Dry-season water allocation in the Chao Phraya basin: what is at stake and how to gain in efficiency and equity[1]

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Abstract: *The Chao Phraya basin has long been a water-deficit basin. Water stored in the Bhumipol and Sirikit dams only allow the irrigation of half of the delta, in average. The share of water available for agriculture in the delta is declining because of higher water abstraction both within the upper reaches of the basin and in Bangkok Metropolitan Area. The question of where, to whom, when and how this scarce resource is allocated is therefore of paramount importance.*

The paper first reviews the sectoral and spatial pattern of allocation in the last 25 years and assesses the efficiency and the equity of this allocation. It subsequently investigates all the options offered to increase management efficiency and proposes some guideline for achieving higher equity and more even sustainability of farming systems. This includes technical, socio-institutional and economic issues.

1 Introduction

The Chao Phraya basin makes up one third of Thailand's territory, encompasses the great majority of irrigated areas and also includes Bangkok Metropolitan Area. The basin can be conveniently divided in three sections (Figure 1). The *upper basin* (the catchment area of Bhumipol and Sirikit dams), the *middle basin* (downstream of the dams, down to Nakhon Sawan), and the lower part (or the *delta*). The yearly inflow into the dams has been declining because of deforestation, decreasing precipitation (Bancha, *this conference*) and growing water abstraction in the upper basin, from 11 to 9 billion m3 during the last thirty years (Molle et al. 2000). In the middle reach, both medium and large scale RID projects and group irrigation based on pumping along the river (fostered by the Department of Energy Promotion). In the delta, 1 million ha can potentially be irrigated (with a high potential for triple cropping), while BMA's demand has risen from .36 million m3/day in 1979 to

[1] This papers presents a few points drawn from the report: Molle, François; Chompadist, Chatchom; Srijantr, T. and Jesda Keawkulaya. 2000. Dry-season water allocation and management in the Chao Phraya basin. Research Report submitted to the EU, draft, Bangkok, 235 p.

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approximately 7.5 million m3/day in 2000 (which includes an approximate 3 Mm3/day from underground water). A twenty one fold increase in twenty two years...

During the dry season, all water users within the middle and lower reaches of the basin rely, by and large, on water delivered by the Bhumipol and Sirikit dams. Declining inflows and growing non-agricultural use makes a despairingly simple equation: water resources for agriculture are deemed to decrease substantially, with a drastic impact on the sustainability of farming in the irrigated areas of the basin. A wide range of solutions have been proposed, debated or opposed by the different stakeholders concerned by the issue. These include:

Increase of supply: This is the preferred option of government agencies which have been engaged in water resources development in the past (RID, EGAT,..). The main solutions are the building of additional dams, the transbasin diversion of water from the Salaween and Mekong rivers, the tapping of more aquifers.

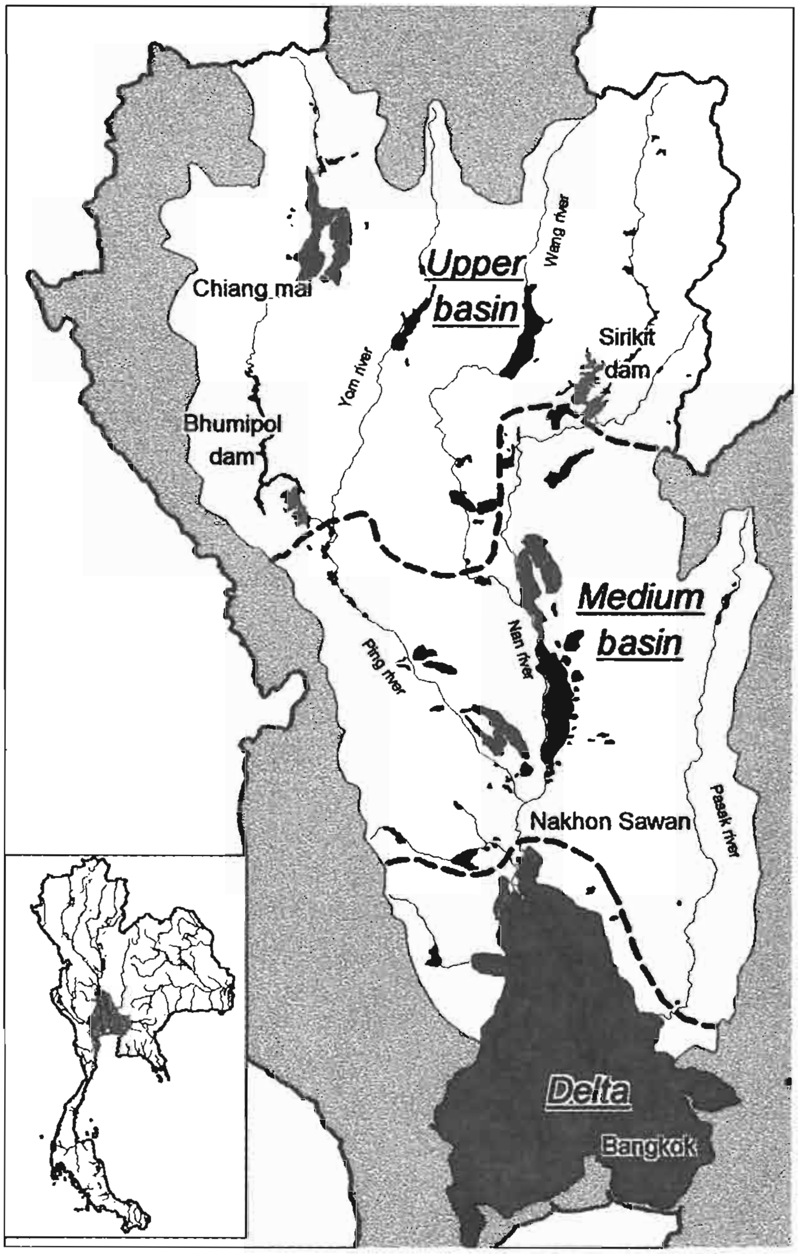
Improvement of overall management: Improved knowledge of hydrologic conditions, better co-ordination, better timing and assessment of water releases, reduction of water released by the dams and flowing to the sea in excess of the discharge needed to control seawater intrusion, etc. Institutional and administrative reforms are also needed to create a Basin Agency which should be responsible for the allocation and monitoring of water supply, for the control of the development of water use, and for enforcing legislation.

Water saving and upgrading efficiency of use: All users may potentially use water in smaller quantities *and* with fewer losses. Irrigators should adopt water saving farm practices and crops with lower water requirements. They should associate in order to adopt patterns of water distribution believed to reduce waste and increase equity. Loss by infiltration in canals could be cut by lining them. Urban tap water networks should be improved to reduce leakage. Industries should adopt water saving innovations and recycling of the water which quality has deteriorated to the point that it cannot be used anymore (a sink in the system).

Economic incentives: In parallel, or as a complement, policies aimed at introducing economic incentives should contribute to water saving ("user-pay principle"), water quality protection ("polluter-pay principle") and to an economically more efficient allocation of water among users (water rights, water markets). Far-reaching administrative and legal reforms are pre-requisite to these options.

All these options have pros and cons, contenders and opponents. The present paper is not intended to address all these options. A first part examines projections of water use and stresses the impact on agriculture in the dry-season. Past records of water allocation in the last 25 years are then assessed and patterns of spatial inequity are emphasised. Attention will then be turned to the allocation and distribution processes, and several improvements are proposed in order to increase efficiency and equity.

FIGURE 1: LAYOUT OF THE CHAO PHRAYA BASIN AND ITS THREE SUB-DIVISIONS



2 Mid and long term perspective on water use in the basin

We must first establish a prospective view on how the pattern of water use is likely to evolve in the near future. All the projections presented below are based on orders of magnitude and average (or median) values; they represent likely trends, and disregard yearly fluctuations.

2.1 Supply side

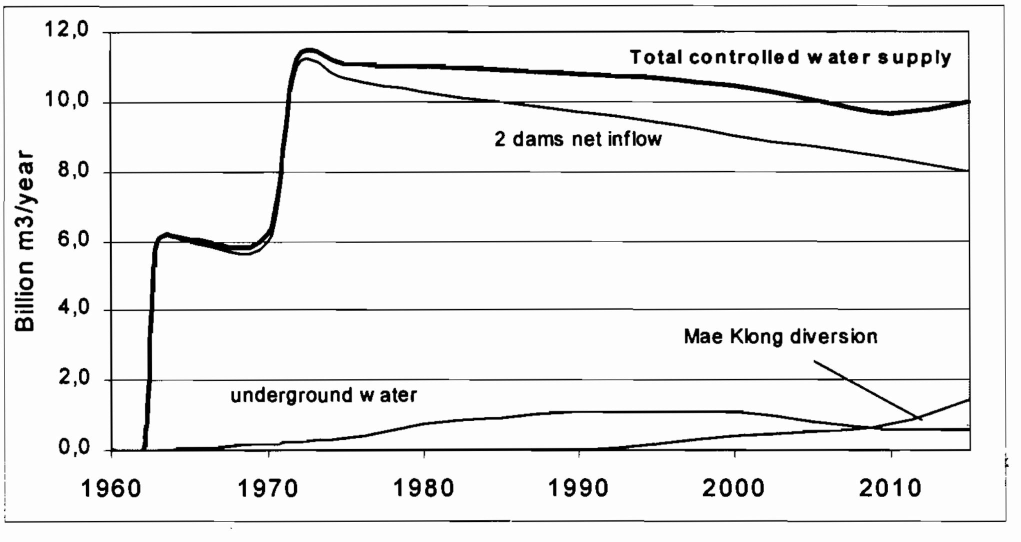
On the supply side, there is little data on how the inflow into the two dams is going to evolve but both the absolute increase of water abstraction in the upper part of the basin and the declining rainfall climatic trend do not allow the slightest hope that supply will increase. In the northern region, the irrigated area is reported to have increased 47% between 1980 and 1989 (ESCAP, 1981). It is estimated that the two dams yearly net inflow (evaporation discounted) has decreased from 11 to 9 Bm3 in the last 28 years and that it will drop another 1 Bm3 in the next 15 years (Molle et al. 2000).

Water diverted from the Mae Klong basin is already reaching Thon Buri in limited amounts (.4 Bm3/year) but the discharge is phased to reach 23 cms in 2010 and a maximum of 45 cms in 2017, in accordance with the gradual development of water treatment units.

There is no reliable data on the exact volume extracted from the aquifer in BMA. Estimates from JICA, ten years ago, amounted to 2.9 Mm3/day and TDRI (1990) concluded that they are probably around 3 million m^3/day (=3 Mm3/day). Bangkok and the surrounding provinces are now believed to use 1.5 million cubic metres out of 2.5 of water pumped from underground aquifers each year (Bangkok Post, 1999). Given (a) that the price differential between piped water and groundwater has not been bridged in the last ten years; (b) that the industrial sector has dramatically expanded, and (c) the admitted unrecorded pumping, there is little likelihood that these amounts may have decreased during this period. Therefore, our calculations are made considering an actual pumping rate of 3 Mm3/day. It is also estimated that the capacity of Bangkok aquifers to supply ground water is about 1 Mm3/day, but that extraction should be less than this capacity in order to prevent land subsidence (Bangkok Post, 1999).

Figure 2 shows that the estimated amount and variation of the different sources of water. Overall, the average total controlled water supply in the basin (from dams, underground water and diversion from the Mae Klong) is going to decrease under 10 Bm3 (with a slight temporary rebound in 2015 due to the full capacity of the diversion from Mae Klong but further decline in the long term).

FIGURE 2: TRENDS IN TOTAL AVERAGE SUPPLY TO THE CHAO PHRAYA BASIN (MIDDLE AND LOWER REACH)



2.2 Demand side

On the demand side, it is assumed that water uses and dams releases in the wet season will not vary significantly. Agriculture will continue to be supplemented with irrigation at similar rates and the impact of the growth of other uses will be marginal because of their magnitude and of the contribution of uncontrolled side-flows. The focus is therefore on the water remaining for dry-season cropping, while the production potential of the irrigated agricultural sector will remain largely above the share of water which is likely to be apportioned to it.

A growing and little elastic demand is governed by the growth of cities and industries. TDRI's projections in (TDRI, 1990) were based on a water demand in BMA projected to grow at 9% per year for residential and 10% for services but the crisis has probably levelled of these numbers. We will consider here different hypotheses of growth from a current value of 7.5 Mm3/day, including 3 M from aquifers. The obvious unsustainable nature of groundwater overdraft means that, sooner or later, the water supplied by the aquifer will have to be drawn from superficial water (Sethaputra et al. 1990). If we consider that at least half of the estimated 3 Mm3/day underground water contribution will have to be transferred to superficial supplies, this means that another 0.55 Bm3 must be supplied yearly by the river system (Chao Phraya and Mae Klong). In other words, Bangkok area is on the way to move from a negligible or secondary user to a main one. Even though, fortunately, a large part of Bangkok needs will be supplied by sideflows, the burden on the reservoirs is still estimated at around half of the total need in superficial water[5].

2.3 Balancing demand and supply

Assuming that the wet season commands an average dams release of 5 Bm3 (as seen from historical series) and that this value will change little in the mid-term (see earlier comment), we may now use the projections on overall supply to deduce both the amount of water available in the dry-season and the share remaining for agriculture after other priority uses are satisfied.

The trend in water requirements for BMA is here estimated for a growth ratio of 5%/year. This demand will be partly met by underground water, Mae Klong diversion and by the Chao Phraya river. Salinity control (water lost to the sea), is attributed a floor value of .5 Bm3 for the dry season. The increase of supply from the Mae Klong and the decrease by half of underground water (passed over to superficial water[6]) are also taken into account. *The average controlled water (dams) which will be available for irrigation and other uses in the delta and middle basin in the dry season will undergo a cut of 15% (from 5.1 to 4.4 Bm3) in the next 15 years.* For yearly growth rates of 3% and 7%, these cuts will be 4 and 30 Bm3 respectively. The decrease will be extremely sensitive to the growth of non-agricultural use

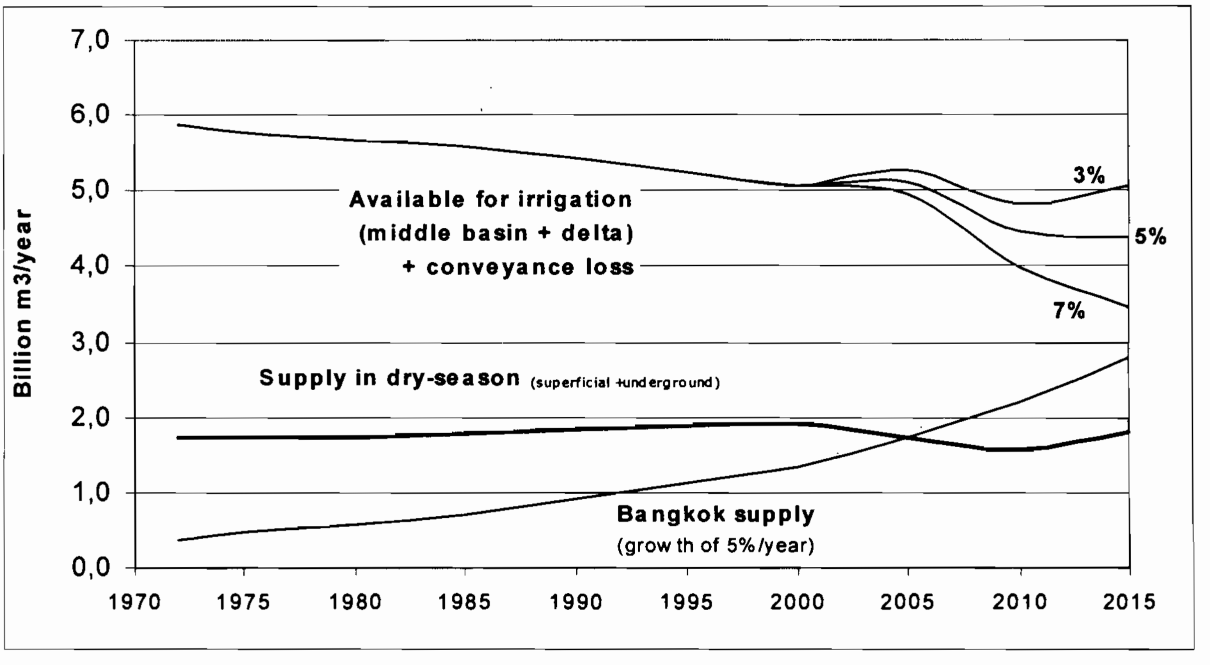
[5] During the month of January, abundant water is coming from the drainage of the floodplain. Dams are contributing mostly in the February-June period, and in some periods of the wet season in some years.

[6] This also means, in passing, that BMA will have to upgrade its capacity to distribute superficial water.

which is now more problematic to assess than before the crisis: using the rates adopted by TDRI in the 1990 study, the cut would be 54%... It is worth noting again that the situation is significantly smoothened by the rising inflow from the Mae Klong basin scheduled over the next decade, without which the drop would be far more critical.

The general picture in the 15 years ahead is therefore one of a significant reduction of the water available for the agricultural sector, which will turn drastic if demand growth returns to pre-crisis levels.

FIGURE 3: EVOLUTION OF THE AVERAGE TOTAL CONTROLLED WATER SUPPLY IN THE BASIN



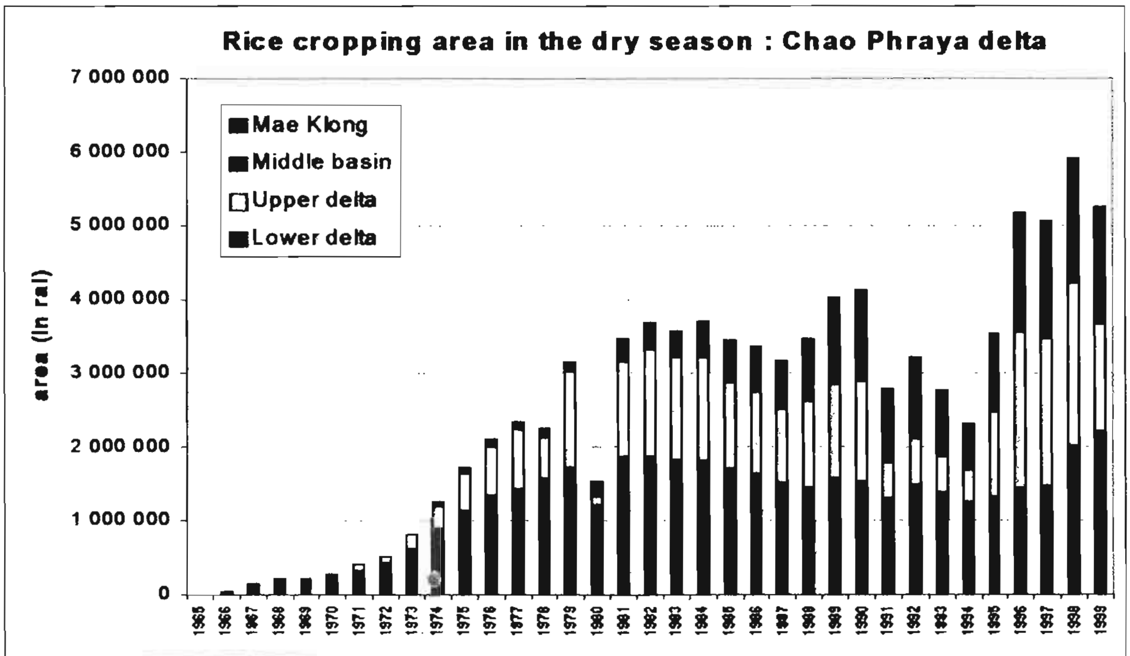
3 Historical patterns of spatial allocation (1977-1999)

3.1 The growth of dry-season cropping

A first surge of double cropping (72,000 rai) was observed in the year 1971 in the upper delta; this was concomitant to the advent of High Yield Varieties (HYVs). A second hike occurred in 1973, further to the beginning of the operation of the Sirikit dam and the threshold of 2 million rai was reached in 1976 ; only three years later, the rice area amounted to 3 million rai (a little less than 500,000 ha), a value which can be taken as an average for the 20 ensuing years. During this period, the upper delta accounted for an average of 45% of the DS rice area, against 55% for the lower delta. Figure 4 also presents the rice area corresponding to the Mae Klong area. From this figure pops up the evidence of a notable difference between the upper and lower parts of the delta: while the later, with an average value of 1.8 millions rai, remains rather stable (although showing a gradual decline due to the encroachment of urban areas), the share of the upper delta is rather hectic. The all times record occurred in 1998, after three consecutive years in which the share of the upper delta exceeded that of the lower delta to reach 2 millions rai. This came along with a surge of triple cropping, amounting to roughly 1 million rai in 1998 and 1999.

To put it short, the lower delta is advantaged in years of shortage, as water is delivered to this area in priority, in order to ensure environmental sustainability, transportation and to control saline intrusions. With water filling up the extensive and dense network of channels of this flat area, there is little scope for farmers to refrain from pumping and for officers to prevent them to do so. In years of abundant water, large supplies are derived to all main waterways branching off the Chao Phraya river in Chai Nat, and the upper delta can extract water first.

FIGURE 4: EVOLUTION OF THE AREA CROPPED WITH RICE IN THE DRY-SEASON



3.2 Cropping intensity

These cropping areas can be translated in terms of cropping intensities. Calculations are based on the data collected and published by RID at the Project level. These data are not deprived of errors[7]. However, apart from being the only data available, their quality can be

[7] Several reservations must however be made. Data for the lower delta seem less reliable because the density of field staff is much lower (no zonemen) and no map is available to really determine the cropping area. The assessment of cropping intensity is also obscured by the fact that cropping calendars are shifted and that the distinction between wet and dry season is not always clear-cut. Some areas may grow only a DS crop and no WS crop, distorting the calculation of the potential rice area. This is responsible for some imprecision in the West Bank, notably Chao Chet and Phrayabanlue Projects and also affects Pho Phya project (which southern tip is on the same hydrological regime as the West Bank) and Phak Hai Project (which in the last 10 years has undergone a drastic shift from WS floating rice mono-cropping towards dry-season HYV rice cropping). What is the potential rice area is not always precisely known. Taking the (running) maximum rice area cultivated over 3 years is not always correct because there might be some fallow land. In Chao Chet Bang Yeehon Project, for example, the

considered reasonably good, particularly when one acknowledges the difficulty of the task of recording land use data (see Molle et al. 1998).

Several types of cropping intensity indices can be calculated (Table 1). The average *rice cropping intensity* is the ratio between the dry-season + wet season rice areas and the estimated potential rice area. Considering the upper and lower delta, aggregated figures give indices of 1.34 and 1.44 respectively, with an average for the delta of 1.38. Cropping intensity can also be computed considering adding field crops (FC) to the wet+dry season rice area. This entails an average increment of the indice of 0.02 for the upper delta. It can also be computed by considering the total non-rice area under cultivation, including fruit trees, year-round vegetable production, sugar cane and aquaculture (Tot). The average indices [DS rice + WS rice + FC + 2*Tot]/[Potential irrigated area], or the *Total cropping intensity*[8], is given in Table 1. It reveals that for the period running from 1981 to 1999, the total cropping intensity has been 1.40 for the upper delta and 1.51 for the lower delta (average 1.45). The same indices, calculated for the last 5 years, yields overall values of 1.57 and 1.70. In conclusion, the upper delta appears to have around 40% of its irrigated area cropped during the dry season, with a rather high elasticity in case of abundant water supply, while the lower delta is roughly half cultivated in the dry season. This last value, however, is strongly influenced by the inclusion of Pasak Tai and Nakhon Luang Projects in the East Bank, both with very low cropping intensity. It is further pulled downward by values of DS rice area for the Rangsit Tai projects which are believed to be underrated. If we account for these two factors and restrict ourselves to the lower East Bank (Rice CI 1.50), combined with the West Bank (Rice CI of 1.70), we find a more realistic cropping intensity of 1.60 for the lower delta, and around 1.80 for the last 5 years. The total crop intensity index is at 1.65 for the lower delta (1981-1999). The temporal variation of the delta rice cropping intensity is given in Figure 5.

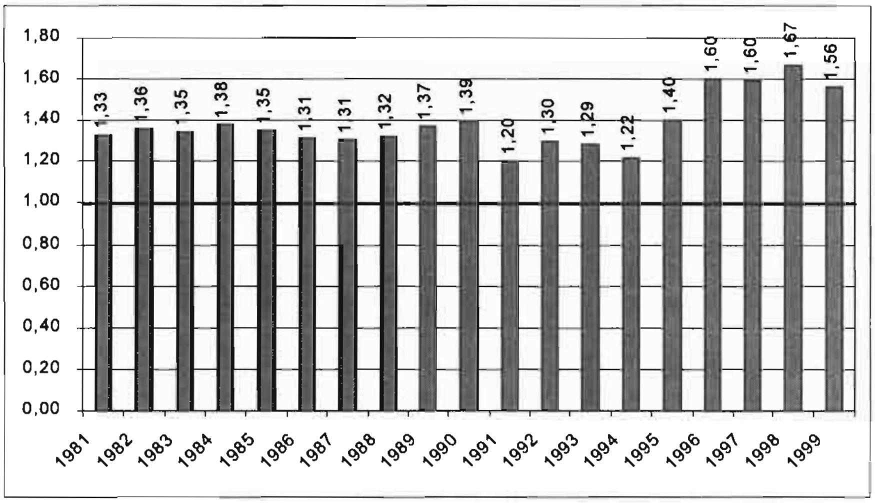
TABLE 1: CROPPING INTENSITY INDEXES

	Rice cropping intensity	Rice + Fc crop. Intensity	Total cropping intensity	Rice cropping intensity	Total cropping intensity
Period	1981-1999			1995-99	
Upper delta	1,34	1,36	1,40	1,52	1,57
Lower delta	1,44	1.45	1,51	1,63	1,70
Total delta	1,38	1,40	1,45	1,57	1,63

official irrigated area is 406.000 rai but the maximum rice area is 310.000 rai. The difference includes non-rice crops, fallow land, and areas changed to built-up. Triple cropping (only recorded since 1998 but much older) also makes things more difficult.

[8] Note that perennial crops are multiplied by two. This is because the cropping intensity indexes considered here are relative to a seasonal rice crop, not to absolute soil occupancy along the year. Full rice double cropping gives an indice of 2, whereas a soil occupancy index would be close to 0.65. Perennial crops are supposed to be equivalent to two crops of rice.

FIGURE 5: AVERAGE RICE CROPPING INTENSITY FOR THE DELTA (1980-199)



3.3 Spatial patterns of dry-season cropping

The contrast mentioned earlier regarding the upper and the lower deltas is likely to be sharpened when observing the smaller scale of the Project level. This readily defines a spatial heterogeneity, both year by year and on the average over 20 years, which translates in terms of *(in)equity*. The quality of the access to water is governed by several factors, including physical, technical and political, which contribute to shaping the spatial pattern of water allocation.

The first index considered here:

CI1= [*(DSrice + WSrice + F.Crops + 2*Perenials)/agricultural potential cropping area*]

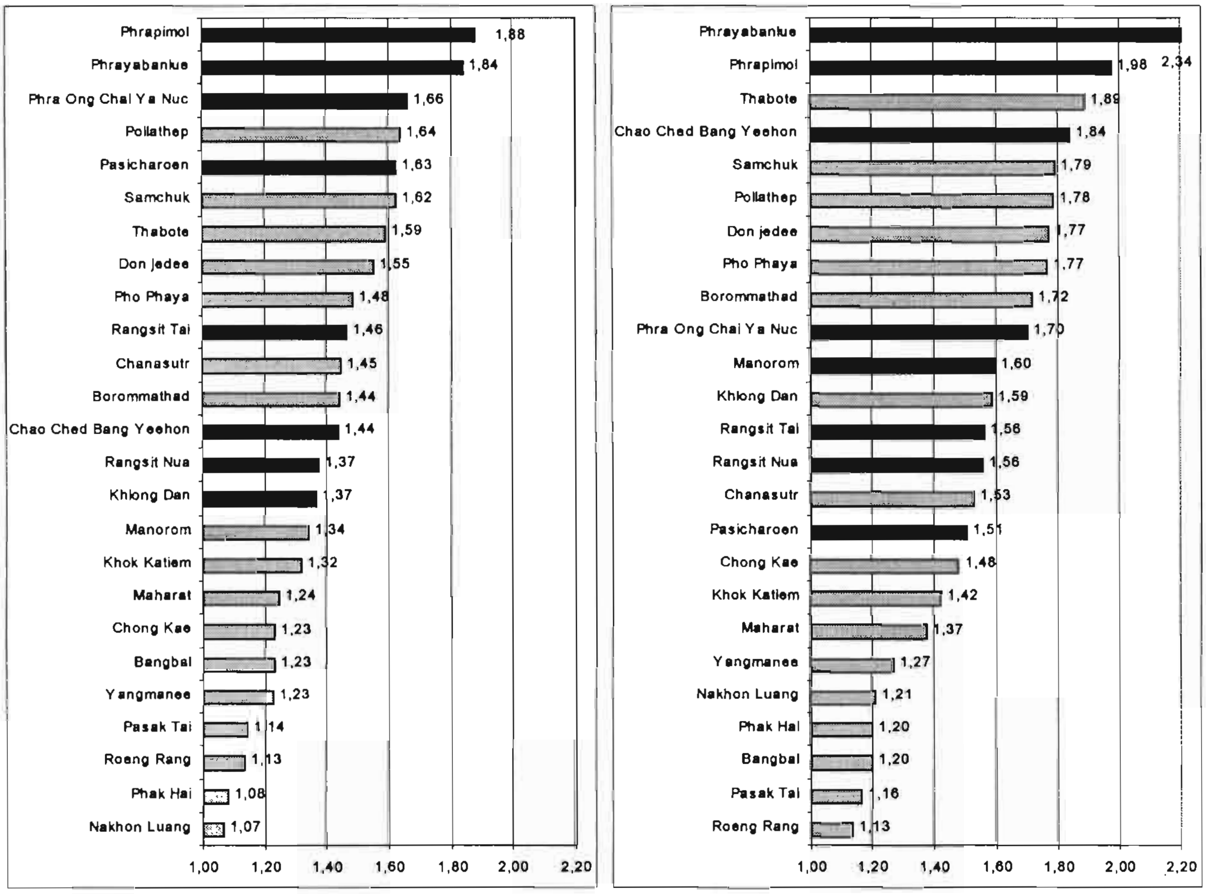
is indicative of the effective benefit drawn from DS cropping (or irrigation) by a given project with its specific constraints ; it includes all crops and takes the *agricultural potential cropping area for one season* as a unit. Figure 7 displays the spatial variation of CI1 both for the 1981-1999 period and the 1995-1999 period. The west of the delta appears to be characterised by much higher indices than the east (especially upper east). The pattern was changed in the last 5 years (with an increase of the cropping intensity in the lower delta) but, while all indices are on the rise, the central and eastern upper-delta still do not reap the full benefice of irrigation.

The Project total cropping intensities just shown are partly biased by the fact that the rice area in the dry-season has been implicitly compared with the *potential rice area in the wet season:* this does not take into account the fact that some projects encompass floating rice areas which are deprived of on-farm infrastructures (ditch, levelling, bunding) and which, therefore, are not candidate to DS cropping.

CI2 = [1+*(DS rice + F.Crops)/potential rice area in the dry-season*], compares *rice cropping intensities* on the *sole* area which can, technically, achieve double-cropping: this serves as a formal index of spatial equity[9].

The values of CI2 by Project are displayed in Figure 6. Inequalities regarding Projects[10] partly deprived of on-farm infrastructures have been reduced but the sheer contrast have not disappeared. For the last 5 year period[11], the magnitude is raised but the order is slightly modified. The spatial patterns of inequity in cropping intensity evidenced remain whatever variation of the index is considered.

FIGURE 6: CI2, RICE+FIELD CROPS INTENSITY INDEX (1981-1999 AND 1995-1999)



[9] This indice, however, creates difficulties for projects which are not fully cropped in the wet season (upper west bank, Phak Hai, Phophya). It is therefore applied only to the projects which do have restrictions of on-farm infrastructure.

[10] Namely: Maharat, Yangmanee, Roeng Rang, Kok Katiem, Pasak Tai, Nakhon Luang, and to a much lesser extend Chanasutr, Borommathad, Chong Kae, Bang Bal.

[11] The indice is only for rice (Field crops non included)

TABLE 2: CROPPING INTENSITY INDEXES, BY PROJECT

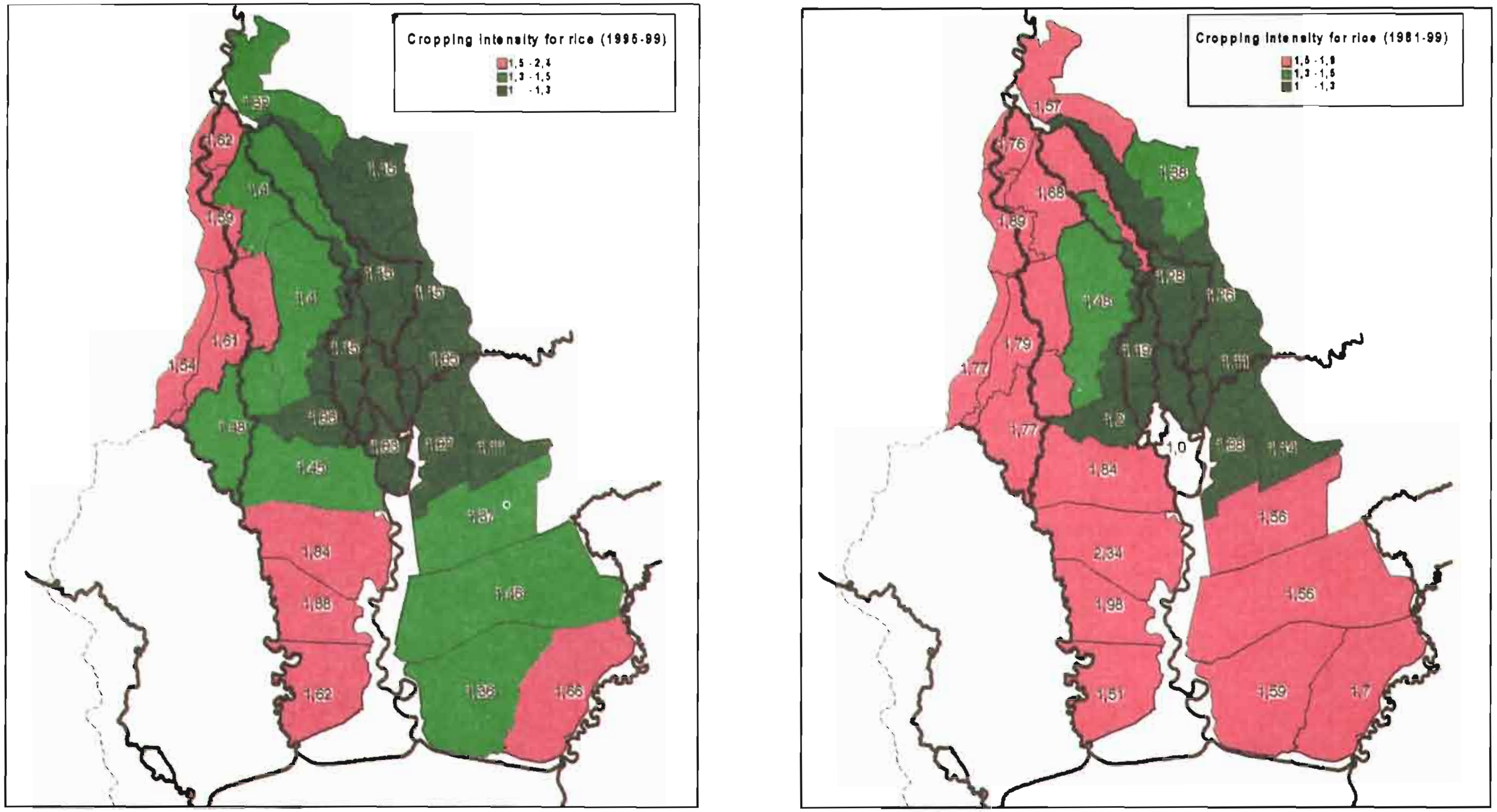
Project	Rice CI	Rice + FC CI	Total CI	Rice CI	Total CI	Rice + FC correct CI	Rice correct CI	%of area with no on-farm
Period	1981-99			1995-99		1995-99	1995-99	%
Borommathad	1,40	1,42	1,40	1,64	1,68	1,44	1,72	5
Chanasutr	1,40	1,40	1,36	1,38	1,48	1,45	1,53	10
Chong Kae	1,15	1,19	1,18	1,38	1,38	1,23	1,48	20
Don jedee	1,54	1,55	1,51	1,66	1,77	1,55	1,77	0
Khok Katiem	1,15	1,19	1,18	1,27	1,26	1,32	1,42	39
Maharat	1,15	1,18	1,18	1,29	1,28	1,24	1,37	25
Manorom	1,32	1,33	1,32	1,55	1,57	1,34	1,60	5
Pho Phaya	1,48	1,48	1,46	1,71	1,77	1,48	1,77	0
Pollathep	1,62	1,62	1,61	1,75	1,76	1,64	1,78	3
Roeng Rang	1,05	1,11	1,10	1,15	1,11	1,13	1,13	15
Samchuk	1,61	1,62	1,52	1,63	1,79	1,62	1,79	0
Thabote	1,59	1,59	1,56	1,81	1,89	1,59	1,89	0
Yangmanee	1,15	1,16	1,15	1,17	1,19	1,23	1,27	30
Nakhon Luang	1,02	1,03	1,03	1,08	1,08	1,07	1,21	60
Pasak Tai	1,11	1,12	1,11	1,13	1,14	1,14	1,16	15
Phak Hai	1,06	1,08	1,08	1,20	1,20	1,18	1,45	55
Bangbal	1,03	1,06	1,05	1,06	1,05	1,23	1,20	75
Chao Ched Bang Yeehon	1,45	1,44	1,41	1,75	1,84	1,44	1,84	0
Khlong Dan	1,36	1,37	1,29	1,49	1,59	1,37	1,59	0
Pasicharoen	1,62	1,63	1,32	1,16	1,51	1,63	1,51	0
Phra Ong Chai Ya Nuc	1,66	1,66	1,59	1,60	1,70	1,66	1,70	0
Phrapimol	1,88	1,88	1,74	1,79	1,98	1,88	1,98	0
Phrayabanlue	1,84	1,84	1,76	2,20	2,34	1,84	2,34	0
Rangsit Nua	1,37	1,37	1,23	1,24	1,56	1,37	1,56	0
Rangsit Tai	1,46	1,46	1,44	1,51	1,56	1,46	1,56	0
TOTAL upper delta	**1,34**	**1,36**	**1,33**	**1,48**	**1,52**			
TOTAL lower delta	**1,44**	**1,45**	**1,38**	**1,53**	**1,63**			
TOTAL	**1,38**	**1,40**	**1,36**	**1,50**	**1,57**			

3.4 Water supply and cropping area

Water supply (the sum of irrigation and *effective rainfall*) can be compared with the total cropping area in order to derive standards of water use and to evidence differences between Projects or variations over time. The upper delta has been divided in 12 hydraulic units[12]; in the lower delta, water balances are precarious. There is a significant inflow, both by gravity and by pumping, into the West Bank from the Tha Chin river (which receives water from the Mae Klong system) and unknown flows from/to the Chao Phraya River. The East Bank receives less water from its bordering rivers. The inflow from Bang Pakong is discontinued in late January and is partly substituted by pumping.

[12] The Roeng Rang and Kok Katiem projects can be separated for aspects of rice cropping but must be pooled for water balance: they thus form the RR+KK section.

FIGURE 7: SPATIAL RICE CROPPING INTENSITY (1981-1999 AND 1995-1999)



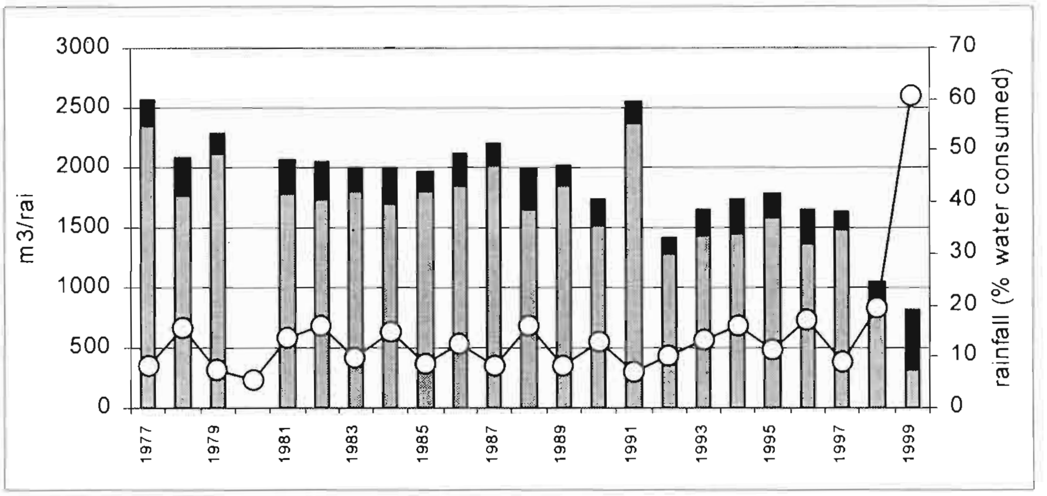
Water balances can be achieved for hydraulic units which have records of inflows and outflows. Inflows are recorded five times a day at all the main regulators of the distribution network. Return flows to the drainage systems are unfortunately unknown. There are a few reasons to believe that these are not of any significant magnitude in the dry season: at the plot level, the great majority of farmers have to pump water from the ditch and they are eagerly combating any loss out of their plot of a scarce water. At the Project level, many of the main and secondary drains are equipped with regulators in order to better retain water in the dry season (they capture superficial and sub-superficial run-off), and little water is passed on to downstream areas. Return flows remain much probably under the 10% threshold. The delta may also get some inflow from adjacent upland areas in case of heavy rainfall. The sections and months concerned have been discarded.

Several possible sources of error impair the accuracy of the estimation of both water supply and cropping areas[13] but estimates of overall seasonal consumption can nevertheless be attempted. Figure 8 shows that (the year 1999 excluded) the average of irrigation water use in the upper delta is 1700 m^3/rai and that there is a declining trend over the years. This decline can be explained by: 1) An increased water use efficiency at the plot level, fostered by the growing pressure on the water resource and by the growing use of individual pumping at the plot level (which strongly encourages water savings); 2) an increased use of shallow tube-wells; 3) a trend towards shifting cropping calendars earlier in the rainy season. This very significantly decreases water use for land preparation (see more on that in § 5). It also shifts an increasing part of the crop cycle out of the January-June period and consequently underestimates the water effectively used by this crop; 4) a growing use of shorter duration rice varieties, especially in triple cropping areas.

The anomaly observed for the year 1999 is mostly due to the fact that most farmers, knowing about planned water restrictions, still wanted to benefit from high rice prices and started their dry-season crop very early, in the October-December period. Considering rainfall raises the total amount of water received by a rai of rice-equivalent to 1929 m^3. These values should be slightly incremented to account for the area cropped out of the January-June reference period.

[13] : inaccurate hydraulic formulas, or the use of the latter in situations where their precision is not ensured; pumps providing unrecorded inflows; errors of reading (gauge), recording (in books) and, in some cases, ad-hoc over or underreporting. To simplify the water balance, we have expressed the cropping area in terms of *rice-equivalent*. In what follows, coefficients of 0.4 for field crops/vegetables, 0.7 for sugar cane, and 1 for orchards and aquaculture have been used. Another difficulty is linked to our limited knowledge of cropping calendars in the dry-season. While we consider the amount of water delivered during the first six months of the year (January-June), calendars – including staggering - may sometimes be shorter, while in other instances they may start before January or end later than June. The impossibility to specify this point over two decades has led us to simplify the water balance, at the expense of some accuracy. We will compare the total cropping areas by *section* (based on RID reports, by Projects) and the amount of water supplied (irrigation + effective rainfall) over the January-June period. Also unknown is the share of water distributed by the irrigation network which is used for domestic purposes (other than agriculture). It has been assumed that this non-agricultural use amounted to between 5 and 10% in the upper delta, and 15% in the southern delta (golf courts, etc).

FIGURE 8: AVERAGE IRRIGATION WATER CONSUMPTION PER RAI IN THE DRY SEASON (1977-99)



Over the 1977-1999 period 11.64 million ha (72.7 million rai) of *rice-equivalent* have been cropped in the whole delta during the dry-season. The corresponding irrigation water supply[14] amounted to 86 billion m^3. The overall estimated effective rainfall is 16 billion m^3. This gives an overall average of 1180 m^3/rai, or 1400 m^3/rai including rainfall. These values should be corrected by a factor of 1.15-1.25, according to the year, to account for the area partly cropped out of the January-June reference period. *This gives an average consumption of water per rai around 1600 m3, or 10,000 m3/ha, with a significant spatial variability and a slight temporal decline, from which 15% is provided by rainfall.*

A similar analysis can also be made for each hydraulic unit. It can be shown that water consumption varies widely (between 1,500 and 3,000 m3/rai), in part because some sub-areas have an unknown and non recorded part of supply from other sources (notably tube wells), head or tail-end location, higher conveyance loss, and difference in cropping calendar.

4 Present planning and allocation

4.1 Control of water use in the basin

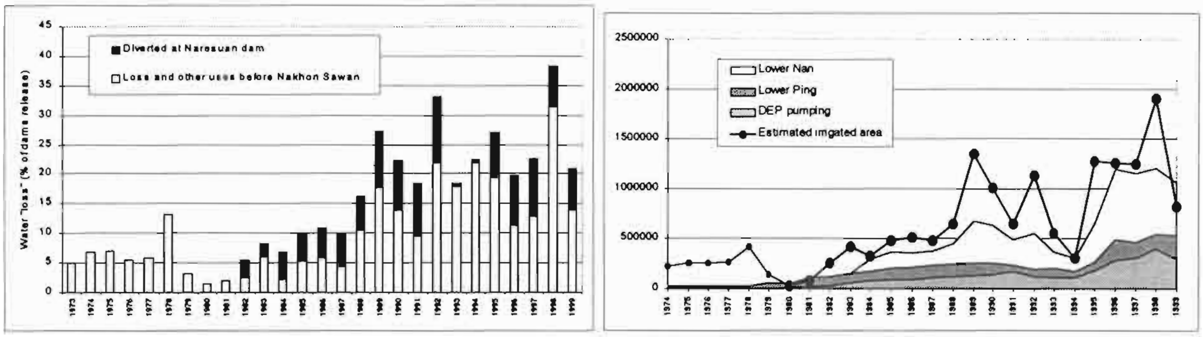
One of the main constraints to both planning and management is the growing share of uncontrolled water abstraction in the rivers, between the dams and Chai Nat. This includes approximately 300 groups of farmers using pumps implemented by the Department of Energy Promotion and RID mid-scale projects.

A quantitative estimation of how much water is withdrawn from the rivers before they reach Chai Nat, at the apex of the delta can be made by considering the water balance between

[14] plus contributions from the Bang Pakong and Tha Chin rivers and from tube-wells (mostly in the northern part of the upper delta). Over a long period, however, shallow aquifers can be considered to be greatly replenished by irrigation; therefore they correspond to recycling within the basin, not to additional supply from outside the system.

the dams releases and the flow at Nakhon Sawan, a few kilometers before Chai Nat, during the driest period: February-March-April. During these three months sideflows are extremely limited. All are dubbed here "water loss", with reference to the delta[15]. Figure 9 shows that while water abstraction in the *middle basin* was only around 5% of the dams releases in the 70's, it has now increased to, say, 25%, with a peak of 38% in 1998 ! This includes "controlled" uptake by RID in Phitsanulok project (since 1982), as indicated in the figure, and in the Lower Ping area (since 1990), but also accounts for the growth of scattered private pumps. The figure (right) also provides an estimate of the growth of the cropping area in the medium basin.

FIGURE 9: COMPARISON OF THE 2 DAMS RELEASE AND THE AMOUNT OF WATER REACHING CHAINAT (FEB. TO APRIL)



A similar phenomena of semi-controlled water abstraction is also developing on the margins of the delta proper. On the Western side, along the Makham-Uthong canal, these areas are now estimated at 80.000 rai. Large ditches branching from the main canal have been dug as far as several kilometres and several pumping units can be observed along the canal (many of them belonging to RID). In the Chong Kaew Project, on the east, fruit growers have installed very powerful pumps along Chai Nat-Pasak canal and even sell water to some other farmers ! In the lower delta, uncontrolled abstraction from golf-courses, real estates, etc. is also wide spread. These examples show that there is at present a growing loss of control on water use in the basin (who, when, how much), partly provoked by the uncoordinated initiatives of various Department, which make proper management increasingly problematic.

4.2 Formal pre-season planning

In 1981, the Cabinet appointed the Dry Season Cropping Promotion Committee chaired by the Ministry of Agriculture to prepare an annual plan, objectives and promoting measures for dry-season cropping. A sub-committee was appointed to collect relevant data and, each year, prepare a plan. After acceptation of the plan, users and agencies would know the plan for dams release and operate accordingly (Binnies, 1997). During the 1991-1994 drought

[15] This does not mean that the delta should necessarily be favoured. However, if we consider that it infrastructures are the oldest and that irrigation had been planned based on the available water resources, it is also legitimate to reckon that later schemes have in fact been built based on the same water resource and that they depleted the initial share of the delta. This has to be questioned on the ground of elementary economic logic.

period, it proved impossible to manage the system according to the plan and the committee ended its work. However the sub-committee continues to meet yearly in order to achieve some co-ordination between agencies.

Normally, at the end of the year (November), the sub-committee (or working group), with representatives from the various Ministries involved (MOAC, DOAE, RID, EGAT, DEP, etc.) is convened with the aim to examine the situation for the whole country and to define the national policy for the coming dry-season. Data are presented by several technical Offices and a preliminary target is set up for the dry season area cultivation. The policy is mostly based on the projection of the active water storage for the 1st of January presented by EGAT. On its side, RID (regional offices) has consulted the Provincial agricultural services and comes out with a crude pre-repartition of the area by Province, with areas broken down according to crops (rice, field crops, trees) and water status (irrigated/non irrigated). Some other aspects are discussed and may also be taken into consideration (this year the Office of Agricultural Economics warned that rice prices were declining and that the planting area should be controlled; in 1996 and 1997, supplies were increased to compensate for the flood damage undergone during the preceding wet season, etc.). The share of water which can be pumped by DEP pumping stations along the river is also specified. These recommendations are further endorsed and made official by the Dry Season Committee, of which the minister of the Ministry of Agriculture and Co-operative (MOAC) is chairman.

The principal figure presented to the meeting is the assessment of the available water for the next dry season (projection of the water stock on the 1st of January). This Available Volume, or *active storage*, (hereafter called AV) is expressed in billion m^3 and generally varies between 5 and 15 billions m^3, but happened to be as low as 3.6 billion in 1980 and 2 billion m^3 in 1992. From the available volume AV (which gives an indication of whether the coming dry-season is to be considered "dry", "normal" or "wet"), a Target Volume (TV) of water release for the January-June period is issued. TV is only a part of AV because of the need of inter-annual regulation and the risk to lack water in the early rainy season, when requirements sometimes offset natural flows or precipitations. There is, however, no definite standard on how much water must be kept at the end of the dry-season, but 2-3 billion m^3 is a minimum basis. The value of TV is transformed in cropping area, following a thumb rule of 1,600 m^3/rai. This Target Area (hereafter TA) is expressed in *rai* and generally varies between 2 to 3.5 million rai.

The relationships between AV, TV and TA are grounded on past experience and are approximately based on the following rules (RID, *pers. com.*):

Active storage AV > 10 Bm3, released plan TV = 6.5-7.5 Bm3; for paddy area TA= 3.1 – 3.3 M.rai
Active storage AV = 7.5-10 Bm3, released plan TV = 6 Bm3; for paddy area TA ≈ 3.0 M.rai
Active storage AV = 5-7.5 Bm3, released plan TV = 4 Bm3; for paddy area TA ≈ 2.0 M.rai
Active storage AV < 5 Bm3, released plan for domestic use and other constraints only.

The global release target TV is subsequently distributed among the various water uses within the basin, namely domestic use, BMA, transportation, control of salinity intrusion, irrigation, with the latter broken down by IRD Region. A weekly calendar of water release is prepared by the regional offices, with the constraint that the total of the weekly releases equate the amount allocated to each of them for the 6 months. Each region also specifies the weekly releases for each of the main canals included in it, together with the cropping area targets for each Project.

Projects are requested to draw maps of target areas, considering areas with possible loss in the rainy season (flood, grasshoppers, etc), to plan the use of RID's mobile pumping stations and to set a weekly calendar for water supply in all the main canals in the Project. All these activities, however, have little or no impact on the already planned schedule and on real water distribution. In parallel, each Project organises meetings at the *zone*[16] level in order to inform farmers about the cropping area allocated to their zone. This is generally done together with the gate keepers, zonemen and sub-district extensionists. Rather than the figure itself, farmers first give attention to the overall policy adopted: "*it is prohibited to plant*", "*there is little water this year*" or "*this year, water is good*" form the basic "*hearsay scale"* on which farmers rely in order to decide to engage in cropping or not. The cropping area announced is also taken as an indication but it is considered together with further advice from officers which qualifies the risk. Project Officers tend to be conservative on the latter as a *protective measure against a possible drastic water shortage lying beyond their control.* They commit themselves to ensure water supply for a limited area, but at the same time may suggest that a larger cropping area is likely to be possible.

4.3 Plan revisions and operational real-time adjustments

In some instances however, peculiar conditions may call for the revision of the whole plan. This generally occurs at the beginning of the season, in January or early February. Two instances of adjustments in the planned weekly calendar have recently occurred (and are probably representative of the two main causes of plan revision): discrepancies between technical and political criteria of target setting (1999); severe mismatch between the planned schedule and effective crop progress (2000).

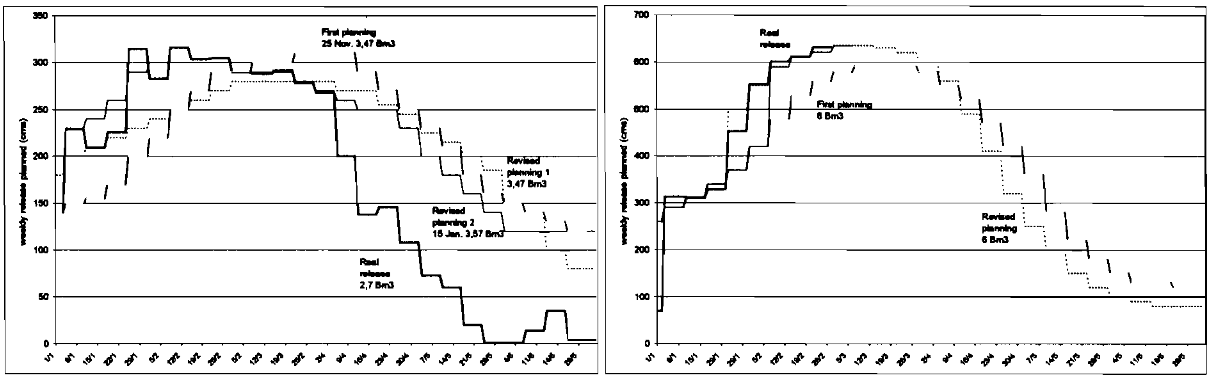
In summary, the allocation process can be typified as supply-driven, guided by experience rather than by clear-cut technical parameters, somewhat flexible rather than rigidly pre-determined. It focuses on the allocation at macro level, with little control on the day-to-day fluctuations experienced at the lower levels but with a concern not to stray too much from the weekly planning, as a way to ensure that the total water released at the end of June do not differ from the overall target by more than, say, 15%. Water supply at lower levels (laterals) is very loosely defined and uncertain.

After the setting of weekly dams release targets, first at the onset of the season, then with possible – although rare – in-season adjustments, RID officers focus their attention upon day-to-day water management. Although EGAT happens to release water amounts very close to those requested (more on this later), irrigation managers have to cope with three kinds of uncontrolled perturbations: pumping irrigation in the *middle basin*; hectic cropping

[16] A sub-unit of a Project (approximately 1000-1500 ha)

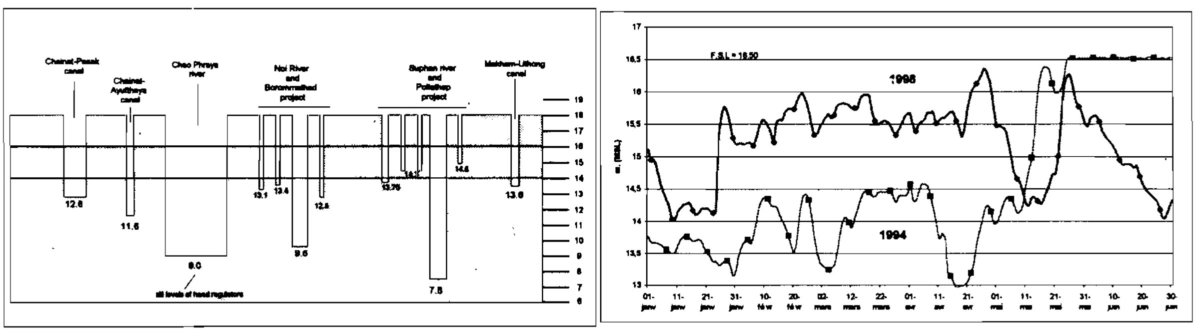
calendar; climatic events. The first perturbation, and partly the third (possible sideflows in May and June), impact on the discharge eventually reaching Chai Nat dam.

FIGURE 10: PLANNING REVISION IN THE DRY-SEASON 1999 AND 2000



An irregular inflow at Chai Nat translates into fluctuations of the water level upstream of the dam. This further disrupts the discharge of all the regulators which control the waterways branching off the Chao Phraya river, upstream of Chai Nat dam, most especially in those which sill level is high. Figure 11 shows that rivers have no problems to get water when the level drops but that most canals do. The main reasons for such fluctuations are the uncontrolled water use in the middle basin and the decrease in dam releases during the week end. As the demand for energy diminishes (many factories and offices close), EGAT reduces releases accordingly. This effect takes approximately 5 days to materialise in Chai Nat dam. In order to limit this phenomena, EGAT has agreed to maintain daily releases during the week end over 60% of the average value for the week considered. Nevertheless, disruptions are still perceptible and resented by RID officers[17].

FIGURE 11: WATERWAYS SILL LEVELS AT CHAINAT (IN M MSL) AND FLUCTUATIONS OF THE WATER LEVEL



Daily data for the dry-seasons of the years 1994 (dry) to 1998 (wet) are used here to show the extent of these fluctuations upstream of Chai Nat dam: 1994 sticks out as very problematic year in which virtually no irrigation water was supplied and the water level

[17] It appears that the lower releases on week-ends are somewhat dampened on the way. If we look at the daily dam releases for each of the weeks of the 1998 dry-season, we find that in fact there are slumps on Sundays. On the average over the 26 weeks, the decrease is 61% of the week average, that is almost exactly the value agreed upon. However, 5 weeks have Sunday releases under 55%, with 3 of them under 50% of the week average.

remained below 14.50 m MSL, this is 2 meters below 16,5 m, the full-supply design level used in the wet-season. In "normal" dry-seasons, the level is generally fluctuating between 15.5 and 16.0 m. Other years also show significant fluctuations and difficulties to ensure a proper level, especially during January and February.

4.4 Management and adjustments at the Project level

In normal situations, Project managers ensure/adopt a continuous flow to all their laterals. If the policy is to follow a year-by-year rotation in which half of the Project only is supposed to grow rice, then the flow to the other half is maintained low, but rarely cut, at least in the head reach. How these limited flows are compatible with classical earth canals equipped with sluice gated regulators and designed to provide gravity flows to laterals at the full supply level is not readily obvious to the observer. In fact, situations vary according to topographical features but the most common case is that of farmers compensating for the lack of gravity flow to their FTOs (Farm Turn Out) by using individual pumping devices. *If operational constraints experienced by RID have forced farmers to develop their pumping capacity, it is all the more true that this – in return – has discouraged whatever regulation improvements RID would have otherwise been pushed to achieve.* Rotational arrangements are part of the paraphernalia but as their implementation entails significant transaction costs, RID officers understandingly prefer the actual *statu quo* according to which their role is to ensure water in the canal, even at the bottom of it, while farmers have implicitly integrated the fact that they will need pumping devices to access water.

The development of the individual pumping capacity has been paramount in easing water management in the dry-season and in providing farmers with the flexibility to easily access any pounding or flowing water. On the negative side, it is equivalent to substituting managerial exigencies for increased monetary costs (pumping equipment and operation), which burden is borne by the farmers. A more subtle negative aspect of this process has also been the strengthening of a pervasive individualistic conception of gaining access to water. Although collective arrangements are sometimes necessary and implemented, there is ample evidence that individual pumping has implicitly reinforced the acceptance that locational advantages necessarily translate into a privileged access to water: head enders can pump water as soon as it appears, in total independence from a possible collective rotational arrangement or other efforts aimed at raising the water level in the canal or increasing equity.

The way, in a context of rather high uncertainty, supply and demand adjust to one another is not obvious and cannot be easily reduced to the classic distinction between a demand-driven process (supply is adjusted to a given demand) and a supply-driven one (inflows are fixed and known in advance and the irrigated area is calculated accordingly). A careful analysis shows that it may in fact be a blend of both, with a delicate and fluctuating dosage of ingredients.

Let us schematised the objectives, constraints, risks and trump cards of the main two parts concerned. Farmers, unless rice prices be really depressed, usually attempt to grow a dry-season rice area as large as possible, two times or more if possible. They must evaluate the risk of doing so according to information given by RID and media. By starting their crop massively and/or by resorting to secondary water sources, they will force RID to supply their crops until the end of the cycle. In case of drastic shortage, they may request local politicians to intervene in order to get an extra supply.

On their side, RID officers both want to serve their farmers and minimise risk. In some instances the second aspect may override the first one and officers are likely to adopt strategies aimed at limiting the expansion of the cropping area. In some instances, they are seen opening middle reach check regulators, allegedly to provide consumption water to downstream areas, but in reality to prevent upstream areas to grow too large an area, which would dramatically increase the risk of future shortage. For officers, shortage means farmers' unrest, political interventions and hierarchical superiors possibly asking for explanations, all things which must be avoided as much as possible. Their margin of flexibility lies in a certain degree of slack in water allocation: they may sometimes allocate poorly reported extra water supplies through releases into drains, by setting pumps along the rivers or by treating them as "*upaphok-boriphok*" (domestic consumption) water. Under-reporting may also occur in times of tighter quota monitoring. An important protective measure is to commit to a low standard target area, in order to transfer risk-taking onto farmers, while giving *off-record* indications on how much risk should be reasonably taken. This is why RID officers are reluctant to plan large areas, even in their demand channelled to the Regional Office.

This system is served by the implicit philosophy conveyed by the development of individual pumping. By fostering the acceptance that farmers along the canal do gain privileged access to water, it chokes claims of greater equity, with their cohort of demanding measures, and fits RID's concern to control the expansion of the cropping area: if the *first-pumping-first-served* principle is endorsed, then any water flow in the laterals will swiftly translate into a green "glove pattern" rice area. The width and the length of each "finger" depends on the flow itself, the roughness of the canal, topography and the pumping capacity of the farmers along its banks.

Should this be seen in a negative fashion ? Does not, after all, pumping lead to a very efficient water use at the plot level and ensure that even limited flows are fully made use of ? It may also be ideally adapted to a water supply characterised by its irregularity and sometimes, uncertainty. However positive these aspects may be, this is achieved at the expense of equity, which will be touched upon later.

4.5 Total water release during the dry season: decision-making

The total amount of water to be released by the dams during the six month period running from January to June is the key parameter of the allocation process and of the inter-annual dam management. In normal years, this amount is usually around 6 or 7 billion m^3. The year 1996 set a record close to 10 billion, while two years of crisis have received less than 4 billion m^3 (1980 and 1994).

4.5.1 What technical guideline for the determination of the Target Volume ?

It stands to reason that the determination of the target volume(TV), that is the total amount of water to be released during the January-June period, is a direct measure of the risk perceived and accepted. This risk is dependent upon the "intensity" of the demand (farmers and political pressure). If a low value of TV is chosen, then there will be enough water to regulate whatever situation may arise in the coming months. On the contrary, if most of the available water is released, we run the risk that water requirements will be high during the next wet-season, which generally goes together with a low run-off into the dams.

Uncertainty remains about how much water will have to be used in the following wet season. On average, monthly sideflows are higher than corresponding monthly requirements and most of the inflow in the dams can be stored. Statistically, however, "dry" months occur frequently and dam water must be released to supplement both rainfall and sideflows. In all cases the dams water balance in the rainy season will be positive but the net stock gain, 4.7 Bm3 in a median year, may be as low as 1.5 Bm3 one year out of ten. In the next dry season, however, dams release will have to amount *at least* to a floor value of 2-2.5 Bm3. Therefore, there is a risk of having an overall yearly deficit of at least 1 Bm3 (or more if releases in the dry-season happen to be higher than the floor value).

Risk will be lowered if the carry-over stock kept at the end of the dry-season (floor value FV) is increased. It appears that at the moment there is no agreed upon value which should not be trespassed. It therefore gives way to conflicting interpretations between the farmers/politicians, who tend to see immediate benefit, and project managers, who are afraid of the major disrupting consequences of a possible drastic shortage or of a dam emptying.

How the target volume TV translates into cropping area is another "quiz". As the relationship is poorly known, it is difficult to estimate a realistic target area TA: consequently it is difficult to follow a decision-making allocation process based on cropping area.

Figure 12 shows the theoretical relationships between the available water and cropping areas, as estimated by Acres (1979) and, more recently, by Pal & Panya (2000). The difference between the two curves in an interesting indication of the initial under-evaluation of the cropping area; the figure also shows the observed historical values. The years 1975 and 1976, with cropping areas much under the potential, are indicative of an early development of dry-season cropping. The years 1999 and 2000, on the other hand, have yielded extremely high cropping areas. This reflects, among other factors, a sharpening of the trend to advance cropping calendars (therefore an increasing part of the rice area is started before the 1st of January), a better registration of triple cropping and possibly an increase in the use of 3 month cycle rice varieties. Discrepancies also account for errors in reporting and for the fact that the water eventually released during the dry season may differ from the "sustainable" values assumed in the models.

To analyse what has been the effective allocation in the past, it is interesting to first examine how the active storage volume on the 1st of January and the 1st of July relate to the amount of water effectively released during the dry-season. We may consider the magnitude of the drawdown of the dams active storage between the 1st of January and the 1st of July (this also considers dams inflow). displays the corresponding values classified by magnitude and also shows the initial and final stored volumes. The lower figure shows these drawdowns classified according to the final volume (1st of July). The years 1974, 1975 and 1976 stand at the extreme right. In those years, Sirikit dam had just been set into operation and water demand in the dry-season was still limited. It is less clear why, for example, the year 1986 only sees a release of 5 Bm3, while almost 8 Bm3 are still available at the end of the dry-season; or why the year 1983 starts with more than 10 Bm3 but releases so much water that only 1.4 Bm3 remains 6 months later, incurring in some high risk.

FIGURE 12: GUIDELINES FOR SEASONAL ALLOCATION, AND OBSERVED VALUES

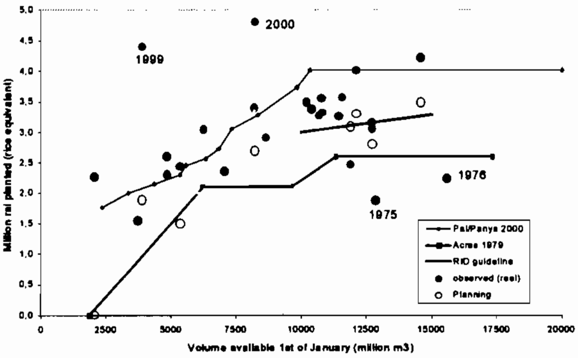
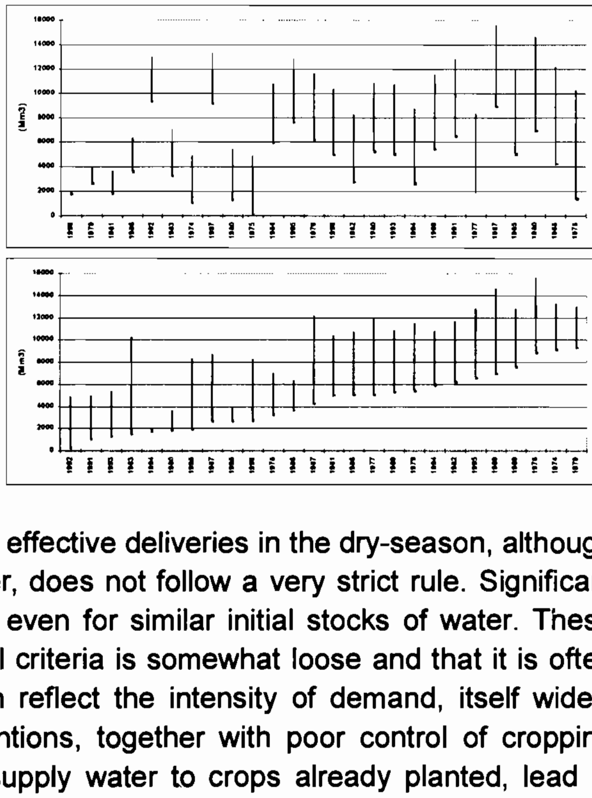


FIGURE 13: ACTIVE STORAGE DRAWDOWN BETWEEN THE 1ST OF JANUARY AND JULY, CLASSIFIED ACCORDING TO THE MAGNITUDE OF DRAWDOWN AND TO THE FINAL ACTIVE STORAGE



From all these observations, it follows that the effective deliveries in the dry-season, although widely governed by the available stored water, does not follow a very strict rule. Significant variations are evidenced between the years, even for similar initial stocks of water. These can be attributed to the fact that the technical criteria is somewhat loose and that it is often challenged by more political decisions which reflect the intensity of demand, itself widely correlated to the price of rice. Such interventions, together with poor control of cropping calendars, which sometimes forces RID to supply water to crops already planted, lead in some instances to very high levels of risk for the ensuing seasons.

Figure 14 shows that the available water (over the dead storage volume) is in most years significantly higher than the amount of water released. This mirrors the will of interanual regulation and/or the limits of the diversion capacity. The lower (thicker) curve compares these first two values with the total amount of water released during the end of the rainy season (September to December). It shows that the 1980 crisis was partly generated by the undue release of 4 billion m^3 during these four months. This was also the case in 1991 and in 1994, as highlighted by the lower part of the figure which expresses the amount of water released in percentage of the remaining water on the first of January.

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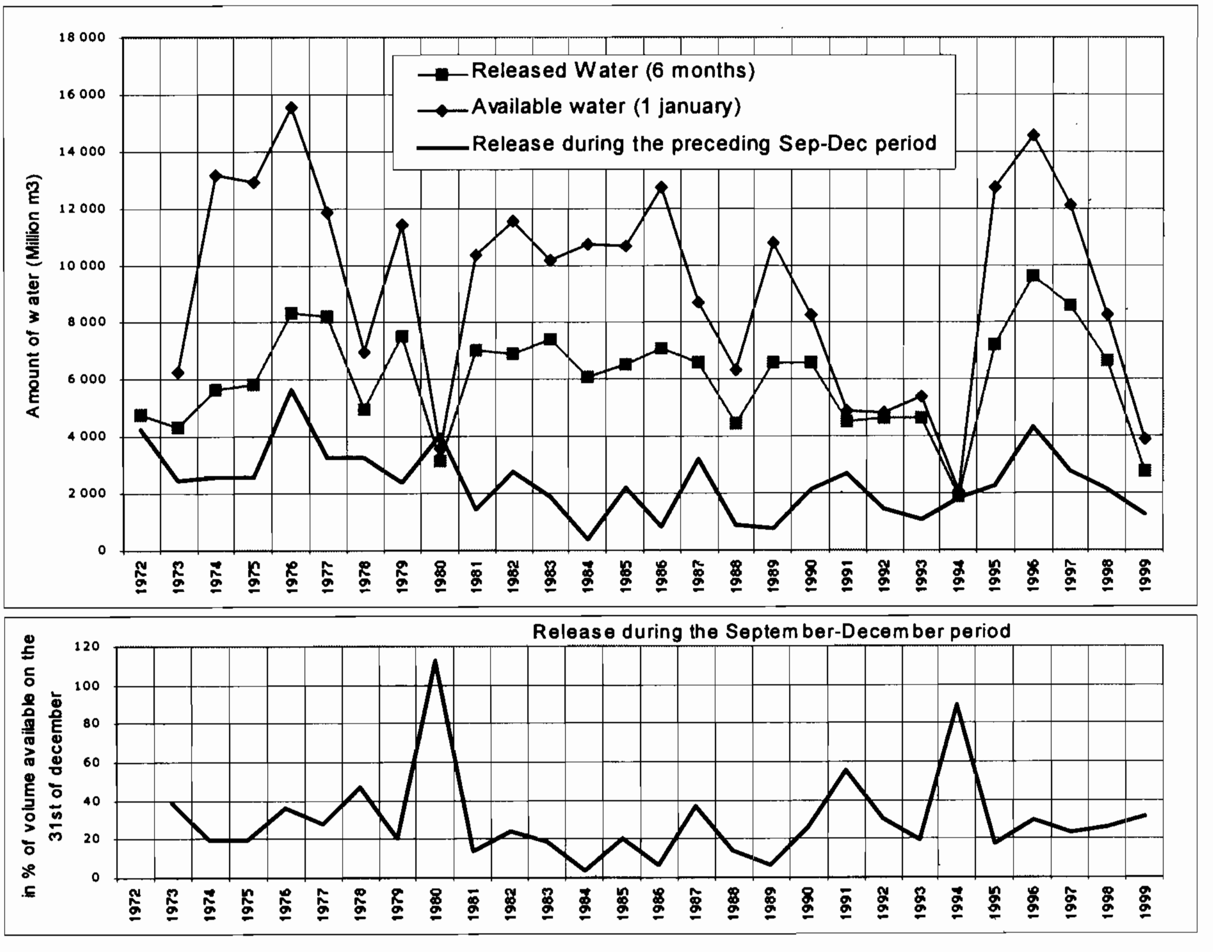
FIGURE 14: SEASONAL RELEASE COMPARED WITH AVAILABLE WATER (1972-1999)



There are several difficulties in determining the most opportune amount of water to be released in the dry-season. One aspect is whether the dams release (and the cropping area) is allowed to take totally different values every year, depending on the stock, or whether it is preferable to have a constant average target, from which will be departed only in exceptional years (very low active storage). Although this problem is classical, there are very few, if any, examples of policy favouring stability/equity instead of instability/efficiency.

5 Improving equity and efficiency in allocation and management

5.1 Dams management

5.1.1 Dams releases vs. downstream requirements

The logics of dam management for irrigation and energy generation are different in some respects but not totally antagonist. RID wants water to be delivered in the dry-season AND in the rainy season – most especially the months of July, August and September - , when and if the rainfall pattern entails specific requirements. These requirements will depend on local rainfall but, above all, on the amount of side-flows generated in the basin downstream of the dams and upstream of the main irrigated areas. Contrarily to common wisdom, this latter requirement is by no mean small and, should sideflows be insufficient, large amounts of water will have to be released by the dams during this period. In years of abundant runoff, water releases are also commanded by concerns of flood control and dam safety. Ideally, water should be stored during the rainy season as much as possible, and released during drier months.

EGAT, on the other hand, is managing a wide diversity of energy generation plants, the largest part of which is thermal based, with hydropower making approximately 8% of the total. All the sources are not equivalent in terms of cost and flexibility. Hydropower generation is most especially appreciated for the facility of switching it on and off at will, which is not conveniently feasible with thermal plants. It is therefore used to cope with peak demands (generally during three periods in a given day: 9 to 11:00 a.m; 14:00 to 16:00, and 18:00 to 20:30) and with outages or emergency shut-down of thermal plants. These are rather common (weekly occurrences) and the dam turbines are frequently solicited to "fill up the blanks".

Should we fail to consider this aspect of scheduling and flexibility, we would readily get to the conclusion that the dams should be managed according to RID's logic: in fact, except for a negligible share of water going through the spillways, the amount of water going through the turbines remains basically unchanged in the long run, as all of it (minus the loss) is sooner or later eventually released. The total amount of power generated is therefore unchanged, but for slight differences in the average head in the turbine[18].

The comparison of the weekly water demands formulated each week to EGAT by RID with effective release show that, during the dry season (and for the last six years data) there is a rather close match between the two. EGAT is therefore following by and large the schedule agreed upon. More generally, we can try to estimate the effective mismatch between dam

[18] keeping more water in the rainy season leads to a higher average water stock and corresponding head in the generators. On the other hand, loss by evaporation is increased, as the water body exposed to the sun is larger. On the whole, energy gains or loss derived from changes in management are at best of the second order and, in any case, not significant enough to govern, or even influence, the policy and schedule of water allocation and release.

releases and water use by looking at whether water is released in excess at Chai Nat dam (that is to say *in excess of* downstream minimum requirements for Bangkok and salinity control, in other words lost to the sea), *independently* of the planned values. This is unlikely to happen in the dry season, as the available water is eagerly awaited by farmers along the canals, but, rather, during the rainy season. Such possible water losses, however, may be both controlled or uncontrolled. The different situations can be broken down in 6 cases:

Situation 1: In the dry season, the system is supply oriented. A given amount of water is released by the two dams (D), based on the stored volume. Irrigation (here including all water uses along canals: Ir) adapts to the water supply and vice versa, but with much less elasticity in the second case. No water is lost at Chai Nat[19].

Situation 2: if, in the situation, just described, water is released at Chai Nat in excess of a given minimum threshold (rather generously chosen here as 80 cms), then the difference is computed as a *controlled* water loss (to the sea) for the system. This is shown in red (case 1).

Situation 3: in the March-June period approximately (the later part of the dry season and early rainy season), some significant natural sideflows may occur in case of rainfall. If there is a situation of water shortage, then sideflows are added and incorporated to the deliveries. In other cases, this water may be considered to reduce dam deliveries[20]. This can happen either because the manager wants to keep the overall supply at the same level (giving more could trigger more planting in the dry season) or because the demand is already satisfied (complement irrigation in the early wet season).

Situation 4: Because, for some reason, deliveries have not been reduced, the inflow at Chai Nat is found to be exceeding demand (or the level of supply that RID wants to maintain to avoid overcropping). In that case, water must be passed on to the Chao Phraya river, resulting in *controlled* loss (case 2).

Situation 5: In the rainy season, sideflows may amount to huge discharges which exceed the needs and/or the diversion capacity at Chai Nat. The excess water is passed on to the Chao Phraya river as an *uncontrolled* loss.

Situation 6: if, in such a situation, water is released from the dams, this release will accrue to the excess water and will not be used. If water is released because of dam safety reasons and/or because of the will to limit the probability of unproductive spill (no energy generated), then these releases are not considered as lost. If this is not the case, all amounts released *in excess* of the minimum requirements for ecological preservation and domestic use downstream of the two dams (1-2 million m3/day/dam) are considered as *controlled* loss (case 3).

Other situations: Without records of forced outages of EGAT's plants and of how much water had to be released to cope with them, it is not possible to estimate how much of these losses must be attributed to these emergency cases. Controlled releases triggered by a situation in which possible future non-productive spill must be avoided - the water level in one of the dams is above the upper rule curve - can be estimated based on the monthly values of this curve. This situation can be shown to be quite rare: it occurred only once, in 1975, for the Bhumipol dam (together with some spill) and four times for the Sirikit dam (in 1974, 1975, 1981 and 1995).

[19] In fact, there is often insufficient release at Chai Nat dam, sometimes provoking damage by salinity intrusion.

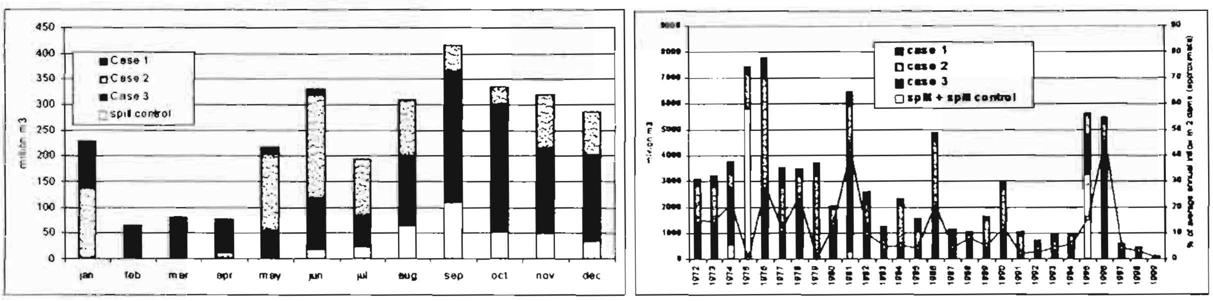
[20] Especially if the deliveries in the first part of the dry-season have exceeded target values.

This description may imperfectly represent all the possible situations but it nevertheless allows a categorisation of the different types of loss and an evaluation of their respective shares within the overall *loss*. These can be tentatively estimated based on monthly values of the water balance in the basin.

Figure 15 provides the monthly averages of the three kinds of loss, together with releases motivated by spill-control, for the 1972-1999 period. As expected, losses corresponding to case 1 concentrate in the first five months of the year. Case 2 losses dominate in the June-August period, while Case 3 losses are paramount in the September-December period. These losses are quite considerable in quantitative terms, especially in the rainy season. The figure also reveals a complementary picture of the yearly total loss along the 1972-1999 period. We can observe: 1) a striking variability of the yearly total water loss; 2) a decline of the total loss, suggesting that a decreasing inflow paralleled by a growing demand have fostered a stricter management of the dams; 3) that the decline affects the three types of loss.

In quantitative terms, the total average yearly loss amounts to 2.9 billion m^3, or 30% of the average inflow in the two dams, including releases for spill control together with effective spill which amount to 350 million m^3). Case 1 is rather limited in magnitude (291 million m^3), while Case 2 and Case 3 losses have similar magnitudes (1.06 and 1.12 billion m^3 per year on average).

FIGURE 15: WATER RELEASE AT CHAI NAT IN EXCESS OF REQUIREMENTS: THEORETICAL LOSS (AVERAGE MONTHLY VALUES AND YEARLY VALUES)



As noticed earlier, the year 1996 sticks out as an horrendous counter-example of the improved management, in terms of loss reduction, observed in the 1990s. More than 4 Bm3 have been dumped to the sea. It can be observed that 1.3 Bm3 have been released from the dams in August, out of which 1.1 Bm3 was lost to the sea[21]. What must also be emphasised, however, is that many significant releases observed from April to September, despite the occurrence of some rainfall, are in general motivated by irrigation requirements and are not, as often claimed by outsiders, released for the sole objective of energy generation[22].

[21] The water level in Sirikit was quite high (between 145 and 149 m) but had not reached the spill level (150.5 m). It is believed that the 700 million m3 releases were a psychological consequence of the exceptional 1995 flood.

[22] This approach, however, probably overestimate water losses. By considering monthly values, we ignore both the errors due to not considering carryover from one month to another (the water released the last five days of a given month is used downstream the following month) and the more significant constraints of real day-to-day management: the lagtime corresponding to adjusting releases to uncontrolled factors, including rainfall.

5.1.2 Dissociating energy generation and other use

At the completion of the Sirikit dam in 1972, hydropower generation accounted for almost one third of the total electricity produced in Thailand. Therefore, the rules and patterns of dam management were designed with the objective to maximise energy generation. In addition, supply was in excess of demand and EGAT was enjoying a significant degree of "slack" which could be managed according to specific energy-generation requirements. This situation can still be found in the Mae Klong (Satoh et al. 1999; Kositsakulchai et al. 1999) but the situation in the Chao Phraya river basin is now clearly the opposite one. Yet, because of the early orientation of dam management for energy generation and because of the flexibility offered by the dams to compensate for forced outages of thermal power plants, EGAT has continued to enjoy a certain liberty in managing the dams. We have seen earlier that this margin of flexibility has been drastically reduced in the last 10 years. As water is getting scarcer in the basin and conflicting interest arise, resources and their management come under growing scrutiny.

Several elements suggest that it is now possible to adopt a management of dams based on downstream requirement and not energy generation. 1) A first element is that hydropower has undergone a dramatic decline in relative importance as a source of energy for Thailand. From one third of the national production in the early seventies, it now amounts to only 8% of it, and Bhumipol and Sirikit dams eventually represent only 4% of the national production; 2) there is an overcapacity inherited from both the economic crisis and overrated projections considered in the past (Watershed, 1999); 3) More flexible production with other dams (Laos) or gaz turbine is or will soon be available (Independent Power Producers, Ratchaburi Plant), which may offer most of the peak generation facility now provided by the dams. Giving priority to downstream use will of course little alters the amount of energy produced (water will still flow through the turbines) but will push EGAT to solve problems of plant outage by using the overcapacity and not water from the dams, and answering to peak demand with other dams or gaz turbines. Indeed it will be a recognition of the changes occurred in both the power generation and water use sectors, and of the adjustments already made.

Other aspects of dam management should also receive attention. Dams release must be responsive to variations in demand, in particular to those due to hydrologic events. Rainfall and natural sideflows in the basin must be detected in real time, translated in projection of inflow and dams releases must be attuned accordingly. The upper rule curve of the dams must be revised in order to maximise the final stored volume rather than the total energy generated. It must investigated whether tapping the dead volume of the Sirikit dam (only justified to raise the head for energy generation) could be recognised as a normal procedure and not as dramatic event.

5.2 Reconsidering cropping calendars

Until the end of the 80's, most of the dry-season rice cropping and corresponding water supply were scheduled from February onward. Only the Chachoengsao Province on the East and the West Bank had different calendars (Kasetsart University and ORSTOM 1996): the former would start dry-season cropping as early as late October, in order to complete it before February, when water gets salty in the Bang Pakong river. The later would attune its calendar to the flood duration and perform one crop before and/or[23] one after. In a year of average flood, that is little water is stored in the West bank, which acts as a buffer, the area with earlier crop establishment (late October) is located in the middle-east of the West Bank (both higher land and better poldered area). As water recedes, rice is established, with the lower/later parts located along the Tha Chin river. All calendars are delayed in case of significant flood.

In the upper delta, the dry-season traditionally began in February, but the most distant sub-areas may start their crop as late as May. *The last decade has witnessed a gradual and complete deregulation of the theoretical scheduling.* This trend has been particularly obvious in the West of the upper delta (Don Chedi, Samchok, Phophya[24]). It has been fostered by the uncertainty as whether (late) deliveries would eventually come and/or be sufficient for a crop of rice. Rather than waiting until late into the season, many chose to start their dry-season crop in continuation of the wet-season one. Such a shift, in the footsteps of the West bank, soon proved much advantageous. Farmers would capitalise on the residual field wetness to cut the drastic peak need of water at land preparation time (between 250 and 300 mm in dry soils conditions). They would also not only benefit from rather abundant water remaining in the waterways until the end of December but also force RID to maintain some supply to sustain their crops during the period in which it should theoretically be suspended. While this shift could have prompted a smooth and acknowledged adjustment of the water schedule, a difficulty arose because of year-to-year variations, as the intensity of demand is linked to the price of rice and its timing to whether the wet season preceding crop has been late (sometimes delayed by a late preceding dry season crop) and, for the lower delta and Song Phi Nong area, when water will recede.

The use of shallow wells (at least for one part of the cycle), has also contributed to deregulating calendars. Farmers with very high cropping intensity acknowledge that they don't even refer any more to conventional seasons (*na-pii, na-prang*). Mention is made of *na-pleng* (the third crop) but others admit that they just don't know what growing-season they follow.

This gain in flexibility has undoubtedly been one of the main factor responsible for the records of cropping-areas observed in the last dry-seasons. Nevertheless, it also blurred all the landmarks used hitherto for allocating water in the dry-season. This calls for the necessity to first recognise these changes, then to incorporate them into the definition of a more flexible and rational allocation process.

The choice of cropping calendars entails wide differences in absolute water requirements. It must therefore be investigated how these have been fixed in the past and whether the logic

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[23] Some parts of the West Bank have long been growing only one wet-season or dry-season crop ; the generalisation of double (or triple cropping) is rather recent and has been mostly allowed by the construction of pumping stations along the Tha Chin River.

[24] The southern tip of the Project (along Song Phinong river) follows a calendar close to the West Bank. Early supplies channelled through the main canals may have allowed upstream farmers to benefit from this water and shift calendars.

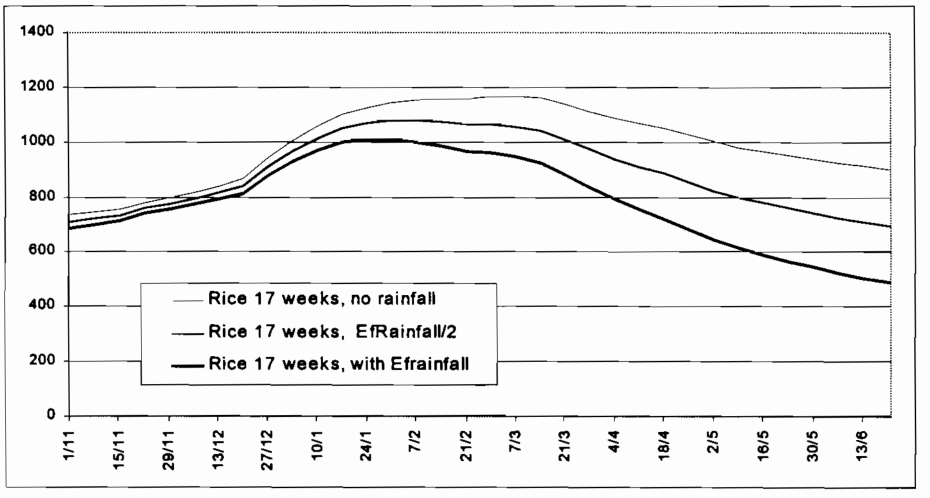
which governed this choice is still relevant under changed conditions. When dry-season cropping developed on a large scale in the mid seventies, the dry-season calendar was determined based on several constraints, including: the necessity to stop operation for maintenance purposes; the need to avoid the drainage of irrigated land into lower lands which are harvested in January; the dry land conditions demanded, in some projects, at the time of sugar cane harvest (in particular to allow trucks to enter the plots); widespread plot-to-plot system requiring co-ordination between farmers and calling for a collective, regular and predictable start of the season; the use of transplanting, also requiring predictability (nursery). For these reasons, water supplies were scheduled to start around the beginning of February, with little staggering. A first exception to this rule was the shift of calendars observed in the West Bank.

Spreading calendars over the November-July period almost doubles the time available to grow a second crop (and allow some farmers to grow three crops over the whole year). This clearly offsets part of the hydraulic constraint of the network, as implied by its limited flow capacity. A second important point to be emphasised here is *the impact of calendar shifting on crop water use*. As climatic conditions (precipitations and ET) vary along the year, the water needs of a given rice crop of, say, 17 weeks, also vary.

In addition to this, the water requirements for land preparation also vary according to time. Land preparation, as practised for rice crops established with transplanting or with the wet broadcasting technique, includes soaking land, ploughing, puddling, levelling and draining water out before sowing. This agricultural operations, depending on the soil characteristics and its initial wetness, can take as much as 300 mm of water. In some types of clays which give way to large cracks when they dry (as observed in some parts of the eastern part of the delta), this amount can even be of greater magnitude. This is considerable, when one remembers that the rest of the cycle will request between 850 and 1,100 mm. If land is already soaked or wet at the time of land preparation, a significant amount of water can therefore be saved. As for rainfall, a crop grown later in the season will statistically benefit more from rainfall than if it is grown early in the year. Regarding ET, evapotranspiration will be at its maximum during March-April, resulting on higher water needs during this period.

We can try to overlay – and aggregate – these different factors in order to see how the overall water requirements vary *with* the date of crop establishment. Figure 17 speaks for itself and shows the dramatic variability of crop water requirement with the date of planting (percolation rates are taken at 1 mm/day). A short duration rice of 13 weeks consumes around 1,350 m^3 when planted in early February but less than 900 if planted before new year. A common variety of 17 weeks receiving average effective rainfall, will require more than 1,500 m^3, if planted in early February. Approximately 30% of the total water is saved for an early planting on the 1[st] of November, 15% for mid-December. Water savings can be all the higher for a very late planting, with a high variation according to rainfall.

FIGURE 16: VARIATION OF WATER USE FOR ONE CROP OF RICE, ACCORDING TO THE DATE OF PLANTING



5.3 Demand management

When considering improvement of efficiency, one generally thinks about avoiding loss in the canals (lining) or at the plot level (use of water by farmers). The first point is a question of civil engineering and will not be touched here. Common wisdom assumes (because the price paid for water is small or nil) that water waste in irrigation is widespread and that large amounts could be saved and redistributed. As many observers who propose the introduction of economic tools keep harping on, "since water is not appropriately priced, it is used inefficiently, and consumers have no incentive to economise" (Christensen and Boon-Long, 1994)[25]. This argument runs counters to reality. Let us first turn to the evidence that farmers are getting the lion's share of Thailand's water resources and pitifully squander it. What comes to the fore, when one looks at the process of water allocation, is that farmers are not getting a larger share through some kind of privilege or preferential treatment but, rather, that they are eventually attributed *the water which is left* (if any). Their "right" is limited to what is not allocated to other needs and they fully bear the consequence of its unpredictable and fluctuating nature. It is incorrect to state that farmers are wasting water just because their share of water is by far the largest. It is so only *as far as* other sectors have not raised their demand to more significant levels, and *because* the government has, in the past, developed infrastructures to allow a productive use of water in irrigated areas.

[25] This seems to be taken as indisputable evidence. See, for example, declarations of a high-ranking officer "Water should be priced in order to increase the efficiency of its use in the farm sector" (The Nation. 2000. April 21); "Agricultural experts agree that water-pricing measures would help improve efficiency in water use among farmers" (The Nation, 1999 Feb. 17); the Director of the National Water Resources Committee director: "In reality water is scarce, and the only mechanism to save water and encourage efficient use is to give it a price" (The Nation, 2000. April 23); the resident advisor for the ADB in Thailand: "International best practices suggest that efficiency in water management can be improved considerably through imposition of nominal water user fees" (Bangkok Post 2000, June 11). This echoes an endless list of similar outright statements: "if water is cheap, it will be wasted" (The Economist, 1992); "Currently, most farmers don't have to pay for irrigation water and, thus, have little incentive to conserve water or to use it efficiently on high-value crops. As a result, irrigation efficiency is under 30%" (TDRI, 1990), etc.

A second assumed evidence which must be put under scrutiny is whether farmers are using water efficiently. Based on common knowledge that efficiency in large state-run irrigated schemes is often found as low as 30 or 40%, there is a tendency to stick to this overall vision without questioning it any further[26]. The first point which needs to be emphasised is that such situations are often found in water systems, common in monsoon Asia, which are not closed (i.e which have by and large resources in excess of demand and out of which some usable water supply is left). The second type of systems are *closed* systems. There has been recently wide recognition of the fact that focusing on relatively low water efficiency at the on-farm or secondary levels could be totally misleading (Keller et al., 1996). Many systems, and river deltas typically account for the most significant of them, *eventually display extremely high overall efficiency.* More generally, what has often escaped the attention of many commentators is that such systems have not been passive in front the growing water scarcity. On the contrary, they have been extremely responsive to it in recent times and have gradually developed flexible ways to access water in all places *where it can be found.* Nowadays, no conventional gravity systems is functioning as it has been designed to. Individual pumping capacity has developed in order to tap water in canals, drains, ponds or aquifer and there are often few unused return flows.

The Chao Phraya delta in the dry season provides the most illustrative example of such a closed system. The first point is that most of the return flow from fields or canals is reused downstream. Favourable specific locations where double cropping is well established are often found along drains, most of which have been gated in order to retain superficial and to capture sub-superficial flows. Pumping in drains is often more reliable than depending on canal water. If we consider the efficiency of irrigation at the macro level, we must reckon that the only waste water is the water which eventually flows out of the delta system, that is to say flows to the sea. As this flow is hardly sufficient to control pollution and salinity intrusion in the rivers mouth (in the dry season), it follows that no or only negligible water is lost. The second component of water loss is the infiltration. It occurs that such a loss is channelled either to shallow aquifers or to deep aquifers: in the first case, it is tapped again trough tube wells or soon returns to the drainage system where it is reused. In the second case it reaches aquifers which flow to the Bangkok area where they are notoriously over-exploited, resulting in land subsidence and horrendous costs in upgrading flood protection and in flood damages[27]. We may therefore venture to state that *infiltration losses in the delta are not sufficient* to offset the depletion of the aquifers. On the whole, if we except losses by evaporation in waterways, which cannot be avoided, we may contend, somewhat provocatively, that the macro-efficiency of the delta is 100% (or more if we consider the depletion of both shallow aquifers (in some years of limited irrigation supply) and Bangkok's aquifer).

[26] "Currently, most farmers don't have to pay for irrigation water and, thus, have little incentive to conserve water or to use it efficiently on high-value crops. As a result, irrigation efficiency is under 30%. Urban consumers and commercial and industrial users pay only nominal water fees that do not reflect the marginal cost of supply" (TDRI, 1991). If 70% of the water delivered to irrigation areas is assumed to be lost, it should also be shown where does such an amount of water disappear to !

[27] It is estimated that the damages of the 1995 flood amounted to 50 billion baht, that is 2 billion US $!

Even when we examine carefully plot irrigation, it is hard to find the decried pattern of wasteful practices. The main reason is that most farmers access water through pumping. This is true for all the farmers located in the lower delta (in this so called flat *conservation area,* water is integrally and individually pumped from a dense network of waterways) and for an approximate 60 % of the farmers in the upper delta. Altogether, it follows that approximately 80% of farmers are resorting to pumping, the great majority using low-lift axial pumps. It follows that because of the costs incurred by these water lifting operations, there is little likelihood that farmers may be squandering water. Estimates of water use in the delta given earlier have also shown that efficiency is rather high. Considering all this evidence, it appears that harking back to this erroneous picture of the farmer as a wasteful villain is altogether thoroughly flawed, unfair[28] and at least misleading.

A corollary of this situation is that, in contravention to official declarations, most farmers *do not get water free*. It goes without saying that these investments in pumps, motors and gazoline are not negligible. It has been shown that these pumping costs, because of very long application times caused by poor land levelling, may even be as high as discouraging sugar-cane growers to apply the adequate amount of water, despite water being available in the adjacent ditch (Srijantr and Molle, 1999). It must therefore be acknowledged that *farmers do pay to use water in the dry-season*, partly in consequence of the failure to supply them with gravity water. It follows that the argument that farmers tend to ignore the value of water is significantly weakened.

A further aspect of the irrelevance of water pricing for achieving water savings in our context is that, as it has long been recognised (Moore, 1989), there is no way to apply some volumetric pricing in gravity low-land rice small irrigation. Therefore, there is no incentive for farmers to save water, even if they pay for it. Even if we decide to define a pragmatic water charge for whatever motivation, there are other drastic obstacles to its definition in medium and large scale gravity schemes. The *quality of the access to water in most large scale schemes of Thailand* is so varied that it is very hazardous to define a single fee *per area unit* under such circumstances. Big differences exist between head and tail-enders and this variability cannot be assessed once for all: the access to water depends upon the overall amount of water distributed in the different canals, itself a yearly vagary. It will be impossible to charge someone who was obliged to pump water from a distant drain up to his plot (sometimes in several successive steps) the same fee than a farmer getting water by gravity at the head of the canal.

A water fee would then be an additional tax and must therefore be considered *within the wider overall context of national taxation.* Asserting that farmers in the Central Plain have never paid for the irrigation system or for water use may be acceptable literally and in a narrow sense: if we consider, however, the revenues siphoned off from rice cultivation by the State through the mechanism of the rice premium between 1952 and 1984, it becomes clear that rice-farmers have indirectly paid back more than it can ever be dreamt of levying through a water fee. The discussion may also include whether cost recovery concerns state investments or operational recurrent costs. It is surprising to see that the former has been

[28] Charoenmuang (1994) reports that in some conflicts in the Mae Taeng Canal Project (Northern Region), "villagers urged city dwellers and government agencies to economise on water consumption".

publicly supported by donors. Even in the United States, Postel (1992) reports that 4 millions ha of the West are supplied "at greatly subsidised prices" by The Federal Bureau of Reclamation (see also Anderson and Snyder, 1997). Irrigators of the California's huge Central Valley Project have repaid only 4% of its capital cost.

In brief, it appears that: 1) there is a significant gap between theoretical economic values of water and farmers' ability to pay; 2) that it is extremely hazardous to define a fee based on the area irrigated in the situations in which the quality of access to water is extremely heterogeneous; 3) that a fee high enough to offset collection costs would, in the actual context of fluctuating rice prices, raise the economic risk attached to farming; 4) that no water saving can be expected from a flat water fee; 5) that the alleged situation of water waste at the farm level is a fallacy; 6) that it is incorrect to state that farmers have never paid for infrastructures or water delivery, as state-recovery was achieved through export taxation; 7) that an additional tax is to be considered *within the wider overall context of national taxation,* where taxes, subsidies and State investments eventually define the reproducibility of economic activities and shape the patterns of shift from the agricultural sector to non-agricultural sectors.

5.3.1 Shift towards low-consumption crops

Another possibility to achieve water conservation is to induce a shift away from rice to field-crops, which consume approximately 40% of the amount of water needed for rice. This, ideally, would allow more farmers to benefit from a second crop in the dry season. Such a shift could be boosted by differential taxes, fixed according to the kind of crop.

Evidence of dynamics of diversification in the delta (Kasetsart University and ORSTOM, 1996) show that farmers display great responsiveness to market changes and opportunities (a point definitely evidenced by the recent spectacular development of inland shrimp farming: see Szuster and Flaherty, *this conference*). Good transportation and communications allow marketing channels to perform rather efficiently. The main weak point remains the risk attached to the higher volatility of field crops prices, which discourage farmers from shifting significantly to non-rice crops. As long as the economic environment of field crop production remains uncertain[29], there is little scope to push farmers to adopt such crops or to sustain criticism on their growing rice, as many have incurred in losses by growing field crops (either by will or suggestion from extension services). Inducing shifts in cropping patterns to achieve water saving by means of differential taxes is believed to be unrealistic while such risk remains.

In addition, there are several other constraints (agro-ecology: heavy soil with little drainage, not favourable to growing field crops; labour and capital requirements, skill-learning, development of proper marketing channels, etc.), which condition the process of diversification and it is doubtful that, in addition to public policies aimed at fostering it, its

[29] It can be argued that rice marketing is also uncertain. However, the political sensitivity of rice production is such that there are limits which cannot be easily trespassed. In contrast, no one really matters if the price of chili (a very intensive cash crop with heavy capital investment) swings from 30 to 2 baht/kg in one year and scattered growers have little means to voice their distress and limit their loss.

pace may be increased beyond what is already observed. Contrary to common rhetoric, farmers do not need to have their water priced to shift to other productions. They will increasingly do so if uncertainty on water and prices is lowered. They have time and over shown dramatic responsiveness to constraints on other production factors, such as labour for example, and have already sufficiently experienced the scarcity of water to adapt their cropping patterns, should conditions be favourable[30].

5.3.2 Linking water management, institutional reforms and economic incentives

It has been shown that the rationale to establish water fees for the purpose of water saving or for cost-recovery is rather weak and based on a poor knowledge of field reality. In particular, water supply at present is far from resembling a "service", with its requirements of quality and certainty. The quality of "service" is linked to the whole "water chain", with all its technical and institutional aspects at various levels. It has also be shown how the farmers (and RID's field staff) strategies have adapted to this context of uncertainty. No collective action can be undertaken under the prevailing conditions. This takes us to imagine scenarios in which the potentially powerful linkages between water pricing (by group), institutional reforms and water management improvement could be activated (Small and Carruthers, 1991). An intermediate solution would be to ensure a water supply at the lateral level (defined as a sort of "right" to be negotiated), and to have farmers' organisations managing this supply at lower levels.

What would be expected is that binding farmers together by granting them a collective right could be a way to "force" them to act collectively in order to (a) achieve greater efficiency/equity within the command area of their canal; (b) to constitute a bargaining power to obtain from RID the water supply they are entitled to; (c) to internally solve the problem of differentiated qualities of access to water and define individual charges accordingly; (d) to instil some formalised notion of water right which could later be conducive to some form of tradability; (e) to constitute autonomous bodies which could later take over a part of the managerial tasks attributed to RID and could further federate at the Project or basin level; (f) to foster, in return, a corresponding improved performance on RID's (and EGAT's) part. The potential benefits are so sweeping that one may be tempted to gloss over the prerequisites to such moves.

We must first investigate what is meant by "improved performance", what are the constraints experienced by these agencies, those which mat lie beyond their reach, and those which offer significant margin for progress. At the other extremity, it must be analysed whether farmers are able or willing to respond as expected.

It has been shown earlier that there are crucial constraints on the improvement of the quality of water delivery in the dry season: a more stable hydraulic regime requires the automation of the main gates at Chai Nat dam, operational procedures to dampen the effect of reduced dams releases during the week-ends, higher responsiveness to hydrologic events, additional weirs and structures in the canals to raise water levels, etc. On an institutional level, it still

[30] The spectacular endogenous spread of sprinklers in vegetable production observed in the Mae Klong area shows that farmers are not opposed to investing and adopting water saving devices.

remains to define how the set of drastic changes needed can be brought into the system with the acceptation and participation of both farmers and agencies. The costs of establishing such a policy, defining sound hydraulic units, involving farmers in the conception phase, co-ordinating uses at the basin level and reducing political interference, controlling and applying penalties on unauthorised abstraction, setting a system in which collected fees are used locally, in particular to pay RID's staff, giving farmers a say in how much water is allocated, where and when, etc. are obviously huge. These changes must also be phased, as an eventual success will be conditional on their concomitant establishment.

All these measures translate in crucial exigencies addressed to the Thai institutional and political setting. Management rules, rights and control must be defined at all the level of the river basin, which challenges the actual definition of roles. The current institutional deadlock includes the sheer inadequacy of current laws with the problems experienced; the confuse definition and scattered attribution of roles and power to the different ministries and strata of the government; and a context of political interventionism and laxity in law enforcement (see more details in Molle, 2000).

6 Conclusions and prospects

There is little doubt that the short-term evolution of the demand/supply balance of water in the Chao Phraya basin demands drastic responses both at the technical and institutional levels. Access to water in the dry season is paramount in defining the sustainability and reproducibility of agricultural households, but the water available is going to decline 15% in the next 15 years (for a growth of Bangkok's needs of 5% per year). The analysis of water allocation in the past 25 years shows: 1) an average cropping intensity of 1.45 in the delta, with a growth in the past 5 years; 2) spatial patterns of inequity; 3) a growing de-regulation of cropping patterns and a further weakening of policy criteria for allocating waters; 4) a system of allocation based on experience but without clear decision making criteria, which increases the risk entailed by political interference in allocation.

Several aspects of dry-season water management have been emphasised. It has been shown in particular that the overall efficiency was quite high, and that the management of the dams was nowadays more neatly attuned to the downstream demand. It was advocated that the evolution of the energy generation sector (small and declining share of Sirikit and Bhumipol dam) should be incorporated in the management policy and that dams should now be formally managed in order to limit or avoid releases lost to the sea (in particular in the rainy season). It was also shown how the definition of cropping calendars impacted on the amount of water used and it is recommended to spread these calendars as much as possible over the October-June period. This means that the schedules must be desaggregated by main canal, allowing more areas to start dry season cropping just after harvesting the wet season crop.

While it is common to hear about conflicts for water within the basin, it is of paramount importance to realise that there is no real competition in terms of allocation among users. This would happen if their respective water shares were subject to weighed reductions in case of shortage, and if these weighing coefficients were a matter of debate and negotiation.

Rather, it appears that the different uses are ranked by priority and that the possibility to reduce allocation for 1) Bangkok, 2) salinity intrusion, 3) pollution dilution and 4) transportation is very limited. In fact, it is agriculture which bears the brunt of the pressure on water resources: not only does its share – defined as the *remaining* available water – decreases over the years, this decrease also entails that this remaining part is increasingly subject to interannual variability. These fact are obscured by the dominant common wisdom that agriculture is indirectly responsible for shortages because of its alleged low efficiency of use. On the whole, it appears that the elasticity of the different water allocations are in sharp contrast and that the agricultural sector is eventually the one which must adapt to changes.

It appeared that the objective of achieving *water saving* through some kind of water pricing is at best illusory, as farmers in the dry-season eventually use only the water which is left, do it rather efficiently, often indirectly pay for that, and have already experienced water scarcity. *Attributing the responsibility of water shortage to poor efficiency is the most widespread and misleading misconception.* Should irrigation gain 10% in efficiency, this would not diffuse any crisis but only raise by the same amount the area that will be irrigated (still well under the overall potential demand). Shortages and crises are not due to an hypothetical low efficiency but to the allocation policy and its impact on dams water stocks. This lack of strong technical criteria in managing dams and in allocating water to irrigation, and the way they are being challenged by political interventions and farmers' uncontrolled planting[31], are conducive to drastic shortages and incur in escalating risks. This does not dismiss the fact that efficiency gains are desirable in that they allow the benefits of water use to be spread to a larger number of users. But it draws our attention on the inconsistency of the commonly stated relationship between efficiency and water shortage. Admittedly, "water is far too important to its users to be the basis for socioeconomic experiments" (Perry et al. 1997). In this regard, the stance that "markets should be given a chance", only because centralised administration has shown its limits, appears a bit short.

It was also advocated that economic incentives would fail and/or would be meaningless unless they are considered as a "binding element" within a much larger reform in which farmers would participate both in decisions of allocation and in water management at the secondary and tertiary levels. Such a scenario not only means drastic technical and institutional reforms, but also that all of them be phased and backed by a strong political will.

In other words, what is at stake is the proper management of the transition from a status of common-pool resource in sparsely populated agricultural areas to one of a collective and participative management in a more complex world, respectful of basic equity and efficiency standards.

[31] The hopelessness of officials is apparent in public declarations: The Deputy Agriculture Minister reports in early 1998 that "plantations in Nakhon Sawan, Tak and Kamphaeng Phet had increased to more than 670,000 rai from a target of 190,000" (Bangkok Post, 1999, January 13), while the RID director admits that "things are out of control", with 330,000 rai under cultivation, against a limit set at 90,000 rai (The Nation; 1999 Jan 8). "Our major concern is that we have no effective measures to control the use of water by rice growers. The only thing we can do is ask for their cooperation to cut down rice cultivation".

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References

ACRES (1979) Chao Phraya - Meklong basin study, Phase 1 - Main report + annexes.

Anderson, T. L. and Pamela S. Snyder (1997) Priming the invisible pump, Political Economy Research Center, 20 p.

Bangkok Post, 1999. B5bn sought to stem land subsidence, 24/1/1999

Binnies & Partners et al. 1997. Chao Phraya Basin water management strategy (main report and annexes).

Charoenmuang, Tanet (1994) The governance of water allocation problems in Thailand, four case studies from the upper Northern Region, in TDRI (1994), Water conflicts, pp 53-86.

Christensen, Scott R. and Arreya Boon-Long (1994) Institutional problems in Thai water management, TDRI, 54 p.

ESCAP. 1991. Assessment of water resources and water demand by user sectors in Thailand, 99 p.

Kaosa-ard, Mingsarn and Nisakorn Kositrat (1993) Economic instruments for water resources management in Thailand, presented at the Workshop of the use of economic instruments in environmental policies, Paris.

Kasetsart University, ORSTOM, 1996. Identification of agricultural and irrigation patterns in the Central Plain of Thailand : prospects for agricultural research and development, 220 p., DORAS Project, Bangkok

Keller, Andrew, Keller, Jack and David Seckler (1996) Integrated water resources systems: theory and policy implications, Research Report 3, IWMI, Colombo.

Kositsakulchai, Ekasit ; Kumnuansilp, U. ; Molle, F. and Pierre Chevallier (1999) Analysis of water and power management of the Mae Klong River basin : a regional management analysis within a national scope, Kasetsart Journal of Engineering. 21 p.

Molle F.; Chompadist C.; Sopaphun P. 1998. Beyond the Farm-Turn-Out : on-farm development dynamics in the Kamphaengsaen Irrigation Project, Thailand, Irrigation and Drainage Systems, Volume 12, no 4, pp. 341-358.

Molle, F. (forthcoming) Social and economic patterns of landlord-tenant relationships in the Chao Phraya Delta, Thailand: an historical perspective, submitted to The Journal of Rural Studies.

Molle, François; Chompadist, Chatchom; Srijantr, T. and Jesda Keawkulaya. 2000. Dry-season water allocation and management in the Chao Phraya basin. Research Report submitted to the EU, draft, Bangkok, 235 p.

Molle, François. 2000. Water Pricing in Thailand: theory and practice. Kasetsart University, DORAS Center, Research Report n°7, 60 p.

Molle, Francois; S. Durongdej; C. Chompadist; A. Joannon and Y. Limsawad. 1999. Improvement of rice cultivation and water management in the flooded area of the Central Plain of Thailand : a zoning of rice varieties by using remote sensing imagery Kasetsart University, DORAS Center, Research Report n°5, submitted to NRCT, Bangkok, pp. 155.

Molle, François; Srijantr, Thippawan. 1999. Agrarian change and the land system in the Chao Phraya Delta, DORAS Project, Kasetsart University, Bangkok, Research Report n°6, 191 p.

Moore, M. 1989. The fruits and fallacies of neoliberalism: the case of irrigation policy, World Development, Vol. 17, No.11, pp. 1733-1750.

Perry, C.J.; Rock, M. and David Seckler (1997) Water as an economic good: a solution, or a problem ?, Research Report 14, IWMI, Colombo, 17 p.

Postel, Sandra (1992) The last Oasis: facing water scarcity, New York: Norton and Co.

Prechawit, Chaiwat. 2000. How to transform the work of water management and maintenance in the year 2000, in "Chuchat day 2543", Royal Irrigation Department, pp. 28-33 (in Thai)

Satoh, Masayoshi; et al. 1999. Reservoir operation principles for stable water supply in the Mae Klong River basin, Proceedings of the Workshop on Sustainable Management of the Mae Klong River basin, p. 13.Bangkok Post, 1997. Call for water price increase to ease worsening shortages, 12/10/1997

Sethaputra, Sacha; Panayotou, Theodore; Wangwacharakul, Vute. 1990. Water resources: shortage amidst abundance, TDRI Quarterly Review 5:3, p. 12-19.

Srijantr, Thippawal, Molle, F. and C. Chompadist (1999) Profitability and yield gap of sugar cane cultivation in the Mae Klong region, Kasetsart Journal of Agricultural Economics.

TDRI. 1990. Water shortages: managing demand to expand supply, 101 p.

Watershed, 1998. People' s forum on ecology. Special issue on water: a source of life or a resource for development ?, Nov. 1998., 68 p.

Wongbandit, Amnat (1997) Legal Aspects, Annexe G of the report "Chao Phraya basin water resources management strategy, Binnies et al. (1997), 74 p.

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