three crops a year, thus compounding the salinity problem. The same situation can be found on the eastern side of the Delta, where projects can also pump water from the Nakhon Nayok River. But the regional office there has no excess water and in addition from January onward, the water in the river is salty (and used in shrimp farms).

Rigid planning is antithetic to both hydrological variations and local heterogeneity. On October 9, 2018, for example, in a meeting with 50 farmers and officials in Zone 1 of Chao Chet-Bang Yihon project, several farmers said that their area had not received water yet, while a woman complained that she had too much water in her field and wanted RID to pump water out… this shows that local conditions are too varied to allow a one-fit-all calendar. This has to do with topography but also with staggering: the fact that not everybody can start land preparation at the same time, since in any project upstream farmers will abstract water and start first.

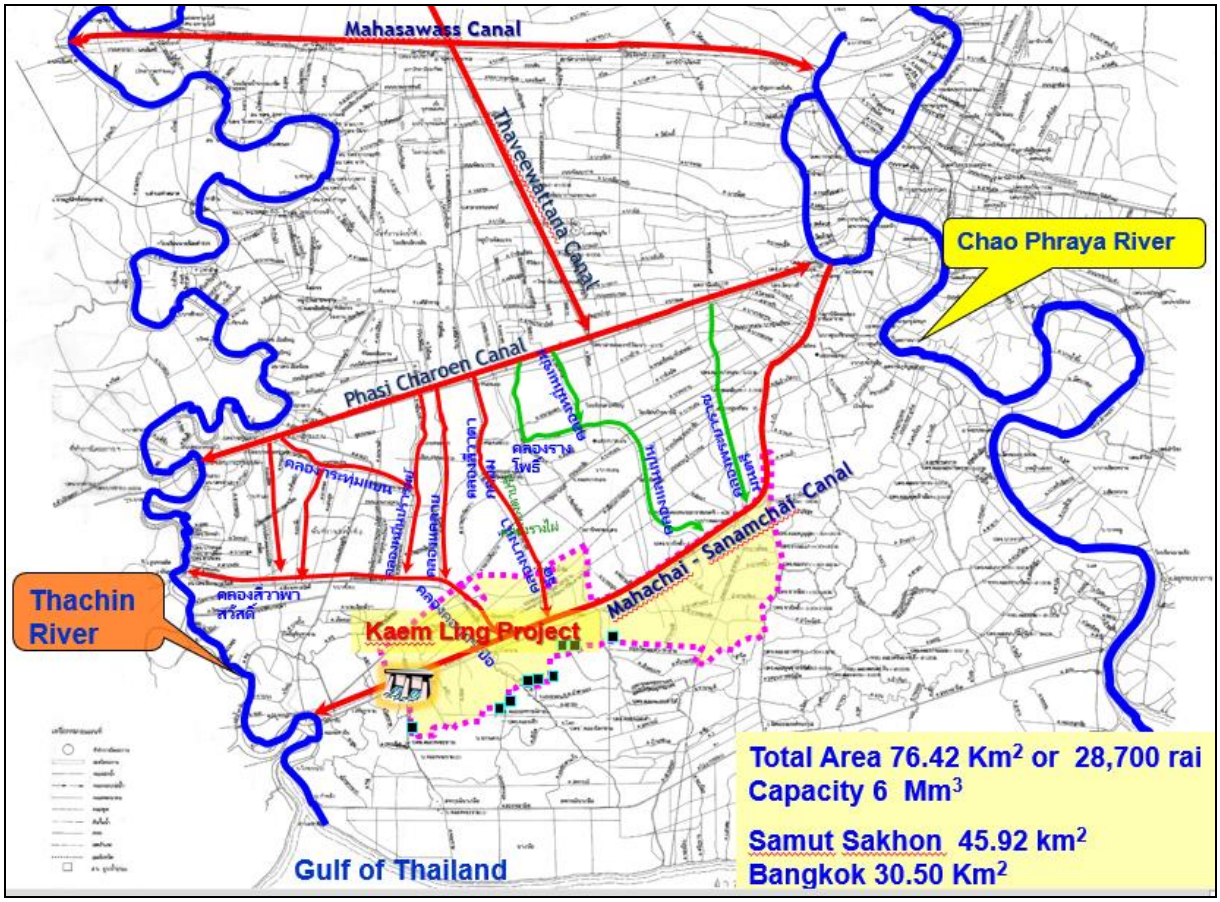
The East Bank's situation bears similarities with that of the West bank. The central office and the Deputy Prime Minister also wanted Rangsit Tai project to be included in the *kaem ling* program, and this project did feature in a few official maps. Because its storage capacity is limited to the channels themselves (water levels in the canal cannot be too high in order to avoid disruption of traffic and urban areas), because contrary to Ayutthaya, the governor (Chachoengsao and BMA) was not interested in the policy, and also perhaps because the hydrological situation is heterogeneous the project has not finally been considered. Managers of the West Bank have also asked repeatedly to have the Phraya Banlue and Chao Chet-Bang Yihon projects removed from the program, but without success.

4.5 Mahachai canal/Sanamchai canal

The Mahachai/Sanamchai canal connects the Tha Chin and Chao Phraya rivers in the lower part of the West Bank (Figure 11). The area upstream of the canal is largely urbanized and home to many industries. The water draining to the Mahachai canal is therefore often polluted. A series of regulators close the many channels that connect the canal to the sea. These regulators mark the limits between freshwater and brackish/salty water and therefore also between agriculture and aquaculture. Dutta et al. (2005) indicate that "DDS (BMA's Drainage Department) in association with the RID had carried out the Monkey Cheeks projects at Canal Mahachai, Canal Sanamchai in (…) Bang Khunthien District"[23], showing that works to close the lower West Bank were initiated long time ago and completed gradually. This project was initiated in 1984, in response to the severe flooding of 1983, as one of the pioneer monkey cheek areas.

[23] It should be noted that the Mahachai-Sanamchai Kaem Ling Project does not belong to the 13 low-lying areas serving as 'monkey cheeks' which fall under the kaem ling policy of 2016 (mentioned in §4.1). The project is, rather, part of the implementation of the general 'monkey cheek' policy vision.

Figure 11: Layout of the Mahachai-Sanamchai canal Kaem Ling area



According to an official website, "The Kaem Ling Project in the Mahachai-Sanamchai canals performs the function of holding flood waters in the upper areas, at the same time, releasing water into the Gulf of Thailand in relation to the tide levels of the sea and relying on an appropriate use of gravity and pumping stations"[24]. Wattanaprateep (2016) specifies that "When the level of seawater becomes lower than the water level in the canal, the flow is naturally driven downwards and when the seawater level becomes higher, the regulator is closed and blocked and water is pumped out".

The project comes under the kaem ling category in that the Mahachai and its tributary canals have been dredged to provide more storage and quicker outflow. But in essence it is a project which, rather than storing water, on the contrary seeks to flush as much water as possible to the sea by making use of both gravity and a high pumping capacity. This is why "water level in the Monkey Cheek shall be kept to the minimum during the rainy season to have more storage for peak flood water" (Wattanaprateep, 2016). By flushing out as much water as possible, flooding conditions in the area are less severe and storage to buffer more serious forthcoming flooding is enhanced.

[24] http://kanchanapisek.or.th/kp2/m_stage/activities_e/ling_e/ling10_e.html

It must be noted however that the storage capacity of the area designated as monkey cheek is only 6 Mm^3, which corresponds to the storage capacity of the canals[25]. To put this volume in perspective this is only half an hour of a typical 3000 m^3/s flood flow of the Chao Phraya. The pumping capacity at the extremities of the Mahachai canal added to that of two minor pump stations totals 74 m^3/s. In the rainy seasons of 2017 and 2018, for example, the floodgates were closed to pump water out but this was not much needed since there was no significant overflow and the parallel canals had the capacity to drain.[26] The floodgates are also activated during the dry season to regulate the flow in order to flush out polluted water.

In summary the area provides a very modest storage capacity and, while it enhances the flood buffering capacity, its management follows a 'maximum flushing strategy' rather than one which would seek to store water during a specific period. It only acts as a very temporary retention area when constrained by the high tidal regime.

5 Management and technical complexities of rice-water relationships

5.1 Consequences of the shift to HYV double-cropping

Many of the problems experienced with flood in recent years cannot be understood without considering the consequences of the shift from traditional varieties (TV) grown in the rainy season to double cropping of HYV that occurred in most of the drainage boxes around 2010. This is why, before turning to the analysis of the 2017 kaem ling policy, we need to first identify and understand the earlier transformation in, and the consequences of, the management of the Chao Phraya Delta floodplain.

5.1.1 Dry season cultivation

At the end of the rainy season, after the land has been drained, farmers are generally eager to start cultivation as soon as possible: first because they will capitalize on the residual soil wetness and limit the water supply needed for land preparation; second because the different sources of water that can be tapped will all decrease with time; and third because an early start makes it easier to later grow a second crop before the next flood or, where the risk of flood is limited like in the West Bank, to grow two more crops. The uncontrolled expansion of a post-flood crop in the dry season is challenging for RID.[27] The water available in the dams is limited and has always been insufficient to allow a second crop across the Chao Phraya basin (and even delta), even more so with the growing demand.

[25] The Mahachai-Sanamchai canals scan store 4.6 Mm^3 and its lesser connected canals can store up to 1.4 Mm^3.

[26] In addition, closing the outlet of Khlong Mahachai removes its capacity to absorb the rising tide and concentrates the strength of the latter on the estuary of the Tha Chin River, causing local flooding.

[27] In 1999, Molle et al. (1999) wrote that "Boosting dry season (DS) water demand goes against RID policy. Therefore, it cannot reasonably be envisaged (…) to support a wide shift from WS to DS cropping, because of the pressure it would add to the water demand in the DS season".

Since the distribution of water across the basin takes time and since upstream projects tend to help themselves first, the availability of water both in terms of quantity and timing will vary widely. This is why a large part of the early dry season cropping is based on local resources which farmers abstract by pumping: according to the area these include groundwater, dredged wetlands (*bungs*) and excavated reservoirs (especially in the drainage boxes), water collected by the box drainage system, and water pumped from the river system: abstracting water from rivers can be done by individual farmers, pumps operated by subdistricts or village administrations, mobile pumps from RID (in particular in times of emergency), and finally fixed permanent large-scale RID pump stations, like those in the West Bank along the Tha Chin and Chao Phraya Rivers[28].

But massive optimistic planting of rice after the flood may be confronted with a lack of water at the end of the cycle, especially when the Bhumipol and Sirikit dams haven't collected much water during the rainy season, as happened in 2019 and 2020. This leads to desperate actions by farmers (Figure 12) and compels RID to find ways to support paddy fields in want of water to avoid damaging media coverage of withering crops: mobile pumps to pump from rivers, extra releases from Bhumipol/Sirikit dams, transfers from the Mae Klong basin, etc).

Figure 12: Farmers desperately trying to salvage their crops by pumping residual resources (Bang Kum box main drain, 2018) (Source: Khun Somboon, Ban Nong Mon)

Such a low stock situation or uncertainty leads RID, like in 2019 and again in 2020, to announce at the beginning of the year that farmers should not engage in cultivating a dry-season crop, as water supply will not be ensured. However, this is chiefly meant to protect RID from later complaints from farmers by making clear ahead of time that they will not take responsibility for crop failure. This is not always possible and reduction in yield or even crop loss may be observed,

[28] Water can also be admitted in by gravity at high tide.

like in March 2016 when 400,000 rai were expected to be damaged[29]. In practice it is almost impossible to prevent farmers from starting cultivation if they have access to some water. RID complains that farmers do not follow their instructions, but feel forced to help provide water to avoid crop loss. In exceptional situations, like in 2019-2020 this is just not possible (see below).

The shift in rice cultivation in the drainage boxes brought about a radical leap in land productivity, as average production per rai moved from 1.5-2 tons in the 2000s to around 8-10 t in present days, and therefore a dramatic increase in farmers' income. At the scale of RID Projects, *the shift also substantially increased the efficiency of water use* since return flows from higher land in the dry season are fully collected by the drainage system and reused, and also since local reservoirs capture part of the resource in the wet season to be used in the dry season. But the shift has also clearly increased the competition between highlanders and lowlanders, who now all vie for resources that are in general insufficient in the dry season.

The same problem is manifest at the level of the basin or the delta: since there is no return flow from irrigation projects to the river system and since, as the boxes increase the cultivable area, they meet a growing part of their need by abstracting water from rivers, the overall Chao Phraya River and Tha Chin River flows, notably at their estuary, are reduced: this worsens the chronic problem of saline water intrusion that periodically affects the lower delta in dry years (e.g. destroying durian and other fruit orchards in Nonthaburi[30], or orchid farms near Nakhon Pathom[31], or even threatening Bangkok's water supply intake[32]).

In addition to the resulting impact on the control of salinity intrusion in the delta, the excess in water demand in the dry season and its associated water crises also have a less visible, yet dire, consequence: to meet this demand RID is often led to *overdraw its strategic reserves in its main storage dams*. This may lead to very low storage at the end of the dry-season, say April, and has two extremely serious implications.

First, dam water will not be available to start the next cropping season and land preparation will be left to depend on rainfall and on whether early rainfall will fill the dams (see below). Second, an overdraft of Bhumipol and Sirikit dams *raises the risk of insufficient storage* for the next seasons. If the coming rainy season is weak and dams do *not* recover (given that they also have to release water for the wet season crop), like in 2015 and 2019, then RID may announce that *no water* is available for the next dry season. Such a scenario repeated over two successive years would just spell doom for the delta and Bangkok's domestic and industrial water supply.

The solution to overdraw dam resources also extends to the Mae Klong basin. When the discharge in the Tha Chin River in the dry-season is insufficient to control salinity intrusion, in

[29] https://forum.thaivisa.com/topic/901818-drought-to-damage-almost-half-a-million-rice-fields-in-central-thailand/

[30] For example, in 2016: www.nationmultimedia.com/national/Water-crisis-turns-acute-30282062.html

[31] The Nation, 2015. Orchid farms threatened by salt water. January 09, 2015. https://www.nationthailand.com/national/30251530

[32] In 2015: www.bangkokpost.com/thailand/general/602988/city-told-to-brace-for-salty-tap-water
In 2019-2020: https://www.bangkokpost.com/thailand/general/1828744/salty-tap-water-wont-hurt-mwa

general because the West Bank projects heavily pumps from it, and that not enough water is available in the Chao Phraya upper basin to send more water to the Phophya regulator (that controls releases to the lower Tha Chin River), then the pressure is shifted to the Mae Klong basin to transfer water to the Tha Chin[33]. Since the Mae Klong Basin is far less under pressure, the transfers already planned can often be increased, but also at the expense of raising risk in that basin. The Pasak basin is also increasingly solicited and now supplies most of the water going to the East bank in the dry season, while also sustaining the Chao Phraya river's lower reach.

5.1.2 Rainy season cultivation

Sometimes in April, then, but again with a large variation, farmers in the drainage boxes would be eager to start a second HYV crop. Establishing this wet season crop, however, is also constrained by water availability which, in that period, is governed by:

- Actual local rainfall, which can vary widely at the beginning of the rainy season;
- Rainfall and runoff in the highlands on both sides of the Chao Phraya Delta that create sideflows that cross the canals and may accumulate in some boxes (e.g. Phophya in the west and Wat Manee or Bang Kum in the east).
- The return flow from the higher land irrigated from irrigation canals.
- Water released by RID from main canals to drains, or by spill at the tail end of secondary canals.
- Inflow from rivers (Chao Phraya, Lop Buri, Noi, Tha Chin, etc) into the box.

These inflows are either natural or, later in the season, managed (for irrigation), or forced, that is, generated with a view to getting rid of excess water in the rivers (affecting populations outside the dikes) or in the canals (risk of overflow and damage).

Irregularity in total supply combined with plot-level heterogeneity (in terms of topography, elevation, distance from water sources, etc) govern farmers' decision on starting a new crop. One would imagine that lowland farmers whose water supply around April-May is constrained could just wait for it to increase since the various components of water supply distinguished above will normally quickly increase as the rainy season unfolds. This is actually what farmers on higher lands, not prone to flooding and served by irrigation canals, do.

But for lowlanders, the constraint then comes from timing: farmers establishing their crop after say, the beginning of June, would have to harvest it after mid-September and be exposed to the risk of flooding. Again, this risk varies highly according to the box, and is higher and earlier in Bang Rakam than in Bang Kum, and in Bang Kum than in Chao Chet-Bang Yihon. Some farmers may choose to sow a traditional variety in order to deal with that risk: this strategy (double

[33] This is done by releasing water to the Tha San Ban Plaa and Chorake Samphan drains that connect the two rivers.

cropping HYV+TV) can be observed in some residual areas of the Bang Kum or Wat Ulom boxes, for example. Others may choose not to grow a rainy-season crop because time is too short, signaling a rather odd situation whereby some farmers in the boxes do not grow rice in the rainy season any more. Many, however, are often willing to run the risk, especially if the price of rice is high. Risk can be partly alleviated by growing shorter-term rice varieties (85-105 days), which however have a lower yield and quality.

It is also important to understand that water availability will vary highly with time and according to the location. Staggering is the process by which crop establishment actually spreads over several weeks (and explains why some "farmers have been late" in establishing their crops). It has a macro level dimension: water released from the dam first traverses the middle basin (which will divert water first), then is diverted at Chai Nat to the different projects, upstream ones being served first.[34] But staggering also has a more local dimension and is the heterogeneous result of several site-specific factors that include topography (e.g. the time taken to drain the plot) and how water circulates (e.g. whether farmers abstract water in parallel from the same source or successively, along a ditch or a toposequence), rainfall (reducing the need for extra water to do land preparation), family or farming-system constraints (e.g. farmers having multiple activities or limited labour, or several distant plots that must be cultivated successively).

While it is wise for lowlanders to start cultivation early, this often chiefly depends on the ability of RID to start distributing water: this is conditioned by the status of the Bhumipol and Sirikit dams and by when precipitations conducive to substantial runoff occur (both river flows and dam stocks then allowing the supply of irrigation water to all irrigation schemes in the basin). Storage is almost always quite low at the end of the dry season, like in April 2019 when the deputy PM revealed that 23 large reservoirs were below 50 per cent of their total water capacity[35], due to the releases made to "*meet the high water demands in the [Chao Phraya] basin during the rest of the dry season*" (The Nation, 2019). The situation can be dramatic if dam storage is extremely low *and* when rainfall and runoff at the beginning of the rainy season are weak, like in April 2016 that came after a 2015 year with very limited inflow. This leads to an extremely late establishment of the main crop, which will then not be fully harvested if and when floods occur in October (or earlier). This is precisely what happened in 2016, when at the end of September 750,000 rai had not yet been harvested[36] and RID had to delay the diversion of water to drainage boxes, creating great tension with the Governor of Ayutthaya who pressed for relieving the pressure on the people living outside the dikes[37].

The necessity to protect the crops that have not been harvested in the boxes limits the amount of Chao Phraya's waters that can be diverted at Chainat[38], and shifts pressure on the river itself

[34] Even if projects officially receive quotas to ensure that they can all start more or less at the same time, in practice, especially when dam releases are limited, it takes time for other projects upstream to fill their whole canal systems and to let enough water to downstreamers.

[35] With stocks on April 15 at 7% of the 23.1 Bm3 they totaled at the beginning of the dry season.

[36] www.bangkokpost.com/thailand/politics/1107369/farmers-brace-as-river-water-diverted-to-farms-to-ease-floods

[37] www.bangkokpost.com/thailand/general/1095713/province-irrigation-dept-at-odds-over-floods

[38] If projects receive too much water, the excess will quickly end up in the drainage system, that is, in the lowland boxes.

causing flooding in the area outside the dike system (typically Lop Buri or Ayutthaya, where some narrow river sections (bottlenecks) can be found), but also outside of the irrigated area, along the Chainat-Pasak canal: since the sideflows coming from eastern highlands cannot be allowed to cross the canal (through the siphons), because this would flood the box, water accumulates along the canal and floods adjacent areas[39], as we have seen in the case of Bang Kum.

5.2 Analysis of the 2017 *kaem ling* policy

The flooding that affected people residing along the rivers, and outside the dike, in Ayutthaya, resulted in the policy proposed by the government in late 2016, which sought to establish a fixed calendar which would prevent such a situation. However, a complex situation, with multiple cropping calendars varying in space and time according (mainly) to access to a variety of (also varying) water resources, cannot be simplified and made uniform without a loss in flexibility and induced negative consequences, as the case studies examined above demonstrated.

As described earlier (§4.1), in 2017, the government promoted a policy which fixed the cropping calendar for 13 drainage boxes in the Chao Phraya basin. The imposition on farmers to respect this calendar was paralleled by a commitment by RID to create the conditions for the crops to be established early, both at the beginning of the rainy season and after the flood, to fill the boxes in order to promote natural fertilization and fisheries, and to compensate farmers, should their crops be damaged before the harvesting deadline in September.

Changing the water regime first has an impact on flood management. With the earlier water regime, the flood management capacity had been enhanced. Indeed, keeping boxes as empty as possible by releasing water whenever possible maximizes the buffering capacity of the drainage boxes. This mitigation capacity varied highly since it depended on how boxes are filled, whether naturally or by diversions from irrigation canals. The *new policy comes with three negative impacts* related to the timing of the flood regime in terms of starting date, intensity and duration.

With the promotion of the 'Release water in plots, release fishes in lowland' project by the governor of Ayutthaya in coordination with the Department of Fisheries (DOF)[40]; the RID and the MOAC, however, this buffering capacity was reduced. By promoting fixed calendars whereby farmers would have to harvest before the 15th of September (or a similar date) so that boxes can be filled, RID starts filling the box even when this is not necessary (and sometimes even not possible), *reducing the buffer capacity that might have been useful in October*. Molle et al. (1999) have shown that on the 1st of October, only 40 % of the box storage capacity in the delta is used, while at the end of the same month boxes are full (97 %). Starting to fill the boxes on the 15th of September strongly *goes against the idea of 'kaem ling'*: this is ironic since this policy is precisely marketed under this banner as a flood mitigation strategy.

[39] Forcing RID to pump part of this water into the Chainat-Pasak Canal, which is generally already full.

[40] Under this project, the DOF will release fishes into the uncultivated paddies as the RID fills the box for around three months. Farmers can thus gain complementary revenue from fishing while waiting for the next sowing period.

That this understanding has been lost in the new policy is illustrated by the instruction given by the governor of Ayutthaya that Bangbal box should start to be filled on the planned date: Bangbal is essentially a polder that can allow inflow from the Chao Phraya River through pipes across its dikes, or by pumping to an elevated irrigation canal. Since the water level in the Chao Phraya River was insufficient to allow inflow by gravity the governor asked for water to be *pumped* into the project… This was hydrologically flawed and economically costly but was dictated by the will to adhere to the plan regardless of the conditions[41].

Second, the policy also seeks to *fully* fill the boxes, actually reverting to the water management mode of the 1990s, *with the difference* that *no* rice is now cultivated in the boxes during the flood period. Doing so brings in fertilizing silt, kills weeds and rats, and allows for fish to grow and local villagers to catch them, benefits that are emphasized by Ayutthaya provincial authorities. In the Bang Kum box, for example, records from the past 5 years show that, in 4 years out of 5, the water level inside Bang Kum box has peaked at a level above 4 m, even with the strategy to keep low water levels in the boxes, which means that the control of weeds and the inflow of silt was also generally achieved to some extent with the earlier regime. Filling the boxes *fully*, even when this is not necessary, also *reduces the average buffer capacity*.

Third the provincial policy seeks to keep water in the boxes for 2.5 months. Lengthening this period artificially does promote fish production[42] but may delay the emptying of the box and therefore the establishment of the post-flood crop. This delay can result in making the cultivation of a second HYV crop in the box more difficult, and also prolongs the hardship faced by isolated people who have to travel by boat, as discussed earlier.

Apart from flood management, the policy also promotes the development of double cropping in the boxes and therefore *increases the water demand in the dry season*. While in the former water regime double cropping was also *possible* it was mostly left to the farmers to find adequate water resources to grow the post-flood crop (even if RID was sometimes forced to help avert crop loss by supplying some water), and to *bear the risk of doing so*. The new policy, in a bid to gain farmers' acceptance, has added the promise that water would be supplied in priority to farmers in the *kaem ling* boxes, in the dry season but also in the wet season to make sure that they harvest on time (mid-September). This not only fosters water demand but also encourages farmers' complaints when the RID cannot comply with its promise.

Last, the policy came with a second 'carrot', with the government committing to compensate farmers in case early flooding would damage their crop. Farmers would need to register and the potential benefits from this promise seem to have generated the registration of a cropping area much higher than the actual one, according to a local RID official in the Bang Kum box.

This new policy therefore appears to be counterproductive as it reduces flood management capacity and adds rigidity to management where adaptive capacity is required. As we have shown, each year is a 'different story' as the water storage status and the pattern of rainfall and

[41] it seems that RID dragged feet and eventually did not comply with the order.

[42] It is yet unclear whether fishing activities have indeed increased or not.

runoff generated across the basin *vary in intensity, space and time*. A fixed calendar as the one proposed for the kaem ling boxes is unlikely to be sustainable. Interestingly the Phophya project, on the western side of the Tha Chin River, is not part of the *kaem ling* policy because the governor of Suphan Buri province refused to be part of it. As a result, it is still managed in a flexible way, with no fixed dates and calendars and farmers attuning their cultivation to actual conditions.

The year 2019 provides an instructive example of how climatic irregularities combined with excessive demand quickly reveal the high vulnerability of the kaem ling policy. The year 2018 had a reasonably good rainy season (that came on top of already rather full reservoirs) and ended with higher than average storage in Bhumipol and (especially) Sirikit dams. But a lot of water was released in the 2018-2019 dry season because of the ever-increasing demand, notably that of the drainage boxes. Rainfall in the upper basin remained scarce during the first months of the rainy season (April to July), which delayed supply by RID and forced it to draw deeply on its two dams in June and July, much below the rule curve (see the evolution of dam storage in the appendix), in part because of the need of an early supply for the drainage boxes. To avoid disruption of Bangkok's water supply by salinity intrusion, RID had to divert 850 million m^3 of water from the Mae Klong River Basin to the lower Chao Phraya River Basin during the dry season[43]. To add to this worrisome situation, dam inflow in the 2019 rainy season remained very low and at the end of the year, total storage in the two dams was around 45% of full capacity (while Pasak dam is at 20% of its capacity). This prompted RID to ban cultivation in the dry-season, against its commitment to serve *kaem ling* drainage boxes in the delta.[44] In late January 2020 only 64 m^3/s were diverted at Chai Nat Dam, and 75 m^3/s released to the Chao Phraya River itself (see Appendix).[45] These extremely low values show that in exceptional conditions RID is effectively applying its policy to support no cultivation in the dry-season.

The key underlying cause of this instability, that is not fully made explicit in public declarations, is the increase in dry-season water demand that results from unchecked expansion of areas that are in a position to claim water in that season. Almost 300,000 ha in the floodplain of the delta have been allowed to shift to double-cropping in a piecemeal way, project by project, without enough consideration of the delta- and basin-level impacts of such a change. In addition, the irrigation area is still being extended in Thailand in general, and the Chao Phraya basin in particular, which creates additional claims for dry-season supply.[46] In January 2020 the minister of agriculture announced that RID was "speeding up the building of 421 Kaem Ling projects", with reservoirs capable of storing 942 million m^3 and a command area over 1.2 million rai, and

[43] The Nation. 20 Jan 2020. 421 reservoirs to help increase water storage capacity.

[44] Satellite images from January 2020 show that the lower delta fully engaged in cropping, while in the upper delta rice is only seen in some areas, mostly the lower Phophya project and parts of *kaem ling* boxes (probably relying on local resources).

[45] Planning targets limited water discharge in the Chao Phraya Basin at 18 Mm^3/day, only for domestic consumption, environmental flow and perennial crops (sugar cane, etc…).

[46] Between 2001 and 2017, the irrigated area under RID control has grown from 16.8 to 20 million rai, not considering kaem ling areas (Agricultural Yearbooks).

that "in fiscal budget 2020, the project will increase another 176,968 rai for irrigation and 199.54 million m^3 for water retention" (The Nation, 2020).[47]

The concept of *kaem ling* is now becoming a commodity. From the image originally used by His Majesty King Bhumibol Adulyadej to underline the importance of flood retarding basins, it is now used by the government as an equivalent of storage: conventional dams-cum-irrigation schemes are now constructed under the banner of kaem ling, as illustrated above. The minister of agriculture also indicated that an "urgent need is development and rehabilitation of water sources to increase water storage capacity. Kaem Ling projects will provide water for consumption in the community by digging a pond in a farm outside the irrigation area of size 1260 m^3 for 40,000 farmers who have asked for support nationwide" (The Nation, 20 Jan 2020). On-farm ponds are, thus, also marketed as 'kaem ling' projects. Although this cannot be developed in this report, the remarkable investments made by the government in the past twenty years in local water resources development (farm ponds, dredging of wetlands and *huai*, small reservoirs, well-digging…) must be emphasized. If these investments have improved the resilience of farmers and allowed intensification (often the cultivation of a second rice crop), their cumulative impact on runoff has never been considered. They, too, contribute to 'basin closure' (Molle, 2004) with more water being depleted locally and less flowing downstream, where large tracts of irrigated land wait for water.

6 Conclusion

This report has first identified several major consequences of the shift from TV to HYVs in the flood plain of the Chao Phraya River. Regarding flood management, the abandoning of the cultivation of deepwater/floating rice circa 2010 has removed the necessity to gradually but fully fill the drainage boxes in the delta. Water levels can therefore be kept at a minimum, but this is of course determined by rainfall and the flood pattern itself. This provides an optimal *kaem ling* strategy in that the buffering capacity is always optimal. It also allows farmers to adjust the starting of the dry-season crop to circumstances.

This paramount transformation of rice cultivation in the floodplain of the Chao Phraya Delta has allowed local farmers to intensify (single/double cropping of HYVs) and to increase their income dramatically, although substantial investments in on-farm development were necessary. Decisions to change the water regime seem to have largely been taken at the project level, without due consideration to their implications at the delta level. Two major consequences must be emphasized, one on irrigation water supply, the other on flood management. First, farmers are now expecting to be allocated water in the dry-season, at least on par with other farmers in the delta. Since they have access to local water resources (*huai*, reservoirs,…) they are often able to start their dry-season crop independently. This increases the implicit dry-season 'water demand' in the basin, which is already way beyond the resources available. In addition, the demand/supply ration is further deteriorating due to continuing water resources development

[47] In contrast, RID is trying to limit triple cropping in the upper west bank, as we have seen in the section on Phraya Banlue.

upstream of the delta.[48] Second, by accepting the shift, the RID has created a second constraint: because they are in the downstream part of RID projects in the delta and only get canal water later in the rainy season, farmers in the drainage boxes often start their cultivation quite late. As a result, the rice is not ripe when excess water reaches the delta (through lateral sideflows and the Chao Phraya River itself) during the rainy season. This prevents RID from diverting water to the boxes and using them as buffer areas. Water accumulates along the Chainat-Pasak Canal and in the river system, between the dikes, causing heavy flooding.

The government, as well as Ayutthaya's authorities, have reacted to this situation by establishing rigid cropping calendars whereby farmers in the boxes would be served first at the beginning of the season (April in Bang Rakam, early May in the delta) in order to expedite cultivation before flood risk becomes significant. But this solution is not proving to be robust: first, RID may not be in a position to send water early, as storage at the end of the dry season can be dramatically low. Second, strong rainfall occurrences can also happen in July, August or early September, when the boxes are not yet available to play their buffering role. Third, boxes are scheduled to be filled at a time when this is sometimes not useful and works against a *kaem ling* strategy that seeks to keep a buffering capacity as long as possible.[49] Or, as seen in the West Bank, RID might not even be in a position to fill Chao Chet-Bang Yihon project if water happens to be scarce that year (triggering complaints from farmers who have made plans according to the promised calendar). In addition, to enhance buy-in of the plan by farmers the government has promised to grant them preferential allocation in both seasons. But excessive needs and dam releases, confronted with climatic irregularities, often make it impossible for RID to stick to its commitment.

After the first year of the implementation of the 13 kaem ling areas, in 2017, the government ventured that "The success of the floodwater retention fields under the Bang Rakam Model project this year proved that it could significantly reduce flooding problems in the lower Chao Phraya River Basin, and also reduce the severe flooding in Sukhothai (…) [as well as] the government's burden to compensate for damage caused by flooding"[50]. Empirical evidence and newspaper releases do not paint a situation that can be qualified as a "success", neither in Bang Rakam (Trakuldit, 2018), nor in the delta (The Nation, 2017a, 2017b). In 2018 and 2019, investments in roads and reservoirs were made in Bang Rakam and RID was more careful not to raise the water levels in the boxes. Yet, the new arrangement is flawed for all the reasons discussed above.

Rigid and uniform calendars decreed by politicians who overlook the local complexities of project management result in unnecessary damage or loss of flood mitigation capacity. Indeed,

[48] For example, Tebkari et al. (2003) have found that observable flows in the Chao Phraya River and its 4 main tributaries decreased in the 1970-1990 period (by 38% at Nakhon Sawan, for example). Although they attribute this trend to changes in landuse in the basin, it is more directly related to the expansion of irrigated areas.

[49] As early as 2012, water expert Sutat Veesakul rightly noted that "Faced with a flood crisis in which water kept rising every day, if "monkey cheek" areas were made to take water too early, a second wave of runoff – possibly of larger volume – could pour in fast, and could become difficult for officials to control. We should let them be flooded at a low level then when water overflows the [river] banks, we can divert the excess into the monkey cheeks" (The Nation, 2012).

[50] www.nationthailand.com/national/30334817

the very nature of the hydrological variability of spatially distributed rainfall, runoff, and storage demands a flexible management. Farmers must adapt to this variability by making risk assessments that depend on their site-specific situation (topography, various water sources, farming systems, etc). By freezing cropping calendars, RID transfers the risk to itself and puts itself in a situation where it may not be able to stand by its commitment.

Strong and rigid orders may be seen by the government as a means of clear action and of ensuring compliance but local managers often have to strike a balance between these orders and the hydrologic reality. The Vice Prime Minister has, for example, instructed RID to keep the discharge downstream of the Chao Phraya dam in Chai Nat under 2700 m^3/s.[51] At the same time, and on the other hand, projects often act based on their own interest alone, and modify the water situation in other projects often without taking possible impacts into consideration.[52] When drainage boxes give up their rainy season rice this is negotiated locally between the project and the farmers, but with little consideration of the 'bigger picture'. This shows how local conditions should be identified, discussed and integrated into a wider plan, rather than the two extremes of either letting projects design their own policies or having the central command imposing a uniform and rigid management.

It must also be understood that pressure on RID to supply more water translates in an increasingly risky management of the dams, generating more frequent extreme events. In the dry season, water allocation is basically a zero-sum game and the spread of dry (and even support to, with the *kaem ling* policy) season cropping over the 300,000 ha of the floodplain necessarily means that either 1) more salinity intrusion will occur in the Chao Phraya and Tha Chin rivers, 2) some areas somewhere else in the basin will be deprived of water, 3) more water will have to be transferred from the Mae Klong basin[53], 4) more groundwater is depleted elsewhere in compensation, or 5) more water will be released from the dams *at the cost of more risk* and crises, that is, periods in which actual cropping calendars conflicts with either a shortage (no water for standing crops) or an excess of water (no room for flooding as the boxes are cultivated).

The four kaem ling cases reviewed also yielded some specific observations or lessons (Table 1). They illustrate in particular the cross-scale nature of water management, that is, how local decisions combined can have delta/basin-level consequences, and how basin level constraints will manifest themselves differentially in a very heterogeneous environment. Changes in cropping patterns and the water regime have shifted flood problems to other locations (the river and the areas along the Chainat-Pasak canal) and at other times, and reshaped the allocation of water in the dry season, the spatial distribution of cropping intensity and –more invisibly- of risk.

[51] In 2018 the maximum value recorded was… 2697 m^3/s, illustrating a well-known consequence of targets bureaucratically or politically imposed in a complex environment that cannot be fully controlled.

[52] For example, in 2006, Chao Chet-Bang Yihon Project did not want to open its regulators to admit more water in, which resulted in Phak Hai project to 'burst'.

[53] This involves pumping from the Tha Chin river and can only be done when storage in the Mae Klong basin itself is satisfactory.

But the complexity of water processes and their manifestation across space and time, make it very difficult to design a uniform management response.

Table 1: Summary of the main characteristics of the four kaem ling areas considered

'Drainage box'	Main characteristics/specificity	'Kaem ling' function analysis (specific points)
Bang Rakam	Flood expansion area of the Yom River (with Sukhothai bottleneck). Sporadic flooding is possible in July or August.	• The area was already used before as a buffer area • It is filled much earlier than in the delta • Claimed impact on flood/supply in the delta unconvincing
Bang Kum	Recent on-farm infrastructure and shift to double-cropping agreed by RID; water sourced from below (drain) and gravity irrigation projects.	• Early management (2000s) reproduced in a rigid way, but *without* rice cropping during the flood period. • Flood mitigation capacity is reduced by early filling and adaptivity is lost. • Sideflows not allowed in and creating flooding along main canal • Increased water demand and competition in the dry season. • 2017 policy not strictly implemented
Chao Chet-Bang Yihon	Mild and infrequent flooding Tripple-cropping common Pumping in and out between rivers and the project	• Rigid schedule ignores the heterogeneity of topography, local poldering, cropping intensity. • Planning allowing RID to impede triple cropping • Pumping costs to drain water in December; and to later supply extra water by pumping
Mahachai	Regulation of salinity (and pollution) for aquaculture	• Storage capacity limited to waterways • The project is actually designed to enhance drainage out to the sea, not inland storage

Now that the shift to HYVs in the drainage boxes has occurred almost 10 years ago it is hard to imagine that reverting to the old cropping pattern is possible. In all cases one of the benefits of the shift out of TVs is to have an optimal kaem ling strategy with regard to flood management and this should be retained. It does not appear to be wise to stick to a policy that promotes a *full* and *prolonged* flooding of the boxes starting at a *fixed date*. This rigid policy has implications that are strongly detrimental to flood management. That flooding should systematically be *full* (as it was before the shift) is justified by reasons of pest control or natural fertilization which seem pretty much ad hoc and little convincing. That it should be *prolonged* is clearly resented by

people and seems to be mainly justified by the intent to make triple-cropping in Chao Chet Project impossible, and also to enhance fisheries. Hydrologic variability makes it hard to ensure these parameters every year, generating complaints from farmers. This is hardly a sustainable policy.

The key remaining point is that of the harvest deadline. The (untold) benefit of a systematic filling of boxes at a fixed date was, perhaps, to send farmers a strong signal that they had no other choice than to adhere to the calendar (because fields would in all case be flooded, even if not necessary from a flood mitigation point of view). But we have seen that both in Bang Rakam and in Ayutthaya, localized flooding could occur even before the fixed date. In the delta these unusual early events have to be explained by the fact that all the boxes, not only those considered by the 2017 kaem ling policy, are cultivated and, therefore, cannot absorb possible early water excess in the delta, as was the case before. This forced the government to also promise compensations in case of early damage. If a fixed date does not work well, can we do without one?

Because of both the variability of hydrologic conditions, systematic low storage at the end of the dry season, the need for staggering, and the impossibility for RID to control farmers' behaviors on the ground it is likely that instances of late harvesting of lowlands in the rainy season will still occur in the future. A principle should be that instead of trying to enforce rigid calendars, farmers should be left responsible for assessing the specific level of risk attached to their plots. Several options can be further explored:

- A more detailed planning could earmark particular boxes which would be used as monkey cheeks in case of early excess of water. These boxes would not be cultivated in the rainy season and be available at any time. This role could be rotated each year[54].

- One way to mitigate risk, in some boxes at least, would be to promote the double cropping of HYV + TV, whereby instead of establishing a late HYV in June farmers could lower risk by sowing a deep-water variety that could stand a degree of flooding and be ripe after the flood: risk, however, is not completely eliminated in case of flooding of exceptional magnitude and duration.

- The priority given to *kaem ling* boxes actually signals a noteworthy 'reversal of chances' in the sense that areas that were markedly at a disadvantage in the past are now possibly poised to achieve higher cropping intensities than uplands.[55] An option is not to accept this 'reversal' and to make allocation to lowlands conditional upon the start of the rainy season. In case of very late precipitations/available runoff or dam water, it could be decided that boxes will not grow a wet season crop and will not be allocated water.

[54] But in years with no flooding, farmers in earmarked boxes are likely to complain of a useless 'sacrifice'. This is exactly what undermined the policy tested by RID in the 1990s to rotate beneficial areas in the dry season within each project.

[55] In practice, water destined to lowlands most of the time has to be conveyed through canals and drains that traverse highlands, where farmers can therefore abstract water on the way, as anecdotal evidence suggests.

- RID could also *not* allocate water to drainage boxes at all in the wet season, while keeping the priority in the dry season. This would limit double-cropping to those who can access (enough) local water sources to start cultivation early (before irrigation canals are able to supply them with water) and avoid flooding, the assessment of risk being left to the farmer.

- Conversely, RID could give its first supply in the wet season to the lower parts of drainage boxes, since higher land can start later, but *not* in the dry season. The second crop would then be limited to those who can grow one based on local resources (as seen on satellite images in January 2020).

All these options are allegedly difficult because of the changing hydrologic regime and because RID is not in control of farmers' decisions: but this is the consequence of having abandoned the former flood management regime.

Despite these difficulties and the lack of evidence of any improvement in flood management, the government continues to claim success for the its policy. In May 2019, the government was discussing the extended application of the Bang Rakam model to Prachinburi-Bang Pakong river basin (starting with a monkey cheek in the Bang Phluang low-lying area in Chachoengsao, as if it was not already used in case of flooding). In Septembre 2019, while visiting Sukhothai the Prime Minister suggested that farmers in flooded areas should do "like the 12 monkey cheeks in Ayutthaya" where they retain water in the rainy season to raise fish (Thairat, 2020).

The specific problem faced by Ayutthaya when it is not possible to divert excess flow to drainage boxes is likely to be solved by the approved project to build a 1200 m^3/ capacity bypass through Bangbal project, which will probably eliminate the trouble created by the current bottle neck near the ancient capital.[56] The similar problem experienced by Sukhothai where the Yom river capacity declines to 350 m^3/s will remain and Bang Rakam will continue to be (with the right bank of the river) the flood expansion area that will receive the excess flow from the Yom River[57].

The ONWR has recently emphasized the need to plan allocation not at the seasonal but rather at the annual or even pluri-annual level. Dam management rule curves can be elaborated to take into consideration mid-term risk. But following these curves restricts the amount of water that can be released and exposes the fact that basin-wide overallocation might be as high as a factor of 2, and that past management have favored short-term benefits (distributing more water) over risk reduction (keeping water to prepare for dry years), which contributes to explaining recurring crises. The year 2019 illustrated the impossibility to adhere to rule curves when demand is so high (see Appendix). The lack of recognition of the manufactured imbalance between supply and demand leads officials to blame climate change and to respond by augmenting supply (with, for example, 2.18 billion m^3 to be potentially imported from the Salween Basin[58]). It prevents us

[56] It has been given a greenlight by the Cabinet in January 2019. The project already went through the design phase and is currently undergoing the process of land acquisition.

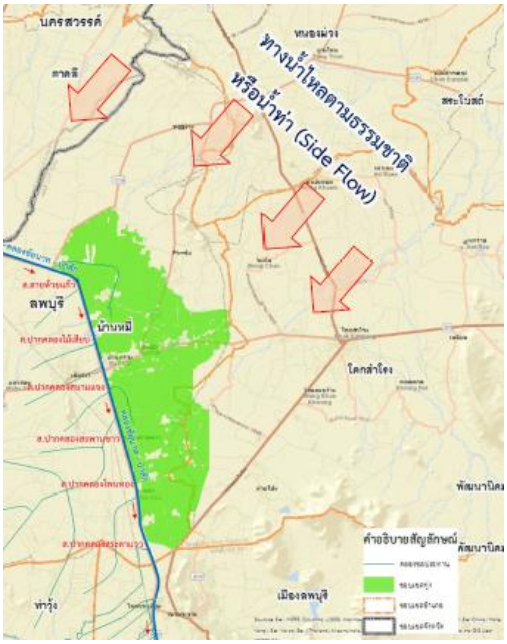
[57] Part of the flow (150 m^3/s) can also be diverted to the nan River.

[58] http://www.onwr.go.th/en/?page_id=4137

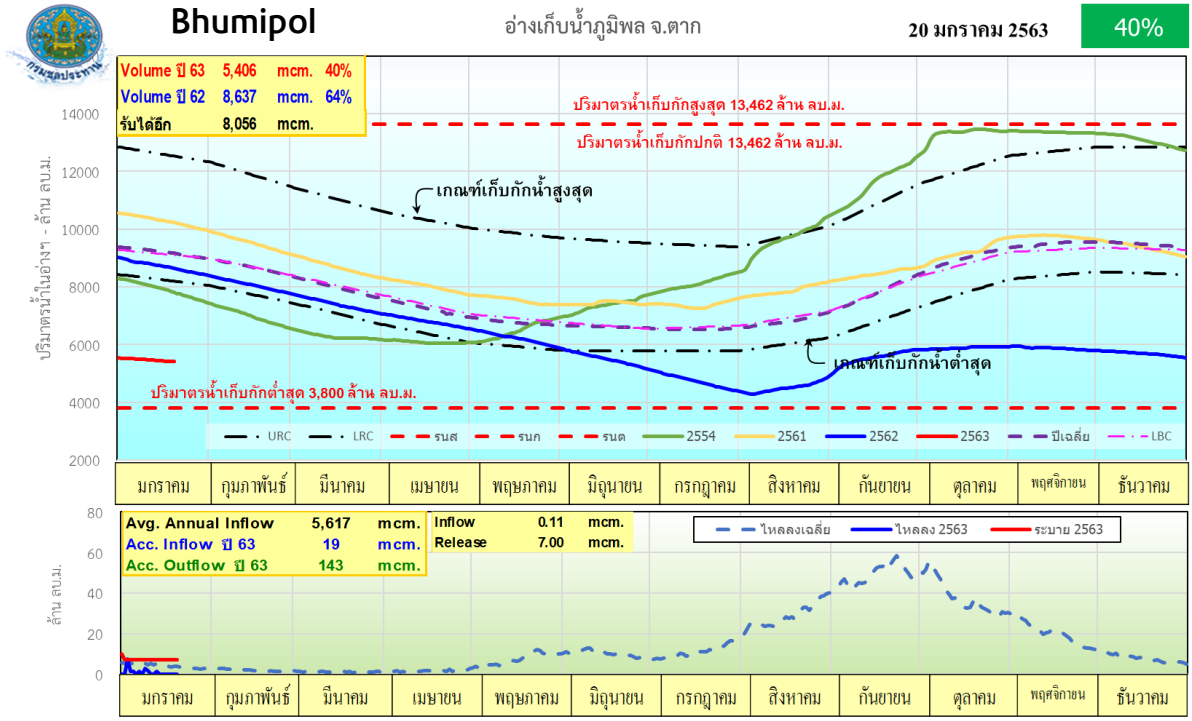
from recognizing that supply will never be enough and that, therefore, allocation mechanism should be made explicit rather than still entertaining the idea that a benevolent state will try its best to serve everybody.

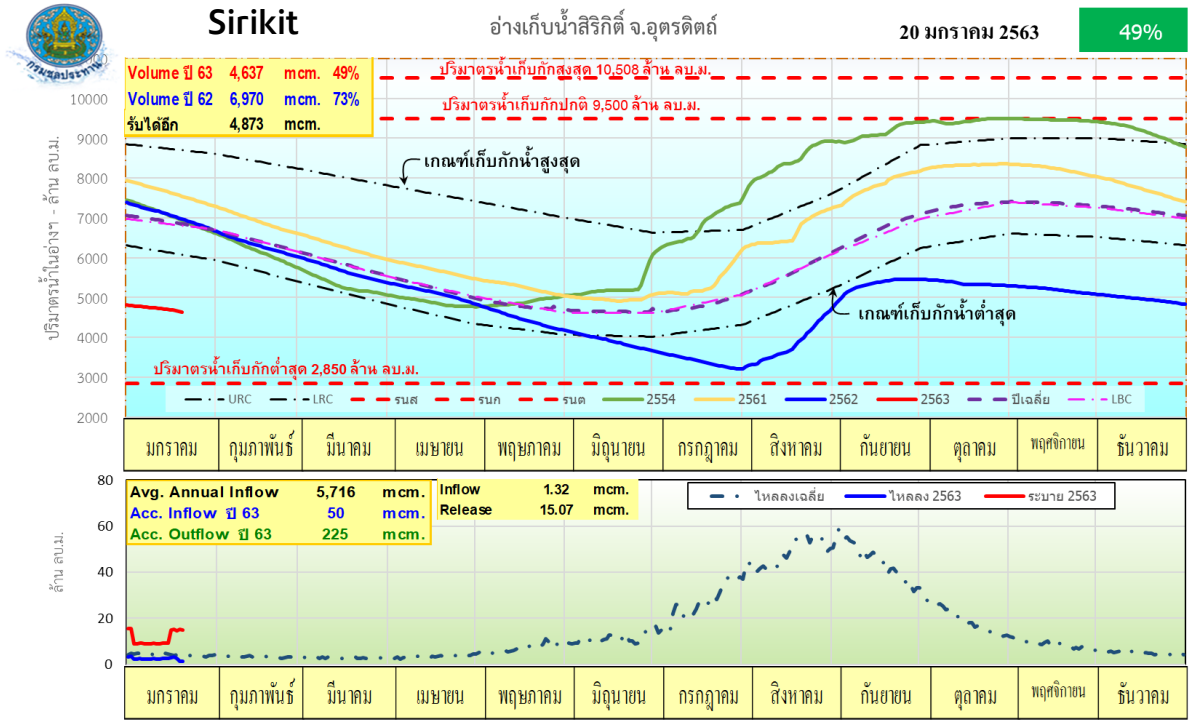
7 Appendix

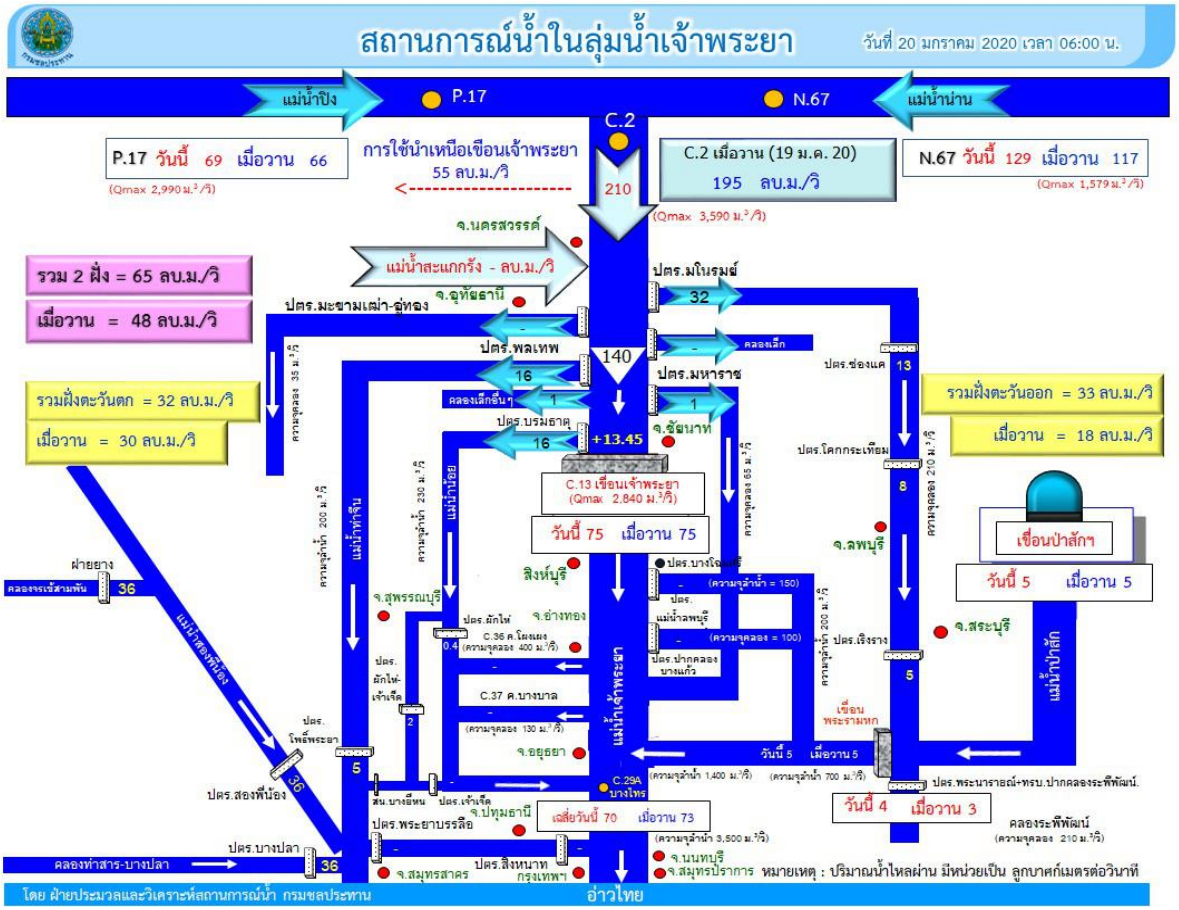
Sideflows accumulating along the Chainat-Pasak canal to avoid their entering the Ban Chomsii box before rice is harvested



The water situation in Bhumipol and Sirikit dams on January 20, 2020







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