Factors and constraints of the adoption of wet broadcasting in the Chao Phraya delta, Thailand

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Abstract

The rice systems of the Central Plain of Thailand have undergone drastic changes in the last 30 years. Technical change has been driven by a combination of factors including demographic changes, land development and water control, and mechanisation. The recent spread of wet direct seeding is put in its historical context and the complementary between dry and wet broadcasting, the two currently dominant techniques, is shown to be related to different socio-economic and hydrologic situations. Some prospects on the scope for further technical change are addressed.

1 Historical setting

1.1 Expansion of rice cultivation with low water control : 1855-1962

Around 1855, the date of the Bowring Treaty between Siam and England, taken symbolically as the starting point of the expansion of commercialised rice cultivation in the Chao Phraya delta, the 300,000 ha of rice area could be conveniently divided in two categories. A first large area encompassed the flood plain of the Chao Phraya river, in which floating rice was cultivated with dry-broadcasting (DB) technique at least as early as the 17th century (Tachard, 1688). A second category was made up of deep-water rice cultivated with transplanting (TP) in various scattered areas of the

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delta where the control of and the access to water was better (land along canals and rivers, mostly in the lower delta, for example the area of Nakhon Chaisi). Most of the time, this transplanted rice could only be grown if water lifting devices were available.

Although transplanting is believed to have been the dominant technique in the first 30 years of expansion (Manopimoke, 1989), the proportion of the two techniques is not clear until the turn of the century. Around 1890, farmers flocking to the tracts of the newly opened Rangsit area successfully adopted the dry-broadcasting technique used in the flood plain (Johnston, 1975). This less labour intensive technique allowed settlers to farm larger areas with better labour productivity and was in line with the uncertainty attached to the precariousness of their tenant status. By 1900, DB was gaining strength and estimates put it at a little less than 50 % in the Central Plain (Stiven, 1903).

The further expansion of the land frontier in the delta was mostly achieved with DB but mention should be made of the use of dibbling, most specially during the very first years following land clearing (Hanks, 1972). In 1922-24, while rice fields already covered 1.5 millions ha, broadcast fields were found to account for 72 % of the rice output (Manopimoke, 1989), a percentage confirmed in 1930 by Montri (in Feeny, 1982) who estimates the share of DB and TP at 70 and 30 % respectively. It's around this date that the land/man ratio reached its maximum in the delta (Molle, *forthcoming*) and that the exhaustion of the cultivable land began to be felt, prompting farmers to raise land productivity by increasing labour input and shifting to transplanting. While rice continued its expansion in surrounding rainfed terraces and upland with, however, some slumps after the Great Depression and around WWII, transplanting was gradually adopted in all locations where it could technically be used. In 1963, TP had been adopted in most of the lower delta and in the surrounding terraces (Fukui and Takahashi, 1969), while physical constraints limited its occurrence in the upper delta at 22 % of the rice area (Small, 1972).

1.2 Gradual intensification of rice cultivation : 1962-2000

The greater Chao Phraya Irrigation Project was constructed during the 1957-62 period. While water was formerly mostly provided to rice from “below”, by gradual flooding, it turned out to be also delivered from “above”, through irrigation canals following natural levees. The higher lands of the upper delta shifted from a water-deficient status to a condition of irrigated land. However, changes in productivity fell short of expectation, prompting worried comments and interrogations from irrigation specialists on the profitability of the investment and on the nature of the constraints encountered (FAO, 1968).

Double-cropping was encouraged as soon as the completion of Bhumipol dam in 1964 ; a few dry years, however, delayed the opportunity to use the dam and farmers’ responsiveness remained low. A first hike in cropping area from 30 to

72,000 rai was observed in the year 1971 in the upper delta ; ¾ of this increase occurs in the Samchuk region because of damage experienced in the 1970 rainy season and because of the dissemination focus of Suphan Buri rice research station, with two HYVs released in 1969 (Small, 1972). A second hike occurred in 1973, further to the beginning of the operation of the Sirikit dam, which notably increased the available water in the dry-season (Ngo, 1980).

The two dams were expected to provide a yearly release of 5 billions m^3 between January and June, but calculation showed that this available water was not likely to allow the irrigation of more than 25 % of the non-flooded part of the upper delta, that is to say around 460,000 rai (or 74,000 ha, in addition to the West Bank in the lower delta) (Small, 1972). This pessimistic projection was further compounded by several factors, including the lack of on-farm development, canal design corresponding to full-supply wet-season supplemental irrigation, lack of credit and incentive to improve the land for tenant farmers, and expected labour shortage at peak periods (Kaida, 1978).

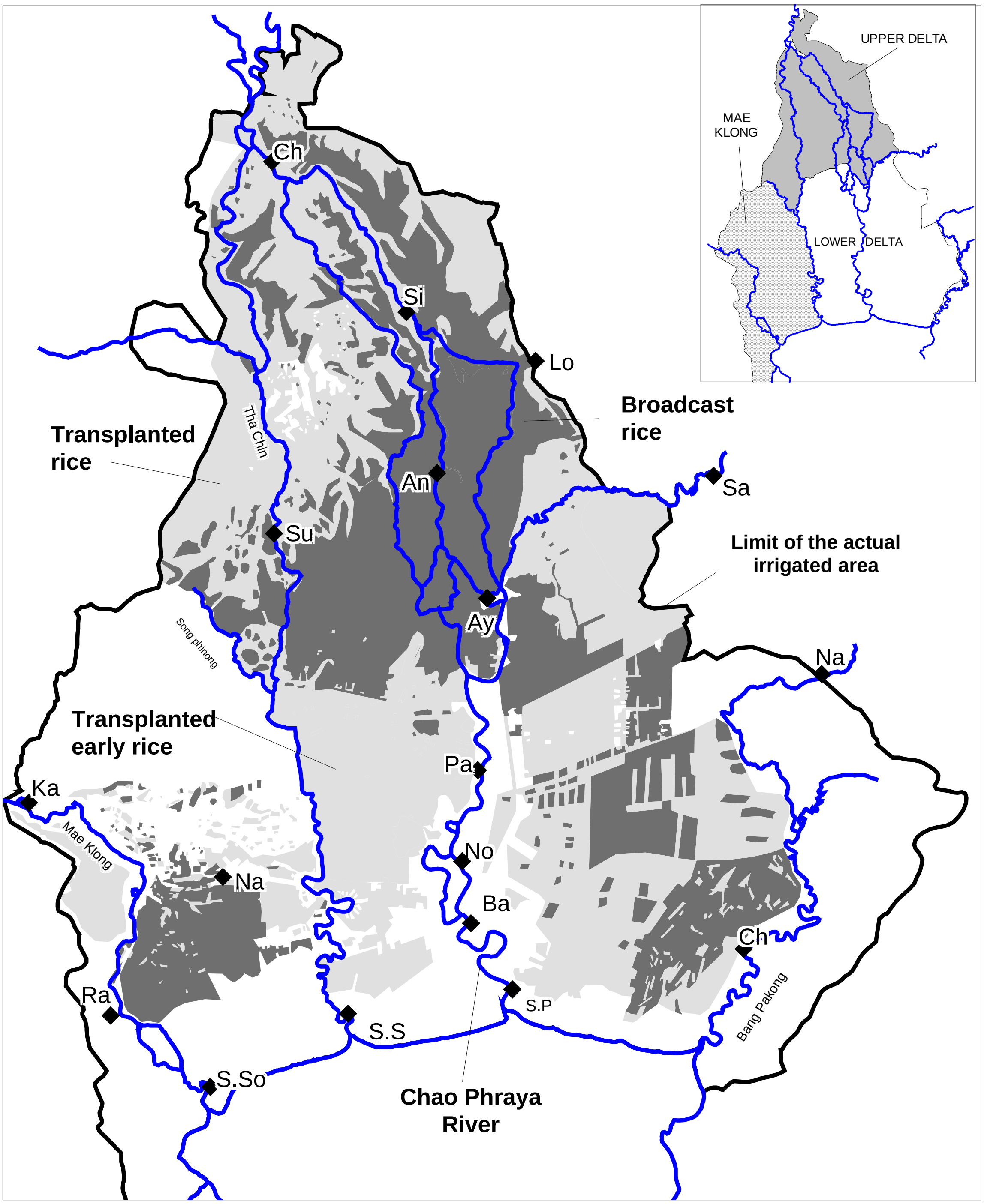
Double-cropping, however, sharply expanded throughout the 70’s (reaching 1.35 million rai in 1979), in line with the increase in HYVs use. Dry-season cropping opportunities and a boom in rice prices in 1973 provided the incentive for their adoption. These changes in cropping intensity, average yields and farm gate price, together with other improvements in credit supply and farm mechanisation, greatly contributed to ease the deadlock experienced around 1970 and to avert the looming crisis (Molle and Srijantr, 1999).

Transplanting expanded further, served by abundant family labour and better water control. From 22 % of the upper delta in 1963, its share rose to 45 % in 1970 (Manomaiphan, 1971), eventually covering, by and large, all the non flood-prone areas, the flood plain remaining cropped with deep-water (33 %) and floating rice (22 %) varieties established with dry-broadcasting. The picture, in 1977, is given by Figure 1, which shows the location of rice areas cropped with TP and DB respectively. It confirms that the upper delta had widely shifted to TP but several low-lying areas under DB, together with the bulk of the floodplain, could still be observed. Significant differences between 1963 and 1977 appear in the East-Bank (east and north-east of Bangkok) (Molle, *forthcoming*). While part of the North-Rangsit Project has adopted TP, the area along the Bang Pakong river (Chachoengsao Province, South-eastern part of the delta) has chosen to (momentarily) revert to dry-broadcasting. Little information has been found to document this situation ; Takaya (1987) mentions (for the year 1980) that rice is “mostly transplanted, sometimes broadcast”.

The map does not wholly encompass the Bang Pakong area (on the east) and the upper Mae Klong project (on the west), mostly planted with sugar cane. For the latter, additional information is provided by the Mae Klong Integrated Rural Development

Program (Kasetsart University et al., 1978), which confirms that 62% of the area along the Song Phi Nong and Tha Chin river had already shifted to TP in 1976.

FIGURE 1: RICE-CROPPING AREA IN 1977. (ADAPTED FROM ILACO ET AL., 1980)



FROM NORTH TO SOUTH: **CH**: CHAI NAT; **SI**: SING BURI; **LO**: LOP BURI; **AN**: ANG THONG; **SA**: SARABURI; **SU**: SUPHAN BURI; **AY**: AYUTTHAYA; **NA**: NAKHON NAYOK; **PA**: PATHUM THANI; **NO**: NONTHABURI; **KA**: KANCHANABURI; **NA**: NAKHON PATHOM; **BA**: BANGKOK; **CH**: CHACHOENGSAO; **RA**: RATCHABURI; **S.P**: SAMUT PRAKAN; **S.S**: SAMUT SAKORN; **S.SO**: SAMUT SONGKRAM.

TABLE 1: BREAKDOWN OF TECHNIQUE PER SUB-REGION IN 1977 (MOLLE, *FORTHCOMING*)

	Broadcasting gross area (km^2)	Transplanting gross area (km^2)	Broadcasting (%)	Transplanting (%)
Upper delta	3436	3680	48%	52%
Lower delta	2367	4423	35%	65%
Mae Klong	828	563	60%	40%
Total	**6631**	**8666**	**43%**	**57%**

The change also affected 33 % of the higher terraces (around *amphoe* Bang Pong) while the south of Nakhon Pathom remains under DB. The right bank of the Mae Klong river, already transplanted in the 1963 census, is attributed a rate of 85% of TP.

2 The spread of wet broadcasting

The situation around 1977, as given by Figure 1, corresponds to the maximum of the expansion of TP in the delta (Table 1).

This impressive growth, however, was the prelude to an even quicker decline, with the advent of direct seeding in the 80's. Direct seeding in muddy conditions was already known by farmers in the Central Plain. In lower locations where water often impounds all year round or, in case of late sowing, when first runoff already accumulated in them, farmers were used to resort to seeding in water or in the mud if any pumping out is possible : this technique is called *pholei*. Panichpat (1990) reports that in the early 70's a rice veteran named Prachern Karnjanomai came up with the idea that sowing with pregerminated seeds could be adapted to normal conditions. The technique, after a series of experiments, became well known as (*naa wan) nam tom (NT)* and can be identified to the more widely known *wet broadcasting* technique (WB). The technique has been used at least since 1975 around Chachoengsao province (Inoue and Bhasayavan, 1982) and in the upper delta during the dry season (Lokaphadhana, 1976) before spreading.

Further data on rice cropping techniques incorporate this change : data on the year 1985 from the Department of Agricultural Extension (DOAE) provide a breakdown of the techniques used by province (Gallois Bride, 1986). Wet broadcasting already accounts for one third of the area, while transplanting has decreased to 31 % and dry broadcasting made up the remaining 36 % (Table 2).

Data for 1992 are provided by the Office of Agricultural Economics (1993) by province : TP is found to make up only 10 % of the area, while wet broadcasting as grown up to 52 %, 37 % remaining for DB. Lastly, the situation in 1998 is given by Kasetsart University and IRD (1996) and Molle et al. (1998). Transplanting can be said to have almost totally disappeared. Rare exceptions subsist. The most recent statistics indicate occurrence of TP only in Provinces (Sara Buri, Lop Buri, Suphan

Buri) with a large share of non-irrigated rice (OAE, 1998). DB is now mostly confined to the Chao Phraya flood plain, with additional secondary areas in the lower Mae Klong area and the Bank Pakong area.

Figure 2 indicates the area where traditional varieties (TV) are used (deep-water and floating rice varieties). It more or less corresponds to the area using DB but the equivalence is not total, as will be shown later. Other rice areas (in white), are currently using WB.

TABLE 2 : PERCENTAGE OF RICE CROPPING TECHNIQUES, BY PROVINCE IN 1985 (DOAE)

Technique	TP	DB	WB	Total
Ang Thong	77	261.7	130.9	469.6
Ayutthaya	323	778.1	1118.2	2219.3
Bangkok	71	63.2	138.7	272.9
Chai Nat	448	284.2	161.5	893.7
Lop Buri	534	392.6	0	926.6
Nonthaburi	14.7	178.4	0.145	193.245
Pathum Thani	0.23	100.3	413.8	514.33
Saraburi	524	127.6	1.6	653.2
Sing Buri	60	152.3	188.5	400.8
Total	**2051**	**2338**	**2153**	**6543**
	31 %	**36 %**	**33 %**	**100 %**

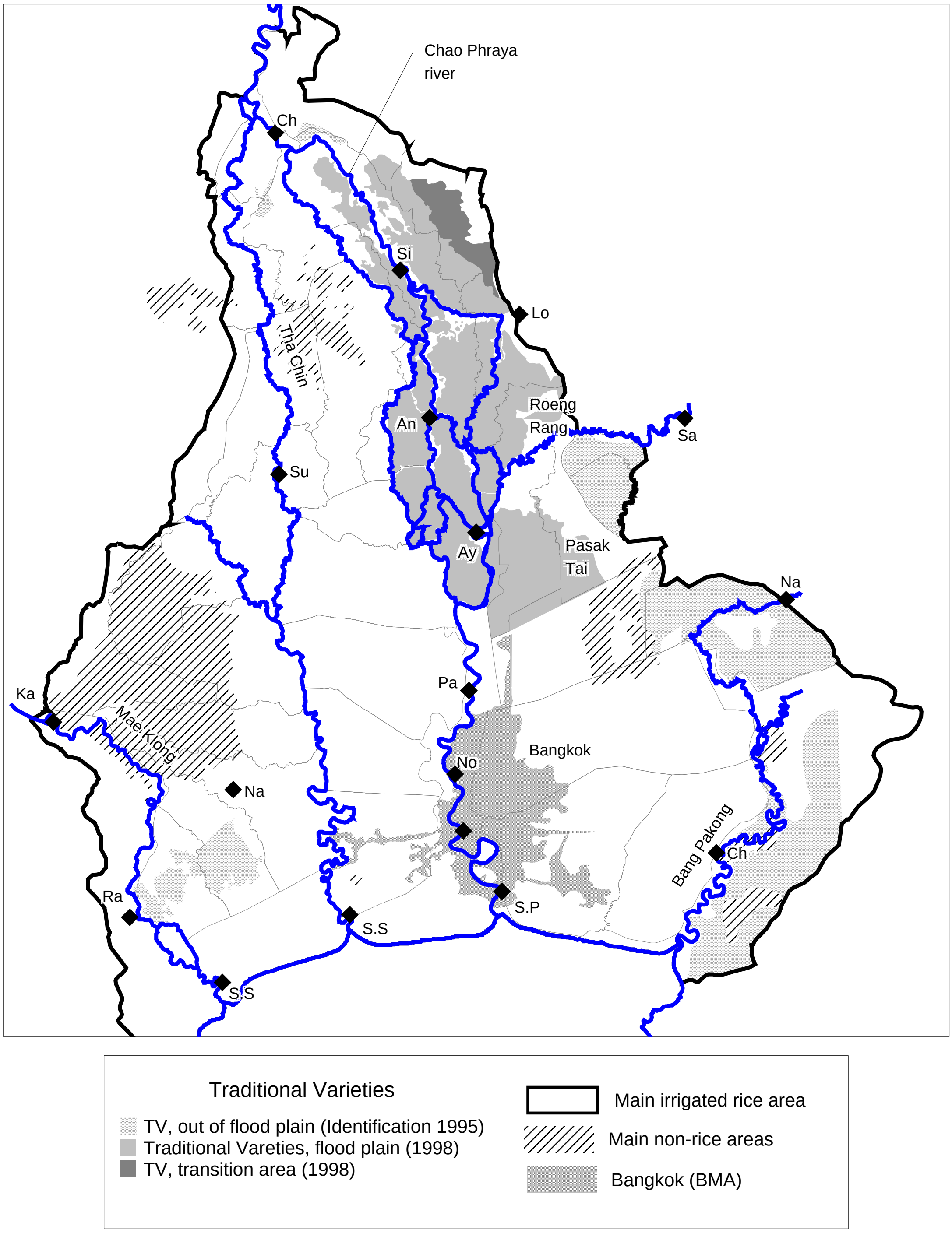
2.1 Advantages of wet broadcasting

The surge and quick adoption of WB obviously raise questions on what factors have spurred them. Several studies have shown that WB promptly gained wide acceptance in the areas for which it was technically suitable, because it was labour saving and economically attractive (Lokaphadhana, 1976 ; Isvilanonda and Wattanutchariya, 1990 ; Wongchanapai, 1982). As early as 1981, it also appears to be supported by the « Wet seeded direct seeding Project » implemented by DOAE (Gallois-Bride, 1986).

The most striking aspect of the adoption of WB is the context of labour shortage which builded up in the late 70's. As the 60's are characterised by a context of "saturation" of the agrarian system, including growing population pressure (Molle, *forthcoming*), it is necessary to explain how such a change has occurred. Firstly, the sixties were marked by the removal of a significant part of the delta population, mostly through migration to the newly opened upland frontier and to Bangkok. During this decade the agricultural population in the rural delta decreased. Secondly, while transplanting in the wet season posed no problems of labour, the advent of double-cropping entailed some bottlenecks in farm operation. While the overall labour supply was still considerable, there were a few peaks of labour demand due to the expansion of double-cropping (Komarte, 1976).

These (punctual) shortages were first dealt with by the rapid spread of two-wheel tractors and the concomitant disappearance of buffalo use for land preparation. In addition, these tractors were useful to power low-lift axial pumps which turned out to be of paramount importance for accessing water.

FIGURE 2 : EXTENSION OF TRADITIONAL VARIETIES IN THE CHAO PHRAYA DELTA (1998)



It is around 1980 that labour shortages surfaced as an overall constraint, at least at the time of transplanting : matching the exigencies of cropping calendars, as governed by the water regime, with labour requirements for TP appeared increasingly difficult. Piecework wages increased and finding hired labour was a real burden. WB offered a way to close the loophole and farmers swiftly resort to the new technique. If we consider a nominal agricultural daily wage of 100 in 1985, we find that the value of this index (deflated by the inflation rate) rose to 150 in 1985 and 200 in 1990 (Molle, *forthcoming*). The surge of WB in the late 1970s in the Chachoengsao Province, south-east of Bangkok, is closely linked to labour shortages and rising real wages (Banpasirichote, 1993). With the shift in techniques, labour input was decreased by 20% (Isvilanonda, *this workshop*).

The shift was also spurred by the fact that making nurseries for seedlings was marred with several constraints (crop care, need of earlier and longer water supply, decrease of the flexibility to chose the starting period of cultivation based on later effective availability of water, etc) and that farmers were satisfied to do away with them.

On the other side, the change of technique proved cost-effective (Isvilanonda, *this workshop*). With the monetisation of labour exchange, transplanting had raised the costs of production ; the change of technique entailed a substitution of labour input (transplanting) by capital input (more herbicide is required to control weeds at crop establishment with WB) but WB appeared, on the whole, cost-effective, as yields were basically unchanged in the shift (Inoue and Bhasayavan, 1982; Isvilanonda and Wattanutchariya, 1990; Lokaphadhana, 1976).

With this additional advantage of increased economic profitability, there was little scope for farmers to continue transplanting their crops. The new, technique, however, required a more careful levelling of the plot and this compelled some farmers to invest in plot improvement. Regarding water use, there is no definite consensus on the impact of the shift. Some observers believe that WS requires more irrigation water than TP and that it is conducive to “big problems and conflicts for water use specially during dry season” (JICA/RID, 1989). We tend to believe that the difference is not so significant and that, in any case, the shortening of the supply period due to the absence of nurseries offsets the increase of water use[3]. The shortening of the rice cycle (and of water requirements) is now obtained with short cycle varieties (90 days).

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[3] Water use is believed to increase because of the shorter duration of plot irrigation for transplanted rice and of the necessity to drain water after puddling and before sowing. The first point is debatable because the nursery, although established over a tenth of the plot, also requires longer supplies, with the same conveyance losses. For the second point, water is often re-used downstream and not lost for the system as a whole.

2.2 From transplanting to wet broadcasting : shift with exceptions

From what precedes, it can be deduced that all transplanted fields have turned over to WB in little more than a decade. While this statement is correct in general terms, a few meaningful exceptions deserve short mention.

A first category of plots are topographically unfit for WB : this includes plots with poor levelling and those with poor drainage : in the latter case, transplanting may have been chosen to establish rice in ill-drained depressions in which water gathers with the first rains and tends to stagnate. In that case, WB (and DB) are not suitable unless drainage can be achieved by pumping. The dramatic development of individual mobile pumping capacity has provided such a function in many cases. Drainage has also been continually upgraded along the last 3 decades. Transplanting is now exceptional in the delta (no more than 1 %) and mostly limited to specific locations or families with tiny plots.

A second set of counter-examples is related to the question of reliability and effectiveness in the access to water. If we compare the transplanted area in 1977 and the actual area under WB, we can observe that some areas have not followed the shift from TP to WB and, rather, have reversed from TP to DB ! This is in particular the case in the Pasak Tai Project, North-west of Bangkok, in Roeng Rang Project and the transition zone, on the eastern part of the delta (see Figure 2).

Such a technical choice is mostly governed by two factors. The first one is the timing of water deliveries : if the large amount of water needed for land preparation cannot be provided satisfactorily or in due time, farmers may prefer to resort to a crop establishment in rainfed conditions and wait for irrigation water. This implies that more stress-resistant deep-water varieties be chosen instead of HYVs but some farmers may also consume directly the rice they produce (whereas HYVs are entirely sold and rice for consumption is bought instead (at a higher cost)). Secondly, the choice of DB may also be attractive because of the reduction in land preparation costs. Farmers with no tractors have to pay around 350 baht/rai for land preparation in case of WB, while the cost is only 140 baht/rai for two runs of a four-wheel tractor in dry conditions (DB).

In such a case, the choice between the two techniques is eventually not fixed and, in particular, is attuned to the conditions of water supply. This can be observed in the transition zone and in the east bank of the Bang Pakong river.

2.3 Relationship between dry-season cropping and wet broadcasting

Technical decisions regarding crop establishment are in fact more complex, when we consider the occurrence of double cropping. The clear-cut descriptions above apply to the case of HYVs (simple or double cropping with WB) and to the case of mono-culture of traditional varieties (deep water and floating rice, with DB). These two situations are to be found at the two extremities of the toposequence (Figure 3). In the first case [A and B], water is provided by the gravity irrigation network, in particular for land preparation. In the second case [D and E], the rice is established in rainfed conditions and is later flooded by the rise of the water level obtained by drainage regulation[4]. In the intermediate situation [C], deep-water rice is planted with either the DB or the WB technique : in case water is allocated for a dry-season crop, a HYV will be grown with WB. In that case, the ensuing wet-season crop - a deep-water variety – is *also* established with WB. This is because the plot is already wet, the soil profile almost saturated and land preparation water requirement reduced[5].

In many instances, too, the dry-season crop is grown very late and there is not enough time to establish a deep-water variety under rainfall and have it reach stages with elongation ability before the water comes. The lower the plot, the higher the risk. This is why some farmers starting a dry-season crop as late as June sometimes prefer giving up the next wet-season crop. Also noteworthy, are areas where farmers establish floating rice varieties with WB (after a dry-season crop).

Figure 3 also shows what secondary situations might sometimes be observed in each topographical location. In the [B] situation, for example, DB can be chosen if irrigation supplies are unreliable (transition zone : see above). These descriptions apply to the flood-prone area of the delta (approximately the grey area of Figure 2). In other parts, irrigation and drainage facilities allow the use of HYVs, with single, double or triple cropping.

2.4 Research issues and scope for further technical change

From the technical point of view, the spread of WB to all areas with good water control may appear as the final outcome of an evolution mostly driven by time and labour-saving considerations. Are further technical changes to be expected or does this technique already provide a blend of factor uses which is unlikely to be modified in the near future ?

Situation A and B: In the areas provided with good water control, further evolutions should be driven by the pressure on water resources, as typified by the decline in the amount of water which, basin-wise, can be allocated to rice cultivation in the dry-season.

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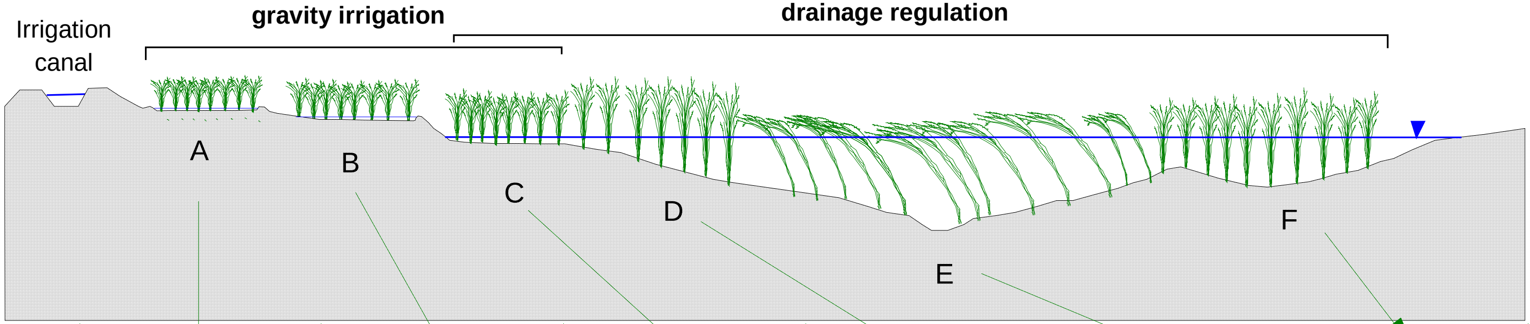
[4] This rise is not due to flooding from the river system, as is commonly believed, but to the regulation of the drainage of inner run-off. For more details, see (Molle et al. 1999).

[5] We have found exception to this situation – farmers growing the wet-season crop with DB after a dry-season crop with WB – but these are extremely rare.

FIGURE 3 : LOGICAL FRAMEWORK FOR THE CHOICE OF RICE TYPE AND CULTIVATION TECHNIQUE



	A	B	C	D	E	F
Main situation	High Yield Varieties wet broadcasting double cropping	High Yield Varieties wet broadcasting single cropping	Deep water rice wet broadcasting single cropping	Deep water rice dry broadcasting	Floating rice dry broadcasting	Deep water rice transplanting
Secondary situation	Favorable situation for diversification	Traditional varieties with dry broadcasting if no water for land preparation	Double cropping if enough water or individual water resource	Wet broadcasting, with pumping water out, if early ponding water		Dry broadcasting, if no early ponding water
Water and plot conditions	good access to irrigation water; good drainage conditions ; good plot conditions	good access to water and good drainage conditions in the rainy season; poor access to water in dry season; good plot conditions.	medium access to water;risk of prolonged flood or water depths between 40 and 100 cm; plot bunding and levelling	poor access to irrigation; prolonged flood with depths between 40 and 100 cm; poor or no on farm development; water level regulated in the drain	poor access to irrigation; quick or prolonged flood with depths over 100 cm; poor or no on farm development; water level regulated in the drain	poor access to irrigation; ponding water after the first rains; bad drainage conditions; plot bunding and medium levelling
Harvesting period	(October)/November		December / (January)		January / (February)	December / (January)
Some varieties	Chainat, Suphan 60 KK 23, KK35, etc		khaw ta heng, luang pratiew, khon keew khaaw pakuat, puang thong, khaw jet luang, etc		khaw lamyaay, pinkew khaw hom thung,etc.	Khaw ta heng, khaw luang pratiew, etc.
Socio-economic features	average rice farm area: 3.5 ha, agricultural diversification, rice intensification		average rice farm area: 4.5 ha (Ayutthaya province), ageing population, rural industries, out-migration			

This should pave the way for other forms of direct seeding, associated with adequate forms of land preparation. A promising technique, observed in a few rare cases, consists in ploughing the plot in semi-dry conditions, and in sowing dry seeds after flooding and draining the plot. Although weed pressure must be dealt with, this technique allows for a significant reduction of water consumption and should be comprehensively tested in the delta. Another water (and labour) saving technique is that observed in the Mekong delta, most especially in areas with a rotation of three rice crops per year: the so-called zero-tillage technique – dry seeds are sown on plots, after the stubs of the preceding crop have been burnt, but with no land preparation. This technique also reduces labour costs and, though already commonly observed in some parts of the delta (Bang Len district, for example), the conditions of its wider dissemination should be investigated.

The necessity to decreasing production costs is likely to be the second driving force of technical change. This could be obtained by more skill in pest and nutrient management, and by lower costs of mechanised harvesting brought about by an increasing supply of harvesters, as is being observed.

Another variant of the direct seeding technique, "*waan ché*", is sometimes observed in the delta : pregerminated seeds are sown in a few centimetres of water and the plot is drained after one day. This may allow a slight gain of time (plot drainage) in some instances, but the technique is well adapted to some types of soils : after being broadcast with WB, some seeds fall on micro-elevations of the mud bed which, in the dry season, are quickly backed by the sun. This may trap some seeds and prevent sprouting, an inconvenience avoided with the *waan ché* technique which may also provide better weed control.

Situation D and E: in the flood-prone areas where dry seeding is used, few technical changes can now be expected. Techniques are dictated by the hydrological regime which is unlikely to be altered. On the other hand, land preparation and harvesting are already mechanised. Changes can be expected in limited areas, following a pattern of abandon of the flooded rice in favour of one or two *post-flood* High Yield Varieties. This shift, initiated twenty years ago in the western part of the lower delta (an evolution to be related to that of the flood-prone area of the Mekong delta), recently expanded to other areas, as described elsewhere (Molle et al, 1999).

3 Conclusions

Wet broadcasting expanded in the Chao Phraya delta starting in the late 70's and replacing transplanting in slightly more than a decade. Labour shortage, especially at peak periods, widespread dissemination of herbicide and cost-effectiveness have spurred its adoption at the expense of TP. Even in the conditions of the Asian small-holder agriculture, transplanting, after thousands years of use, has become a burden. Its abandon is observed in many places of Southeast Asia, such as the Mekong delta, for example, where the average farm size is much lower than the 4 ha figure of the Chao Phraya delta.

After the mechanisation of threshing and land preparation, and after the demise of transplanting, the remaining and last labour intensive bottleneck of rice production was harvesting. In the delta, its mechanisation was initiated around 1990, starting in areas cropped with HYVs and later spreading into the flood prone area, with 72 % of the latter being harvested mechanically in 1998 (Molle et al., 1999). This sequence of drastic cuts in labour requirements now opens the way for an easier management of *larger* farms with hired labour and mechanisation, a possible destabilising element for small holder based agriculture. An embryonic development of such farms (> 20 ha) is observed in the flood-prone area of the delta (Molle and Srijantr, 1999).

From the technical point of view, the spread of WB should pave the way for other forms of direct seeding aimed at reducing both water use and production costs. These includes dry-seeding on plots wetted by irrigation, dry-seeding associated with zero-tillage techniques, as sometimes used in triple cropping, and the development of improved pest and nutrient management.

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