Agricultural and irrigation patterns in the Central Plain of Thailand

Preliminary analysis and prospects
for agricultural research and development

DORAS PROJECT

Kasetsart University **ORSTOM**

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The DORAS Project

The DORAS (Development Oriented Research on Agrarian Systems) Project is a joint research programme between Kasetsart University and two French Research Institutes, namely CIRAD (Centre de coopération Internationale en Recherche Agronomique pour le Développement) and ORSTOM (Institut de Recherche Scientifique en Coopération pour le Développement). CIRAD and Kasetsart University cooperate since 1991 within a programme on cotton development, whereas ORSTOM signed an agreement with Kasetsart University in 1994. Since this year, these two last institutions launched the Research Programme: "Agricultural Dynamics and Water Management in the Central Plain of Thailand".

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Chapter 1

Presentation of the study

1.1 The role of the Central Plain of Thailand

The Central Region of Thailand constitutes a key area in Thai agriculture and its economy as a whole. Its core area, the Central Plain proper, is provided with fine agricultural land (2 millions ha), extensive infrastructure (roads, irrigation system), and is located close to the main urban market of the capital and to port facilities. The Central Region accounts for 53 % of the sugarcane national production (half of this comes from the Central Plain) and contributes to rice self sufficiency and surplus for export : approximately one third of the 18.5 millions tons of rice produced annually, comes from the Central Plain, although it represents only 19 % of the rice-growing area (OAE, 1995). The share of Thailand in the world rice market fluctuates between 18 and 32 %, wheras its overall production corresponds to approximately 4 % of the world production (Benz, 1992).

Although subject to crop diversification, this deltaic region is however poorly suited for field crop cultivation : maize, sorghum, mungbeans, oil and fiber crops are scarce; major national exports such as rubber, pineapple or cassava do not originate from the Central Plain. Shrimp production, around 10 % of the national production, is still limited when compared with the southern region.

Although its southern half was reclaimed quite recently in Thai history, the Central Plain has undergone deep transformations over the last 150 years. In more recent times, industrialisation and urbanization (8 out of 14 million people who live in the in the Central Plain, reside in Bangkok and its vicinity) have occurred alongside a sharp change in agriculture marked by mechanization, intensification and diversification. These transformations have progressively changed the traditional features of the Central Plain, often seen as an extensive rice growing area, interspersed with upland sugarcane cultivation and backyard farm orchards.

The Central Plain also acts as a focus for a national change in agriculture : here innovations are tested (e.g mechanization), new crops introduced (e.g baby corn), new agricultural activities (e.g orchids farms) and technics trialed, social changes observed (involving rural communities interacting with the Bangkok Metropolitan Area) which could foreshadow large-scale social upheavals. The BMA is the core of the region : it accounts for 78 % of the value added in manufacturing and 50 % of the GNDP (Siamwalla, 1991), as well as concentrating the bulk of the national industrial and services sector.

Agricultural transformations

On one side, agriculture has kept pace with the changing water control conditions in the delta. These have been transformed by the construction of an impressive

network of canals and channels under the command of the Ministry of Agriculture and the Royal Irrigation Department. The progressive taming of the flood of the Chao Phraya river has reduced the area devoted to low land traditional rice-cropping, whereas the introduction of gravity and pump irrigation has contributed to allow rice intensification and, in particular, the use of High Yield Varieties (HYVs).

It is sometimes asserted that rice cropping in the Central Plain of Thailand has mainly remained extensive, as it used to be in former times. In fact, it has an average yield of 3 t/ha (48 thang/rai) which, although still above the national average of 2 t/ha - which includes rainfed areas in the Northeast (50 % of total) - can be considered quite low if compared with some other Asian countries. Nevertheless, various factors must be taken into consideration and this study aims in particular at providing some data on this issue :

- First, the average yield of rice cropping in the Central Plain is derived from extremely varied and often contrasting situations regarding intensification and rice cropping techniques. These range from floating rice cultivation to intensive triple cropping. Therefore, such an average value can be considered meaningless, just as comparisons between countries, which seldom consider comparable situations.

- Second, the water control at farm level is often under expected or assumed conditions, as a result of the priority given to the construction of primary and secondary canals and facilities.

- Third, the average farm size of 4 ha (25 *rai*) can still be thought of as considerable when compared to similar deltaic situations, such as those encountered in Vietnam, where this value goes as low as 1.3 ha and 0.3 ha in the Mekong and Red river deltas respectively. This of course does not favour high levels of intensification, especially if we consider at the same time the sharp decrease of labour at farm level because of migration to urban centres.

Moreover, the agriculture of the Central Plain has undergone several deep and quick transformations, some of which are still ongoing. These transformations are bound to be indicators of much wider transformations in Thai agriculture.

- The late sixties and seventies, for example, saw the beginning of mechanization, with buffaloes quickly replaced by four wheel and, mainly, two wheel tractors.

- In the eighties, the labour shortage increased drastically and was responsible for the near disappearance of the transplanting technique in the region. As a consequence, wet broadcasting (with pregerminated seeds) was adopted wherever water conditions allowed.

- During the present decade, the labour constraint has also contributed to the quick mechanization of harvesting, essentially for rice but also for sugarcane.

In the seventies, cropping intensity and overall production were sharply increased with the dissemination of dry-season rice cropping (which reached a plateau of 500,000 ha). However, water shortage was soon experienced as the storage capacity, upstream in the Chao Phraya basin was insufficient to meet the overall growing water requirements.

On the other hand, in parallel to a process of intensification, agricultural systems had to respond to an increasingly diversified demand from the urban and international markets. Besides the West Bank and Damnoen Saduak's traditional areas of fruit and vegetables production, several other spots of diversification have mushroomed with a very large range of produces (fruits, vegetables, flowers, orchids, fish, shrimps, poultry, etc.). The left bank of the Mae Klong Project and some areas around Bangkok, such as Rangsit Nua, have for example, experienced deep transformations in cropping patterns.

This trend is currently being supported by government policies aimed at changing the structure of the traditional rice-based agriculture. This policy is due to the necessity to offset the loss of regional competitiveness in rice cropping and to enforce water saving cropping activities in the delta.

Regional and sectorial interactions

Such dynamics give way to different and sometimes complex situations : intensification, regional diversification and off-farm activities (including farmers giving up agriculture) cannot be understood without considering the other economic sectors. The Central Plain is distinguished by the diversity of situations which can be encountered. By its location, surrounding the capital, it mirrors the relationships between urban and rural areas and foreshadows future social transformations.

A fundamental aspect of these interactions is the difference in the level of remuneration in the agricultural and the industrial sectors, which partly accounts for the pattern of permanent and seasonal migrations. At this point, it is obviously necessary to consider also industrialisation in rural areas and the flexible pattern of pluriactivity which is so commonly encountered.

Migrations, and their impact on labour cost and availability, also demonstrate that the regional changes observed must find their consistency at a higher level of analysis.

Water, as one of the main factors of production, also stresses the necessity to adopt a systemic approach within the scope of the water basins of the main rivers here considered (Chao Phraya, Mae Klong, Pasak, Bang Pakong). This underlines, in particular, the multi-purpose management of the Chao Phraya river, and the interdependence of development, be it agricultural or industrial - in the different parts of its basin : it also reminds the importance of the river for different uses (electricity generation, irrigation, navigation, domestic use, dilution and flushing of salt and pollution). The supply of Bangkok requires, for example, approximately 2.5 million m^3 per day. The multi-use of water also has an impact on water quality which has already jeopardized some agricultural activities in the south of the delta.

The understanding agricultural dynamics in the Central Plain, with its focus on the diversification process and water management, is also likely to provide hints which can be useful to further understand dynamics in Thailand as a whole.

In addition, the issue of agricultural dynamics in the Chao Phraya delta can be considered as a case study for a broader theme concerning all tropical deltas in

Southeast Asia. These deltas are rice bowls with a capital or a major city in their centre and are undergoing a process of intensification and diversification under partly controlled water conditions.

At present, the growth of rice production in neighbouring countries, the constraints on water, the opportunities for diversification, urbanisation and industrialisation, all contribute to accelerate the transformation of the agrarian systems of the Central Plain. This project aims at characterizing the conditions and consequences of these transformations in order to outline improvements and policies for the future. As such, it therefore emphasizes interdisciplinary and systemic approaches to agrarian systems and ecological environments.

1.2 The objectives and methodology

Objectives

The present study constitutes the findings of the first phase of the Research Programme on Agricultural Dynamics and Water Management in the Central Plain of Thailand, carried out by the DORAS Project. This first phase is an identification study designed to provide an overview of the region and to meet the following objectives :

- to assess the overall **diversity** of situations and to identify the main contrasts, especially regarding cropping systems and water control conditions
- to identify the main problems and dynamics and to establish an initial grading of their main determinants.
- to provide guidance for the choice of representative areas for the detailed research, surveys and monitoring of the second phase of the Project.
- to involve researchers from different disciplines in a participative and interdisciplinary approach of the region.
- to set up an extensive documentation about the Central Plain, including books, papers, thesis, statistics, data base and a Geographic Information System (GIS).

Methodology

A preliminary step was necessary to make official contacts and to collect data from various government offices (NSO, Ministry of Agriculture, Ministry of Interior, Royal Irrigation Department,..). Preliminary maps, statistical analysis and synthesis of books were also obtained and discussed by the Research Team.

From November 1994 up to March 1995, fields surveys and visits to the 45 RID's projects of the Central Plain were carried out. Scientific and pragmatic consideration led to choose RID Projects as a basic unit for the first step. At the scale of the Central Plain, it was first of all possible to better assess the importance and impact of water infrastructure and management. However, RID Projects not only collect data on water management, but also information on land use and environmental issues which have also been considered. In addition, interviews with farmers and with some

officers of the Department of Agriculture Extension (at *amphoe* level) helped us characterize the cropping patterns and check the limits of the main zones.

During the same time, secondary data was collected, processed and mapped, using Mapinfo® GIS software. The principal sources used in this report are listed below :

- NRC2D database; since 1986 the Ministry of Interior has carried out an extensive bi-annual survey at village level in the rural areas. The data base totals almost 300 variables, with different indicators on socio-economics and agriculture (see chapter 5 and annexes for more details). The data used hereafter corresponds to the year 1994. The detailed analysis of the information at *tambon* level evidenced many flaws in this data base. Its accuracy is not sufficient to consider absolute values for a few selected *tambons*. Nevertheless, it can be used to display some of the main contrasts in the region and is therefore relevant when considering the objectives of this study and its regional scope.

- The population census of the National Statistics Office which are carried out every ten years : 1960, 1970, 1980, 1990 (*amphoe* and *changwat* levels).

- The agricultural census of the National Statistics Office ; 1963, 1978.

- Data from the Office of Agricultural Economics : yields, land use series (*amphoe* and *changwat*).

- Data from the Royal Irrigation Department : land use (maps and data), rainfall and others (at Project level).

Mapping of statistics was achieved using maps of RID Projects, *changwat* and *amphoes*. The data related to *tambons* is displayed in circles centred in the approximate centre of gravity of each *tambon*.

The basic layers (rivers, irrigation and drainage networks, main roads, *amphoes* and irrigation Projects) were digitized based on a 1:250.000 map provided by the Royal Irrigation Department and completed by more precise digitizing for some irrigation Projects.

The maps of cropping patterns and water control were set up on the basis of the RID Projects maps and different satellite images channelled through the National Research Council of Thailand (NRCT). A digital picture of the 25th of December 1993 was also processed with the kind collaboration of NRCT.

- Spot image (Mae Klong area, 1988), processed by Arjarn Pongsan

- TM full bulk images (25th December 1993 (digital data), January 1994, 28th of October 1994, March 1995, April 1995); image and maps from the survey of the Office of Agricultural Economics (O.A.E, 1994).

Additional field trips have been done to check the information of the satellite images and to specify some particular cropping patterns.

Scope of the study

In this report, "Central Plain" is roughly referring to the triangle joining Chai Nat, Phetchaburi and Chachoengsao and encompasses : the irrigated areas within the Mae Klong and Chao Phraya Main Projects, together with some marginal areas located out of these hydraulic units, mainly along the Chao Phraya river and along the seashore; three independent Projects (Kra Siew, Nakhon Nayok and Khlong Priew); four subprojects bordering the Bang Pakong river. The gross area under consideration here covers 15,537,500 *rai* (i.e 2,486,000 ha), whereas the "official" irrigable area[1] stands around 11 millions *rai* (1,760,000 ha) (fig.1.1). Its border is marked by important cities such as Chai Nat, Kanchanaburi, Lop Buri, Saraburi, Rachaburi.

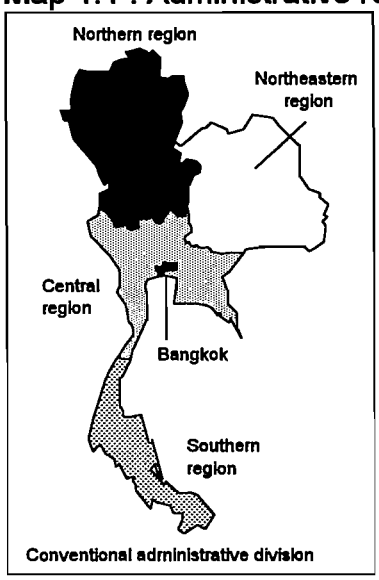
Therefore it does not match the administrative Central Region, which, in addition, has different administrative definitions : the area generally referred to as "Central Region"[2] extends from Trat Province, on the East, to Kanchanaburi, on the West, with the northern limit defined by Chai Nat Province (see fig 1.1). This Central Region, in more recent documents, sometimes appears divided in three sub-regions: the Central Region proper (Chai Nat, Phra Nakhon Si Ayutthaya, Lop Buri, Saraburi, Sing Buri, Ang Thong, Bangkok and Vicinity), and the Eastern and Western Regions (fig 1.1).

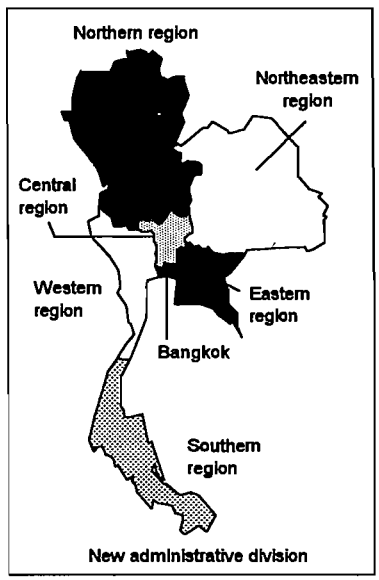
Our study area includes most of this Central region and parts of the eastern and western regions. Only the *changwats* of Pathum Tani, Phra Nakhon Si Ayutthaya, Ang Thong, Sing Buri, Nakhom Pathom, Samut Songkhram and Bangkok are totally included in the study area.

[1] This area, corresponding to the irrigable area of the RID sub-projects, cannot be known with precision because of increasing encroachment of urban and industrial areas on agricultural land. Conversely, some irrigated areas (for example, along the Chao Phraya) are not included in RID sub-projects.

[2] which curiously enough, the yearbook of the "Agricultural Statistics of Thailand" describes as the "Central Plain", although it extends from the Burmese border to the Cambodian one.

Map 1.1 : Administrative regions





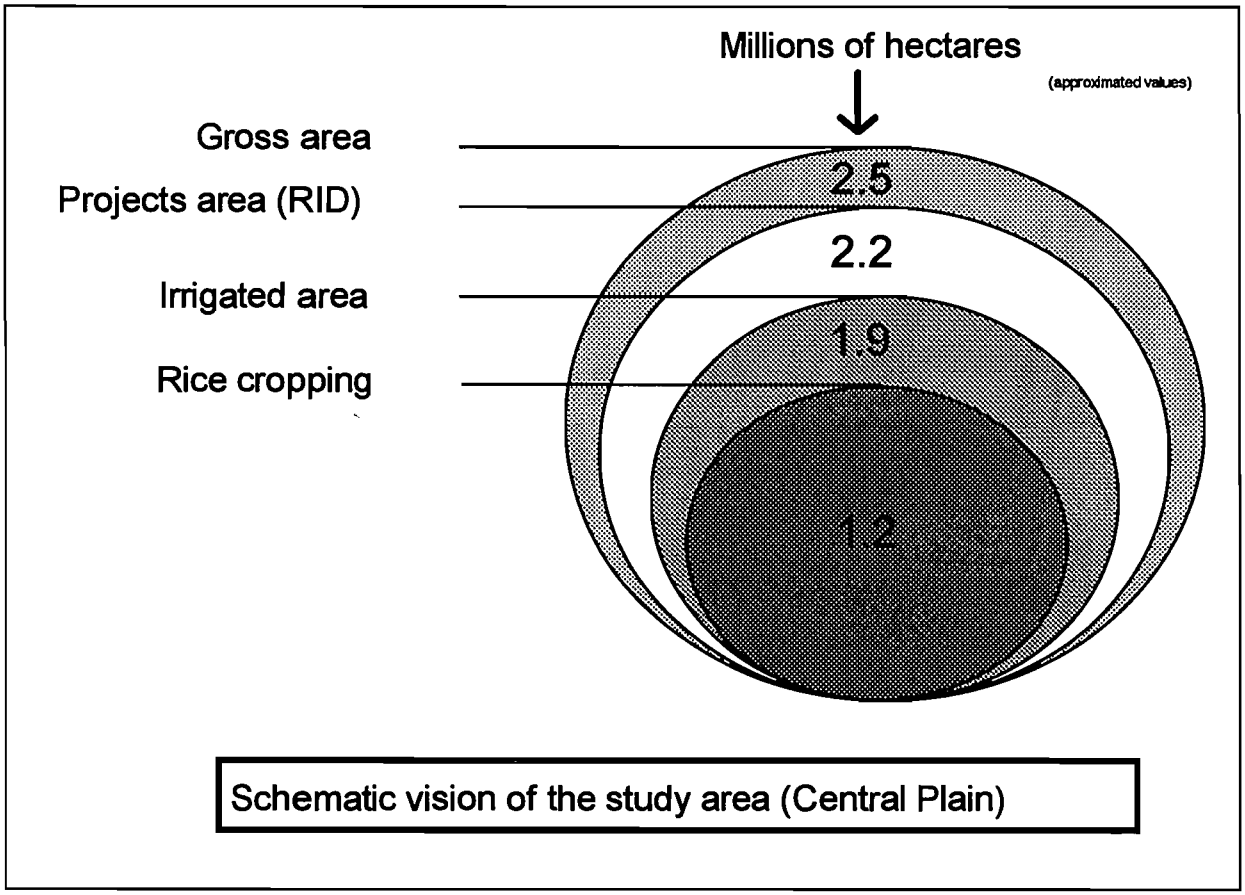
Map 1.2 shows the limits of the irrigated area, the main cities and the *changwat* which contribute to the Central Plain. Only those of their *amphoes* which are included in the Central Plain are indicated, giving a total of 110 *amphoes* (+ Bangkok Metropolitan Area), and a total gross area of 2,765,800 ha (17,286,250 *rai*). It is worth noting that some of these *changwats*, especially along the western limit, have a significant part of their area located in the rainfed neighbouring areas. Statistical data corresponding to these *amphoes* must therefore be interpreted cautiously.

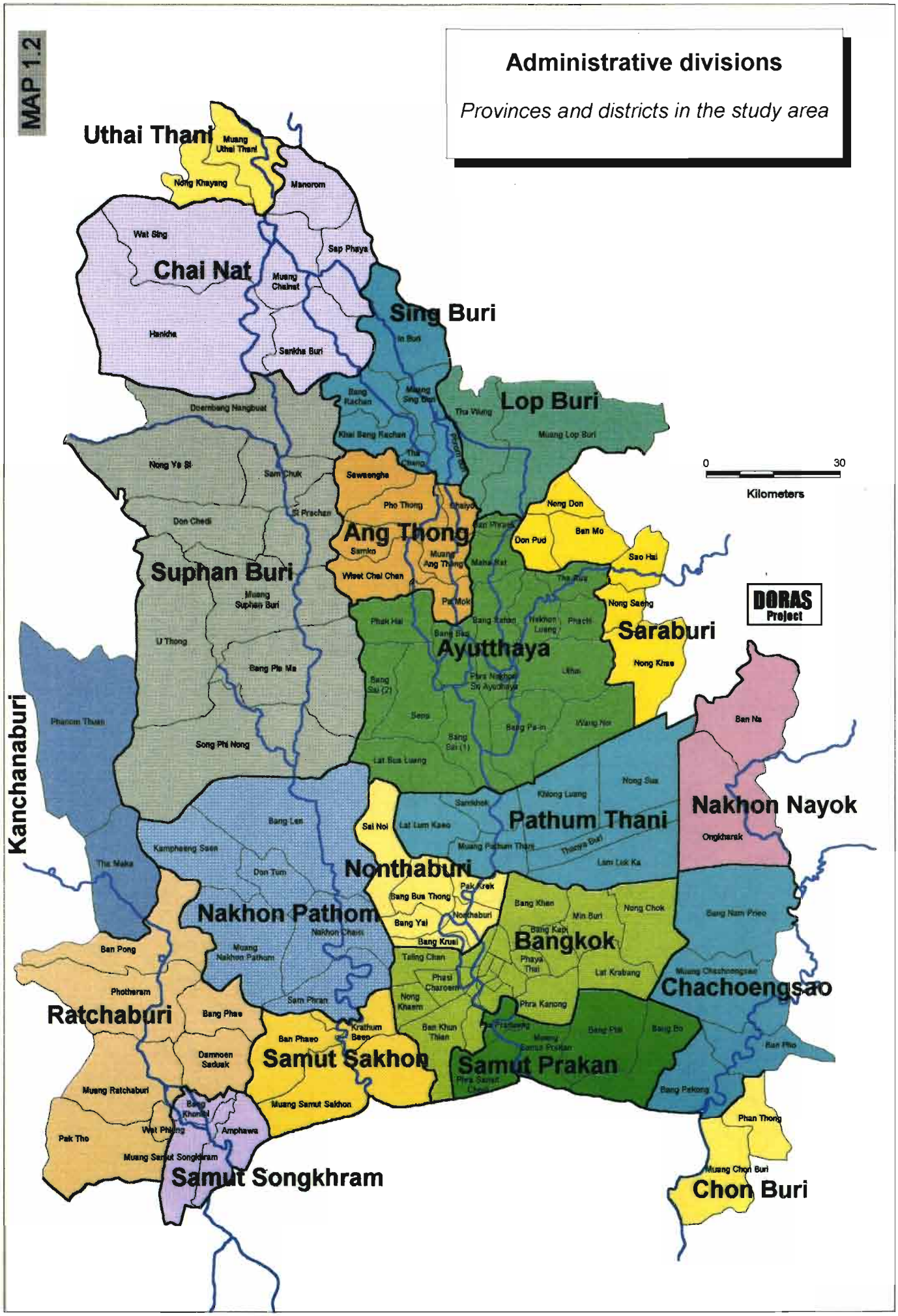
Together with the administrative level of *amphoes*, the hydraulic units constituted by the sub-Projects of the Royal Irrigation Department will be considered. The forty three sub-projects belong to **four Regional Irrigation Offices** : the 10th Region (Head office in Kanchanaburi, for the Mae Klong Project), the 7th Region (Head office in Chai Nat, for the Chao Phraya right bank), the 8th (Head office in Lop Buri, for the Chao Phraya right bank), plus the 9th Region (for the Bang Pakong area).

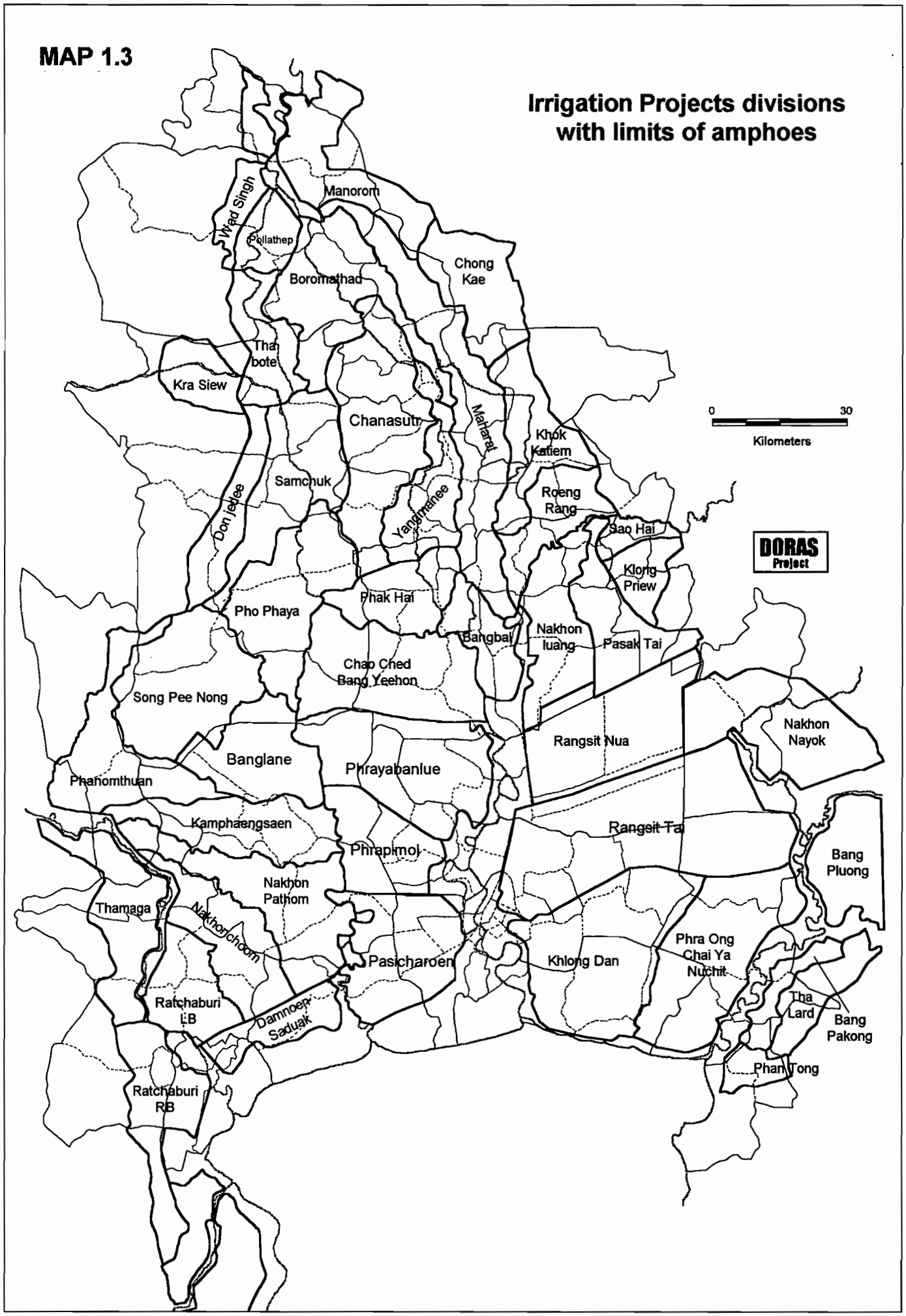
Map 1.3 shows how these two sets of units overlap. It can be consulted if more precise location is desired when analysing the different maps of this report.

Figure 1.1 gives an overall sketch of the study area : with a gross acreage of 2.5 million ha, among which 2.2 is under the administration of the Royal Irrigation Department, approximately 1.9 million ha can be considered irrigated. Rice cropping covers 1.2 million ha.

Fig. 1.1 : Schematic view of the study area




MAP 1.2
Administrative divisions
Provinces and districts in the study area
Uthai Thani
Muang Uthai Thani
Nong Khayang
Manorom
Wat Sing
Chai Nat
Muang Chainat
Sap Phaya
Hankha
Sankha Buri
Sing Buri
In Buri
Bang Rachan
Muang Sing Buri
Lop Buri
Tha Wung
Muang Lop Buri
Doembang Nangbuat
Khai Bang Rachan
Tha Chang
Nong Ya Si
Sam Chuk
Sawaengha
Pho Thong
Ang Thong
Samko
Muang Ang Thong
Wiset Chai Chan
Pa Mok
Maha Rat
Nong Don
Don Pud
Ban Mo
Sao Hai
Nong Saeng
Saraburi
Nong Khae
Don Chedi
Si Prachan
Suphan Buri
Muang Suphan Buri
U Thong
Bang Pla Ma
Song Phi Nong
Phak Hai
Bang Ban
Bang Sai
Nakhon Luang
Phachi
Ayutthaya
Phra Nakhon Si Ayutthaya
Uthai
Bang Sai (2)
Sena
Bang Pa-in
Wang Noi
Bang Sai (1)
Lat Bua Luang
Kanchanaburi
Phanom Thuan
Ban Na
Nakhon Nayok
Ongkharak
Khlong Luang
Nong Sua
Pathum Thani
Sanam Chai
Sai Noi
Lat Lum Kaeo
Muang Pathum Thani
Thanya Buri
Lam Luk Ka
Bang Len
Kamphaeng Saen
Tha Maka
Don Tum
Nonthaburi
Pak Kret
Bang Bua Thong
Bang Yai
Nonthaburi
Bang Khen
Min Buri
Nong Chok
Bang Nam Priao
Nakhon Pathom
Nakhon Chaisi
Bang Kapi
Bangkok
Bang Khun Thian
Bang Phli
Bang Bo
Ban Pong
Muang Nakhon Pathom
Taling Chan
Phaya Thai
Lat Krabang
Muang Chachoengsao
Chachoengsao
Photharam
Sam Phran
Phasi Charoen
Nong Khaem
Phra Kanong
Ratchaburi
Bang Phae
Krathum Baen
Ban Phaeo
Samut Sakhon
Samut Prakan
Damnoen Saduak
Muang Samut Sakhon
Bang Pakong
Ban Pho
Muang Ratchaburi
Bang Khonthi
Wat Phleng
Amphawa
Pak Tho
Muang Samut Songkhram
Samut Songkhram
Phan Thong
Muang Chon Buri
Chon Buri
0
30
Kilometers
DORAS Project


MAP 1.3
Irrigation Projects divisions with limits of amphoes
Manorom
Wad Singh
Pallathep
Boromathad
Chong Kae
Tha bote
Kra Siew
Chanasutr
Maharat
Khok Kathiem
Samchuk
Don jedee
Yangmanee
Roeng Rang
Sao Hai
DORAS Project
Klong Priew
Phak Hai
Pho Phaya
Bangbal
Nakhon luang
Pasak Tai
Chao Ched Bang Yeehon
Song Pee Nong
Rangsit Nua
Nakhon Nayok
Banglane
Phrayabanlue
Phanomthuan
Kamphaengsaen
Rangsit Tai
Phrapimol
Bang Pluong
Nakhon Pathom
Thamaga
Nakhonchoom
Phra Ong Chai Ya Nuchit
Pasicharoen
Khlong Dan
Tha Lard
Bang Pakong
Ratchaburi LB
Damnoen Saduak
Phan Tong
Ratchaburi RB
0
30
Kilometers

Chapter 2

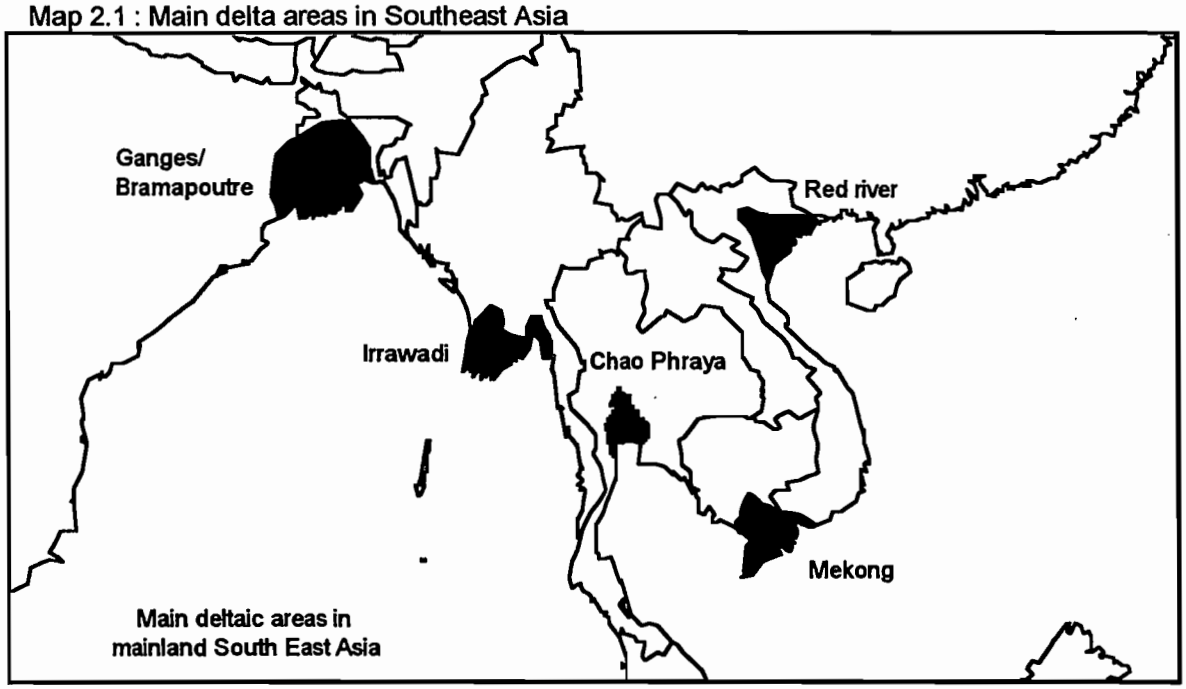
The Central Plain of Thailand : the setting

2.1 The Central Plain and its natural environment [1]

The Chao Phraya delta is one of several major river deltas found in Southeast Asia. Map 2.1 shows a sketch of the four largest deltas, namely - from the west to the east - the Irrawady river (Myanmar), the Chao Phraya river (Thailand), the Mekong and Red rivers (Vietnam), to which we added the Ganges/Bramapoutre rivers (Bangladesh). All these deltas are often referred to as "rice bowls" given the overall predominance of rice cultivation and their importance in the national food production. They all include in their centre or close proximity a main urban centre (Dhaka, Yangon, Bangkok, Ho Chi Minh City, Hanoi).

The Chao Phraya and Mekong deltas, together with Cambodia, have a fairly contrasting climatic regime, with average monthly monsoonal rainfalls quite limited (200 mm/month), if compared with other monsoonal regions where they reach 600 mm/month (Irrawadi delta).

Map 2.1 : Main delta areas in Southeast Asia



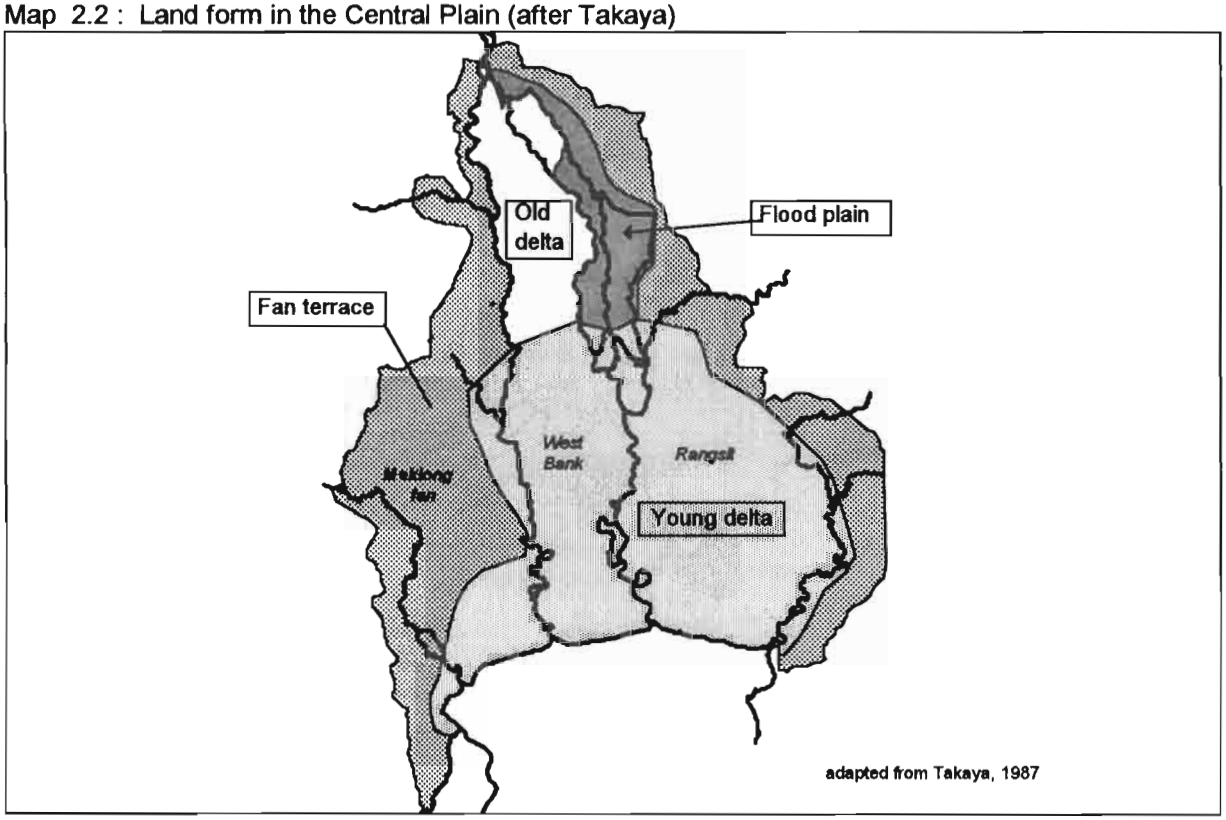
[1] This section only intends to provide general information about the physical aspects of the Central Plain, without entering in details. Description of physical features are borrowed from Takaya (1987), to which the reader can resort for further information.

2.1.1 Land form

A division of deltas according to land form and hydrological criteria given by Takaya (1978) has been found applicable to most of the deltas and its simplicity enables us to often refer to the categories he has evidenced. The Chao Phraya delta can be conveniently divided into four main zones (see map 2.2):

- In the upper delta, we can first of all distinguish the **old delta**, which covers an area between the Suphan Buri and the Noi river. The old delta is fossilized (its deposition ended several tens of thousands of years ago) and is characterized by a significant relief. In the northern part, we can find an alternance of high natural levees and depressions lying four meters lower (in which drainage conditions are often insufficient and deep water rice has to be grown). Further south is a sugarcane area with highly retensive soils and some depressions planted with rice. In the southern tip, we find a transitional zone between the old delta and the flood plain, where water coming from the north accumulates without possibility of drainage to the Noi river (which level is generally too high), and where floating rice and deep-water broadcast rice are grown.

Map 2.2 : Land form in the Central Plain (after Takaya)



- This old delta is bordered on its eastern side by the **flood plain** : this area includes the Noi, Chao Phraya and Lop Buri rivers from Chai Nat to Ayutthaya. It consists in an association of very low depressions, back swamps with fine heavy clay, and natural levees along the rivers, often standing 4 meters higher than the depressions. Their soils are loamy to sandy. A few milena ago, incursion of salt

water into the southern part of this area left young marine clays (with strong acidity) that are now close to the surface. In the back swamps and lower parts of the natural levees, traditional floating and deep water rice are cultivated, whereas improved varieties can be found in the highest parts, sometimes with double cropping. This flood plain was the core area inhabited by the Siamese and has always grown a wide variety of crops. Animal husbandry, duck-raising and field crop cultivation are also important activities. This flooded area extends to the west, up to the south of Suphan Buri, where a similar flood plain can be found along the Song Phi Nong river.

- The southern part of the delta is a very broad tract of extremely flat land, which is well demonstrated by the fact that the elevation of Ayutthaya (its northern point) is only two meters, although it is located 100 km inland. Surrounding the last reach of the river, the so called **young delta** therefore constitutes a large area where floods can spread and water accumulate.

  Its western part, between the Chao Phraya and Tha Chin rivers, is often referred to as the **West Bank.** Its eastern side can be divided into the **Rangsit area** and a coastal zone where aquaculture is well developed. It also comprises a slightly elevated area (2.50 m) around Bangkok (deltaic heights).

- Around these three zones, we can find the **fan-terrace complex**. These terraces are normally not as fertile as the low lands and are water deficient in that a dense network of water streams drains water towards the centre of the delta. This drawback is now offset by gravity irrigation. They nevertheless present some scattered depressions where rice is grown and where drainage may sometimes be poor.

  The main fan terrace is constituted by the alluvial deposits of the Mae Klong river, which present fertile soils, most of its higher parts being covered with sugarcane, whereas the lower areas are planted with rice.

Regarding stratigraphy, four main units can be found in the Central Plain : the Pleistocene marine deposits (the older ones), the Holocene marine deposits, the (recent) fan deposits and hard rocks.

The Holocene marine deposits lay horizontally, covering the central part of the Chao Phraya delta. Marine clays and brackish clays, which are the main constituents of the Holocene deposits, are potential sources of salt and acid sulphate. These deposits have mostly been covered by freshwater swamp deposits brought by the rivers, as the sea receded. Superficial marine deposits can be found only in the very tidal area.

Pleistocene deposits lay below the Holocene deposits in the central part of the delta but, while old sediments in the centre of the delta continue to sink and to be overlaid by new deposits, they are lifted in the margins of the delta. They lay as low as 15 m below the ground surface at Bangkok but appear at elevations of more than 10 m above sea level in many places along the margin of the plain. The Pleistocene marine and brackish clays are also potential salt and acid sulphate suppliers.

Nevertheless, they are not as strong as the Holocene clays, because they have been weathered and leached out, as indicated by the presence of spherical concretions of iron and manganese oxide called pisoliths (Hattori and Takaya, 1989).

2.1.2 Main soil characteristics and distribution

* *Taxonomy*

According to the soil taxonomy, we can distinguish 6 main soil orders in the Central Plain, namely, Entisols, Inceptisols, Mollisols, Vertisols, Alfisols and Ultisols (tables 2.1 and 2.2). The main lowland area of the young delta mostly consists of Inceptisols, which means young soil (Map 2.4). Its southern part consists of marine clay deposits and its northern parts of brackish sediments, although both have later received superficial freshwater sediments.

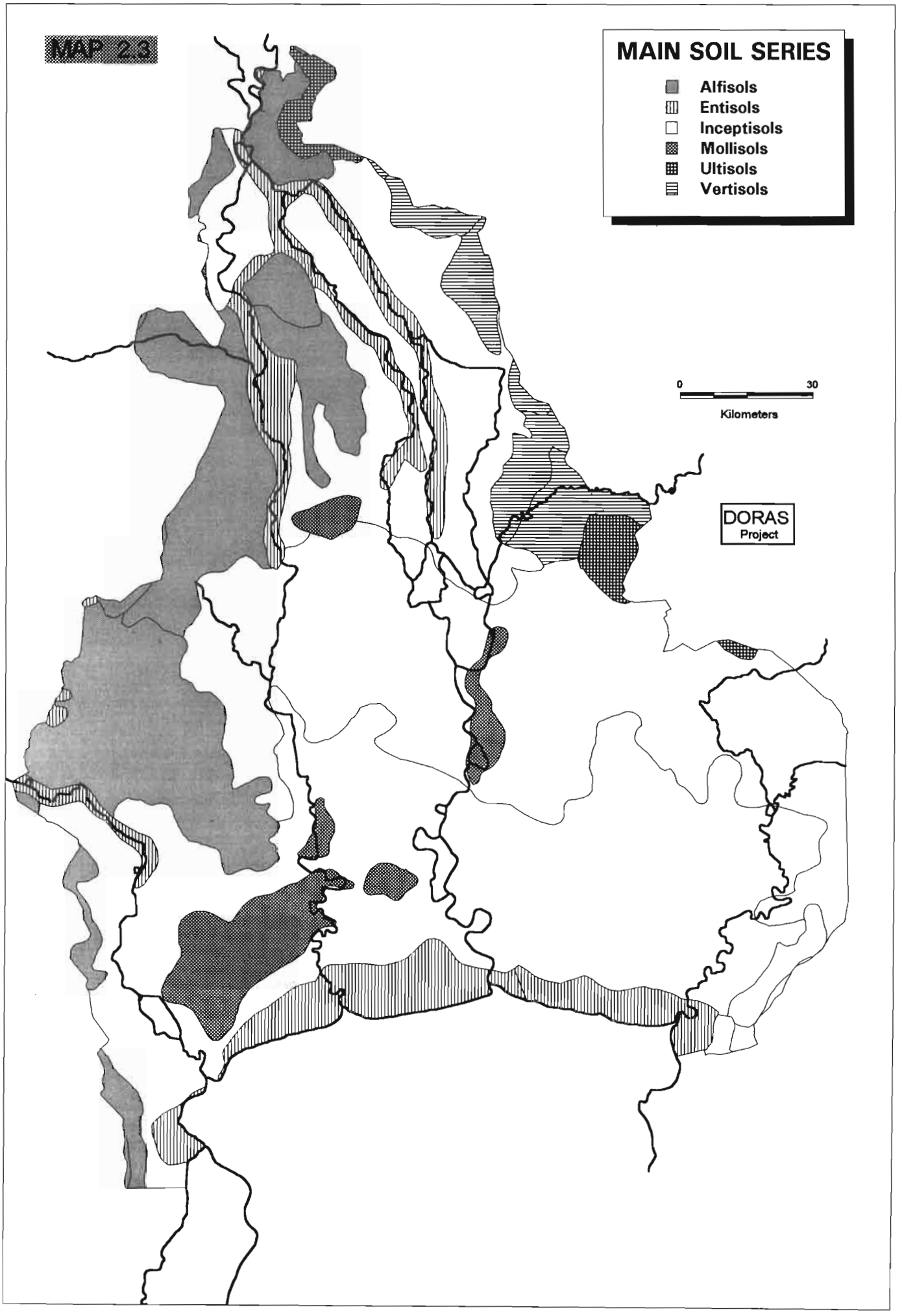
Along the levees of The Chao Phraya, Tha Chin and Mae Klong rivers and in the tidal areas where mangroves and marshes are predominant, we find soils known as Entisols, which are the most recent deposits favoured with high fertility; on the coast, this quality is, however, offset by brackish conditions and salinity constraints.

Mollisols are soils with lower clay content and often correspond to vegetable and fruit orchards areas. They are concentrated in the Damnoen Saduak area.

Alfisols are found in the western fan terraces; they are medium textured non calcic brown soils in the Mae Klong fan, which was active until recent change in the water regime brought about by irrigation and land development, and more weathered low humic glay soils in the Krasiew fan and part of the old delta.

Table 2.1 : Taxonomy of dominant soil series in the Central Plain

Order	Soil series (*Family name*)	Remark
Inceptisols	Rangsit : Rs, Sena : Se and Ongkharak:Ok (Sulfic Tropaquepts, very fine ,mixed, acid)	Acid sulfate soil
Entisols	Tha Muang : Tm(*Typic Ustifluvents, loamy, mixed ,non-acid*) and Tha Chin :Tc (*Typic Hydraquents, fine, mixed, non-acid*)	Levee Active tidal flat
Alfisols	Kamphaeng Saen; Ks (*Typic Haplustalfs, Fine-silty, mixed*)	Upland crop such as sugarcane cultivation
Vertisols	Tha Rua :Tr (*Aquentic Chromuderts;Very fine, montmorillonitic*), Ban Mi : Bm (*Entic Pelluderts, Very fine, montmorillonitic*)	Expanding clay
Mollisols	Bang Len : Bl and Damnoen Saduak : Dn (Bang Len series raised bed) (*Typic Haplaquolls, Very fine, montmorillonitic*)	Vegetable production
Ultisols	Pak Tho; Pth (*Aeric Plinthic Paleaquults, clayey, kaolinitic*)	Alluvial deposit


MAP 2.3
MAIN SOIL SERIES
Alfisols
Entisols
Inceptisols
Mollisols
Ultisols
Vertisols
0
30
Kilometers
DORAS
Project

On the eastern side of the delta, we find black heavy clay soils rich in montmorillonite. These vertisols have been formed in a limestone area, in which weathering converts sediments in heavy clay instead of laterite, because of the absence of iron and aluminium.

In the eastern part of the Chao Phraya delta (Nakhon Nayok province), some soils belong to the order of Ultisols, where the prefix "ulti" connotes "extreme leaching", which relates to a rather sandy structure.

Table 2.2 : distribution of main soils in the Central Plain

Order	Area(km^2)	Percentage
Inceptisols	16013	64.5
Entisols	2303	9.3
Alfisols	4117	16.6
Vertisols	940	3.8
Mollisols	1097	4.4
Ultisols	358	1.4
Total	24828	*100*

* *Soil problems*

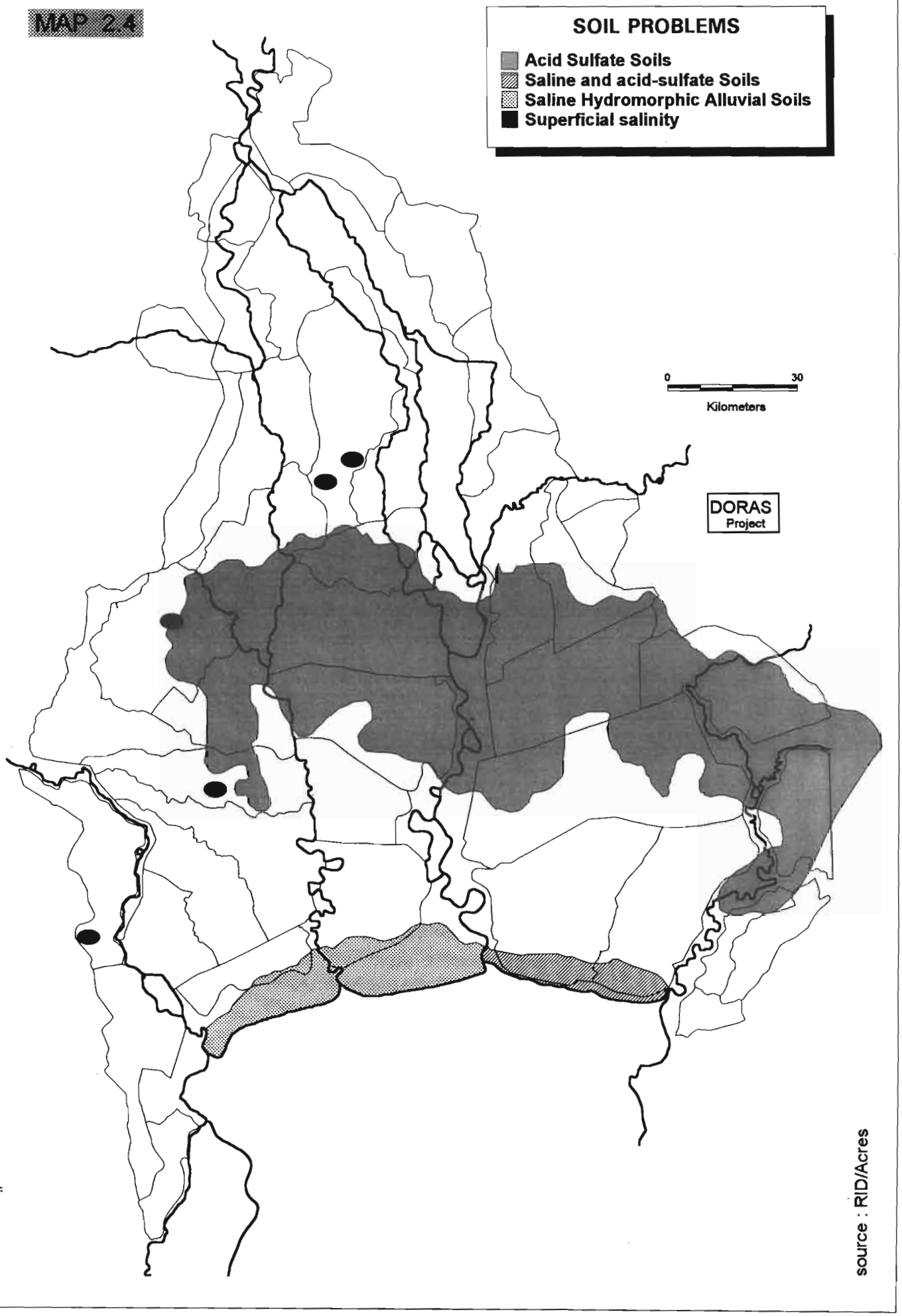
➢ Acid Sulphate Soils

Acid sulphate soils, with pH as low as 3, occur on the upper half of the young delta, where brackish sediments and poor drainage conditions prevail. There is an estimated 1.5 million hectares of acid sulphate soils in Thailand, of which about 90 % occurs in the Central Plain.

Acid sulphate soils can be divided into two major groups : potential acid sulphate soils and acid sulphate soils. The potential acid sulphate soils are classified as Sulfaquents, such as the *Bang Pakong* serie. They are common along coastal areas, very poorly drained, with a clayey texture, high pH, greenish or bluish colour, high salinity and pyrite (FeS_2) content. The drainage of these unripe soils results in the formation of true acid sulphate soils. Some of these areas, covered with marshes and mangroves have been cleared for salt pans or fisheries. These soils have a low potential for agricultural production and require heavy investments in soil amendments.

The true acid sulphate soils are mainly Sulfic Tropaquepts such as *Cha-am, Thanyaburi, Rangsit, Sena* and *Ongkarak* soil series and Typic Sulfaquepts. They also include the Typic Tropaquepts such as Bang Khen, Ayutthaya, Don Muang, Tak Bai, Bang Nam Prieo and Mahaphot soil series. These soils present a very low pH which is caused by the oxidation of iron sulfides (sulfates come from sea water trapped in the marine deposits) into sulfuric acid and complexes of iron/aluminum sulfates called jarosite : yellow mottles of jarosite mark the end of the oxidation reaction.They are poorly drained, clayey textured soils. The degree of acidity in the root zone of the top soil layer depends on the amount and depth of jarosite. Most of these soils are used for rice cultivation.

MAP 2.4


SOIL PROBLEMS
Acid Sulfate Soils
Saline and acid-sulfate Soils
Saline Hydromorphic Alluvial Soils
Superficial salinity
0
30
Kilometers
DORAS
Project
source : RID/Acres

The main limitations of these soils for agricultural production are acidity, phosphorus deficiency and toxicity of soluble Fe and Mn. A high water table should be maintained in order to prevent pyrite oxidation but this is hardly practicable, because of lack of water in the dry season. Generally, the management of acid sulphate soils in the country includes the use of lime and the application of fertilizer (nitrogen and phosphate).

Acid sulphate soils extend along an east-west belt between Ayutthaya and Bangkok, with particular occurrence in the Rangsit area and the north of the West Bank (see map 2.4).

➢ Saline Soils

Some salinization problems occur because of salt intrusion in the main estuaries. In normal conditions, marine water intrusion is controlled by maintaining an appropriate discharge in the main rivers. This is possible only in mainstreams regulated by dams in the upper basin. In the Bang Pakong river such a regulation will be possible only after the construction of a planned dam near Chachengsao. In the past, the fruit orchards situated along the Chao Phraya (durian, orange) have suffered important loss because of salt water intrusion.

Other problems with saline soils also occur when digging marine sediments too deeply, in areas near the sea shore, such as Nakhon Chaisi.

A quite new salinization process has also appeared in the Kamphaengsaen and Song Phi Nong Projects at the interface between rice and sugarcane and in other spot locations of the old delta (see black areas in map 2.4).

This problem is mainly due to the rising of the water table by abundant irrigation during the dry season, in some areas where underground water is brackish. It appeared about ten years ago, that is to say five to ten years after double cropping expanded (especially in the Mae Klong Project). Sugarcane cultivation turns out to be impossible and farmers must return to rice farming in order to lixiviate the soil.

2.1.3 Hydrography and hydrology

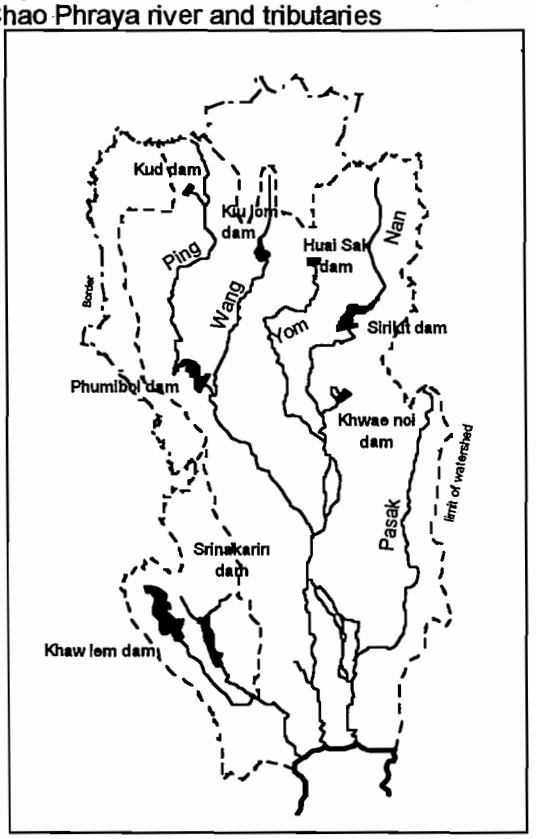
The Chao Phraya delta only constitutes the tip end of a large water basin which extends from the Gulf of Thailand up to the northern border and totals 110,000 km^2 : this area corresponds to one third of the country (map 2.5). The upper and medium part of this basin can be divided into four smaller catchments corresponding to the Ping, Wang, Yom and Nan rivers. Approximately one third of the basin is controlled by storage reservoirs, the Bhumibol dam (on the Ping river) and the Sirikit dam (on the Nan river), being by far the two largest ones.

All these tributaries meet near Nakhon Sawan to form the Chao Phraya river which, 50 km further, in Chai Nat, will be diverted into the irrigated scheme of the delta proper.

The Chao Phraya delta is crossed by four main water ways. On the western and eastern sides respectively, are the Mae Klong and Bang Pakong rivers. In its middle, the Tha Chin (or Suphan Buri) river flows almost in parallel to the Chao Phraya itself, the latter with its ramifications into the Noi and Lop Buri rivers which meet again near Ayutthaya, together with an eastern tributary : the Pasak river (see map 2.6).

These rivers are not completely independent. The Pasak river is a tributary of the Chao Phraya whose flow is divided into four main waterways (Thachin, Noi, Lop Buri and Chao Phraya rivers) which sometimes re-merge together or are interconnected by canals. The Mae Klong also contributes for around 50 m^3/s to the Tha Chin river, through the drainage system of the irrigation scheme, which are partly reused in the West Bank.

Map 2.5 : Water basin of the Mae Klong river, Chao Phraya river and tributaries



The Chao Phraya river has an average annual runoff to the sea of 24 billion m^3, which indicates a run-off coefficient between 15 and 30 % (JICA, 1989). The Mae Klong river contributes with 10 billion m^3; these values can be almost doubled in exceptional years. These two mainstreams are now partly controlled in their upper reaches by means of storage dams (see § 2.5). Peak discharges at the Chao Phraya diversion dam are found to be over 4,000 m^3/s.

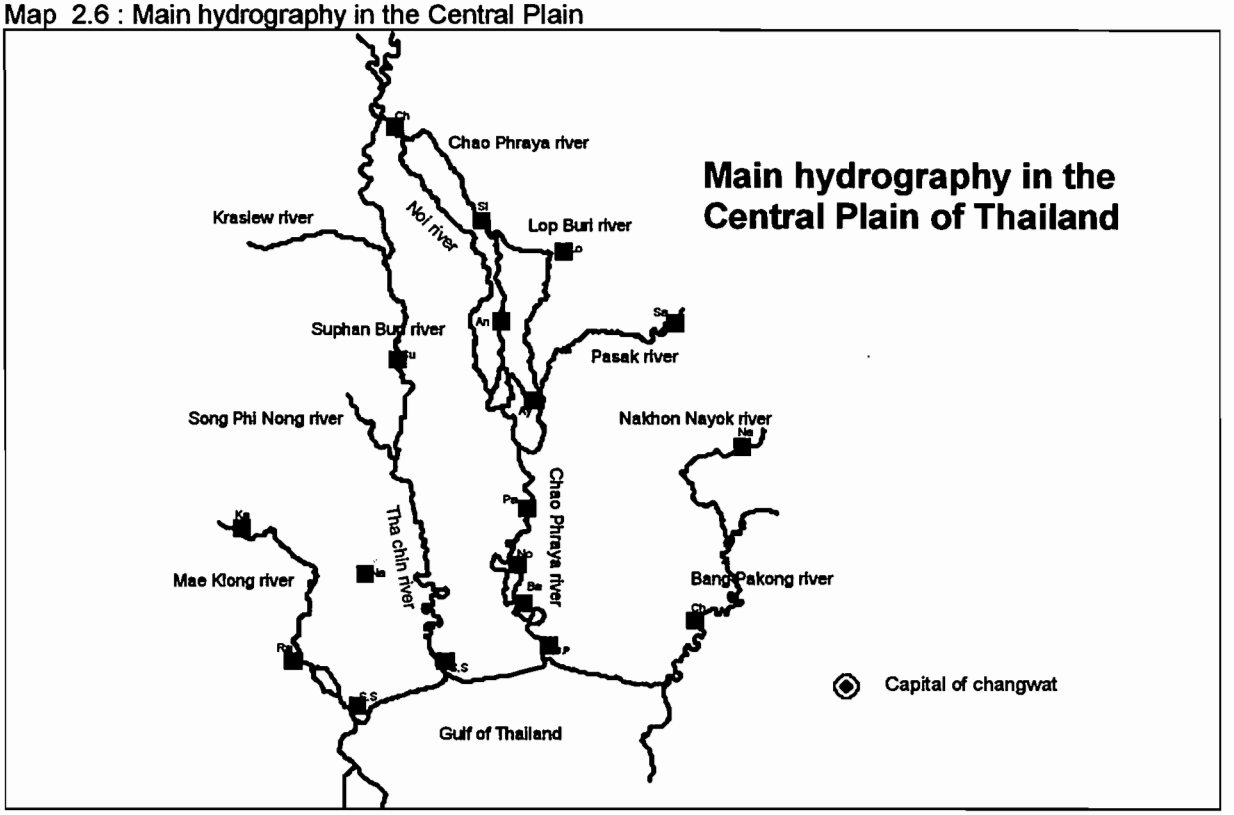
However the hydrological regime is still marked by a sharp contrast between the dry season (December to June), when discharges dwindle down and regulation is needed to match the different requirements in the basin, and the rainy season (July to November), during which flooding is common and a complete control is not possible. Given the seasonal structure of rainfall, once water is drained out to the sea and discharges in the river have gone back to normal, most of the young delta will dry up and be deprived of water. This contrasting natural pattern of alternation between excess and lack of water may partly explain the rather recent colonization of the lower delta. The transformation of such a harsh environment and the control of water requires high investment in construction and excavation works.

Flooding is irregular in time and space. It varies of course from year to year but - apart from some specific locations - does not always affect the same areas with the same intensity. In fact, flooding is a result of local rainfall, side flows from surrounding areas, the combination of the runoff of the different rivers and of the tidal regime. Management by man (quality of drainage, edification of dikes, use of pumping stations, diversion of flows in the different waterways, etc..) is being

constantly improved and many areas now have a rather good control of the flood in normal years, although they still bear features of extensive rice cultivation. Nowadays, flooding is rarely caused by overflows of water over embankments but is controled - and sometimes provoked - by the use of regulators built in the drainage system.

The different parts of the delta, as described above, are unequally affected by floods. The fan terraces and the higher parts of the old delta have acceptable drainage conditions whereas the young delta has almost no slope, which implies that excess water will take a long time to drain to the sea, process which, in addition, will be possibly hindered by the fluctuations of the sea level provoked by the tide. The W Bank is therefore partly flooded during two or three months.

Map 2.6 : Main hydrography in the Central Plain



2.1.4 Climate

Thailand has a climate dominated by the monsoon regime. Most of the country can be classified as Tropical Savannah (Koppen 'AW') with the exception of the South-east and Southern Peninsula, where Tropical Monsoon ('AM') predominates, and the Northern Mountain areas where higher altitudes produce a climate classified as Humid Subtropical ('CW').

The average monthly temperatures in the Central Plain range from 25° to 33° C. Figure 2.1 exemplifies the climatic features of the station of Suphan Buri. Minimum average temperatures are seldom lower than 20° and, even if some punctual coldness between 10 and 15° may be recorded, this means that there is no real

temperature constraint for rice cropping. Only some excessive temperatures may affect negatively rice flowering in April.

Average humidity remains fairly high (between 75 and 80 %) but this may hide daily variations. In the Damnoen Saduak area, for example, humidity during the night is almost 100 % but it slumps down to 70 % during the day. This has an impact on Class A pan evaporation which, in Suphan buri (Fig. 2.1), is lower than 150 mm/day with the exception of September and October for which the 200 mm ceiling is attained.

Whereas the average annual rainfall of the country covers a large range (between 900 and 4,000 mm), in the Central Plain it remains between 900 and 1300 mm (map 2.7). Although the western parts receive 25 % more precipitation than the eastern ones, differences in rainfall patterns in the Central Plain does not induce contrasting agricultural situations as most of the area is under an irrigated or flooded regime.

Figure 2.1 shows the monthly distribution of rainfall in Suphan buri and the corresponding ETP curve. Three main seasons can be distinguished; a rainy season from May to October, a cool and dry from November to February, and a hot and dry from March to May. It can be observed that average rainfall is only higher than ETP in the August-September-October period, which may be surprising to one who bears in mind the image of a monsoonal tropical region with plentiful water.

Figure 2.2 shows a frequential analysis of a decade rainfall in Kamphaengsaen. For this station, average annual rainfall is 970 mm, with a minimum amount of 730 mm ensured 4 years out of 5. An average of 44 % of rainfall occurs during this pre-season, whereas 51 % falls during the September-November period.

Rainfall by decade in the 1975-1995 period has been compared with the corresponding average evaporation (Class A pan : EV) and with half of this value. Fig 2.2 shows the probability of the rain to be higher than these two values. Between the 10th of April and the 20th of August, the probability of having the precipitation match the evaporation is always lower than 0.5, which points out the importance and necessity of irrigation[2].

Table 2.3 shows the distribution of years according to the month in which the rainy season begins (defined by Rain> EV/2). For each class, the probability to have no, one or two months of water shortage (under the rather strict criteria of Rain < EV/2) is specified.

Table 2.3 : Occurrence of dry spells (Kamphaengsaen station 1975-1995)

Start of the rainy season	May	June	July and after	total
no dry period	28 %	9 %	5 %	42 %
1 month dry period	24 %	5 %		29 %
2 months dry period	21 %	5 %		26 %
Total	73 %	19 %	5 %	

[2] these values may be considered as indicative as the number of years considered (20) is two low to allow statistic reliability

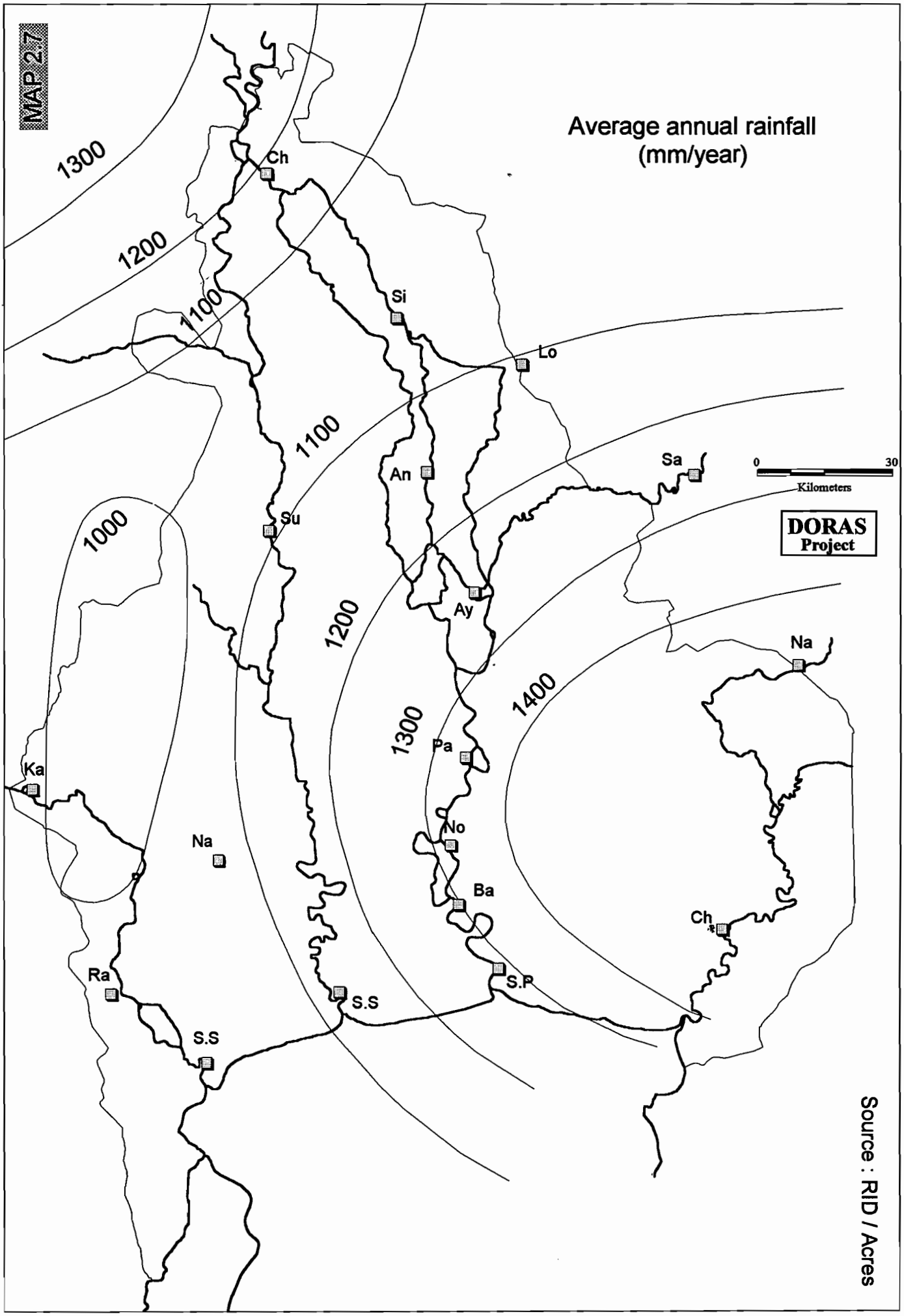
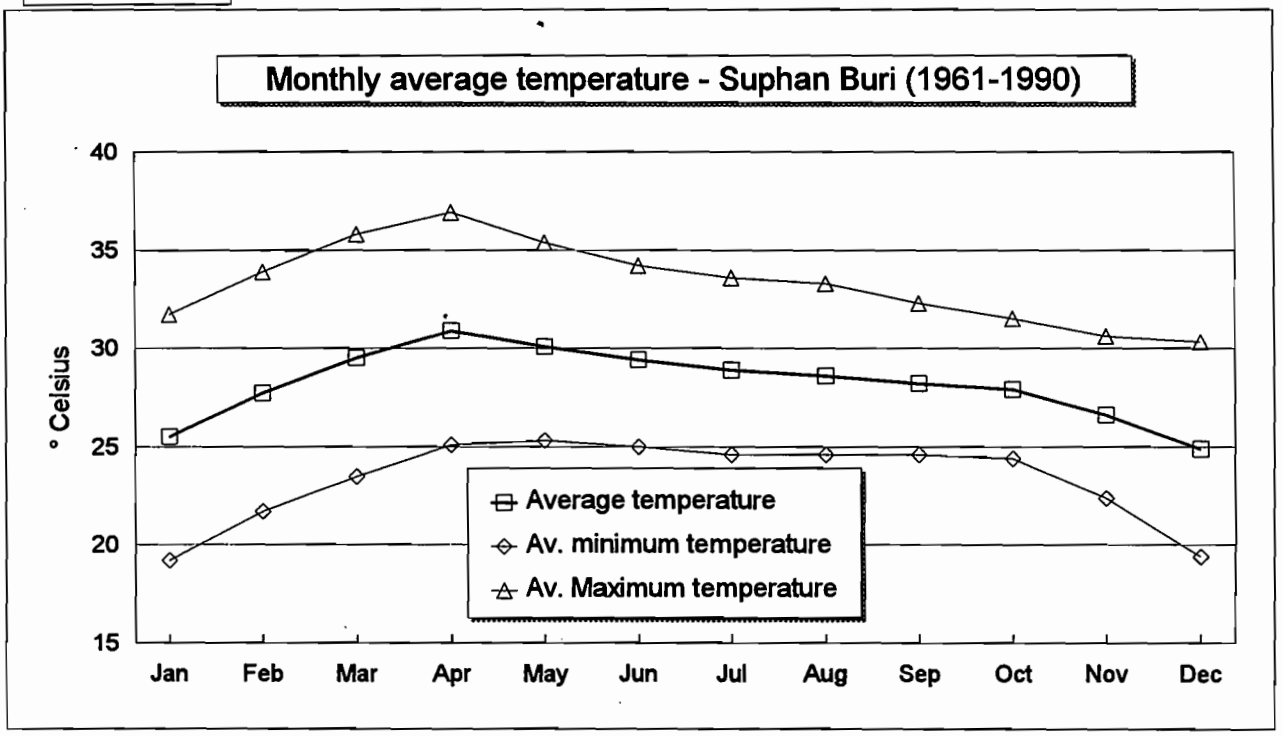
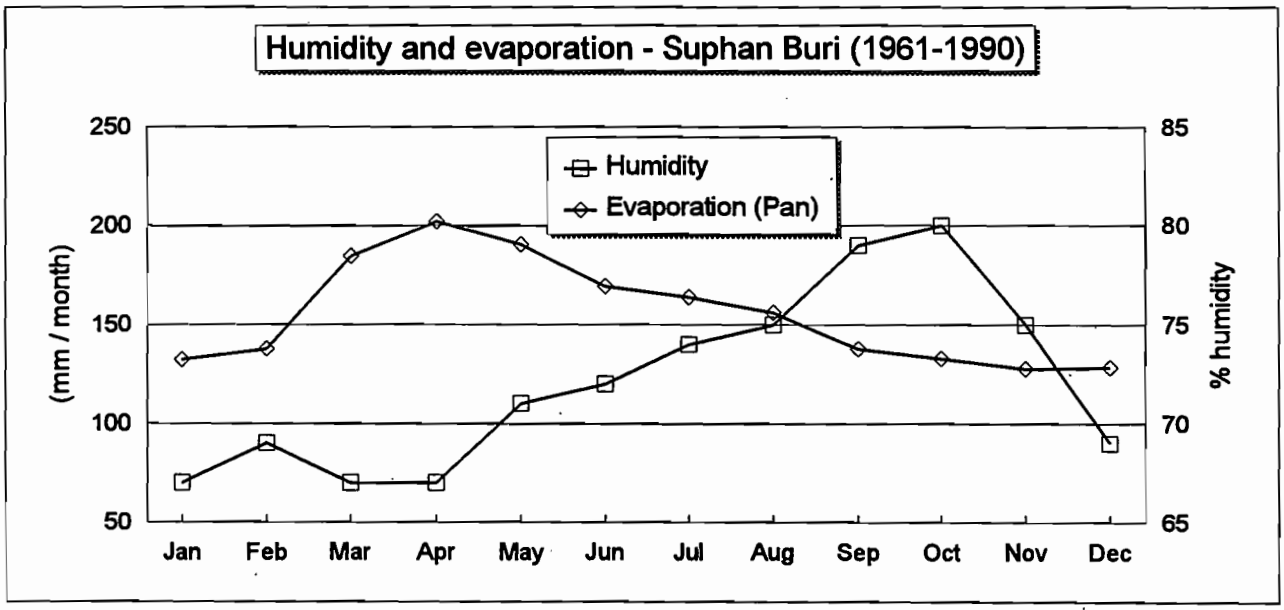

MAP 2.7
Average annual rainfall
(mm/year)
1300
1200
1100
1100
1000
1200
1300
1400
Ch
Si
Lo
An
Sa
Su
Ay
Na
Pa
Ka
Na
No
Ba
Ch
Ra
S.S
S.S
S.P
0
30
Kilometers
DORAS
Project
Source : RID / Acres

Figure 2.1


Monthly average temperature - Suphan Buri (1961-1990)
° Celsius
40
35
30
25
20
15
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Average temperature
Av. minimum temperature
Av. Maximum temperature


Humidity and evaporation - Suphan Buri (1961-1990)
(mm / month)
250
200
150
100
50
% humidity
85
80
75
70
65
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Humidity
Evaporation (Pan)

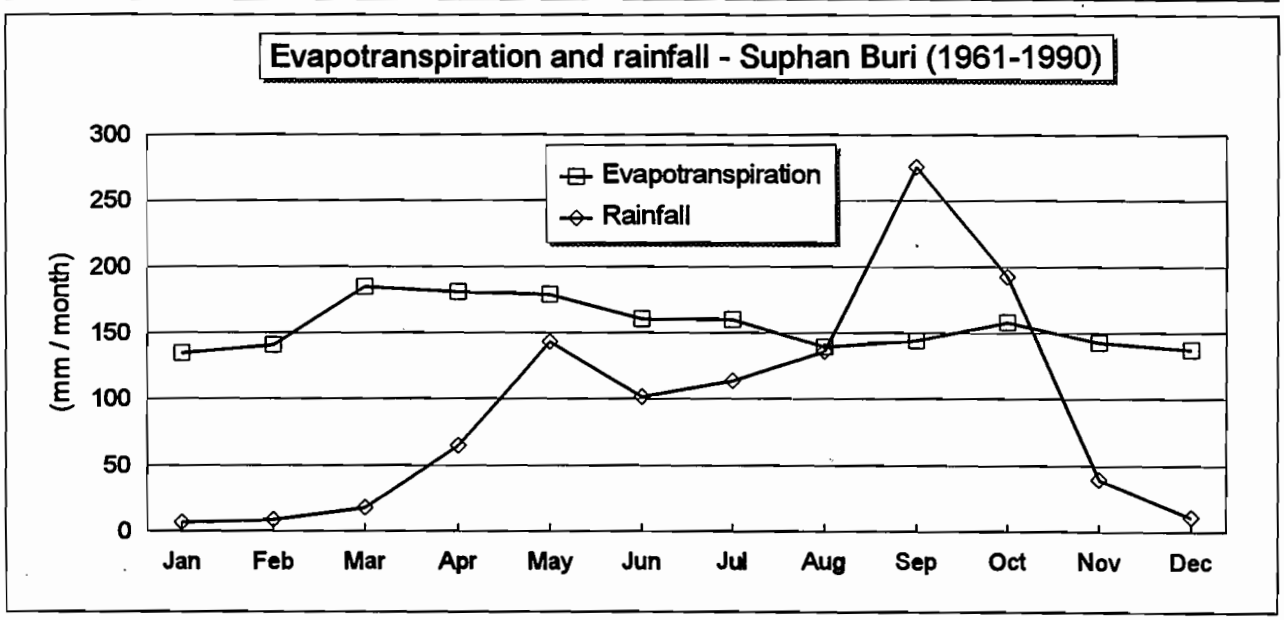

Evapotranspiration and rainfall - Suphan Buri (1961-1990)
(mm / month)
300
250
200
150
100
50
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Evapotranspiration
Rainfall

Fig. 2.2

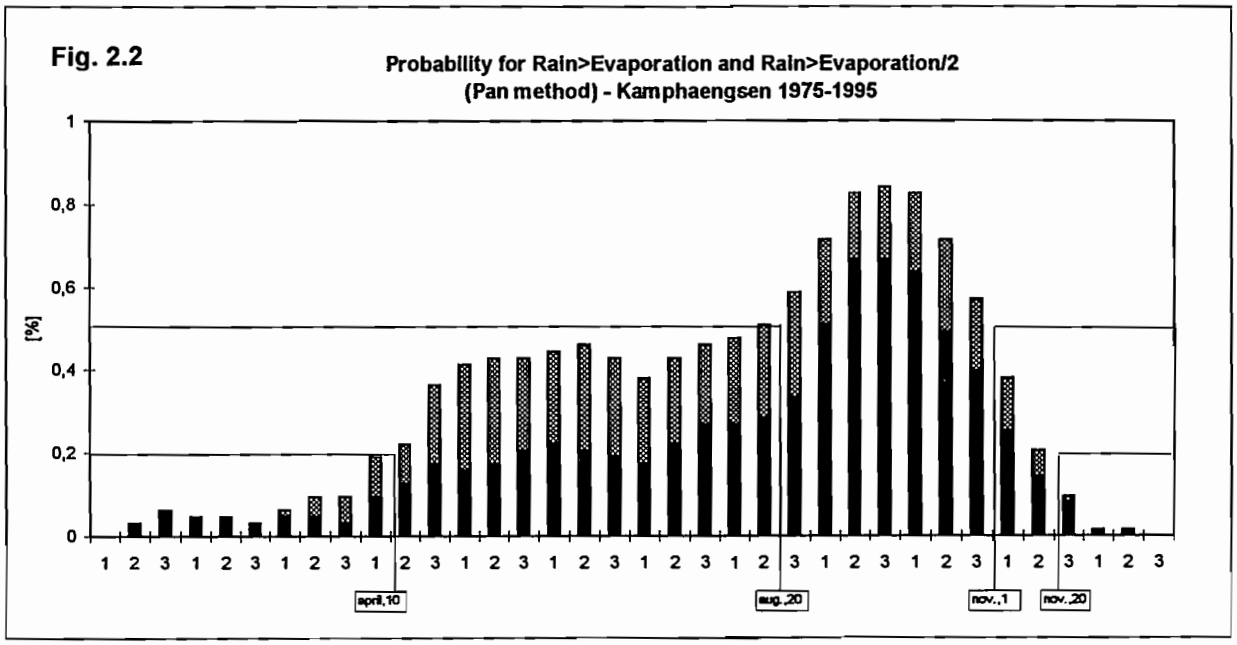
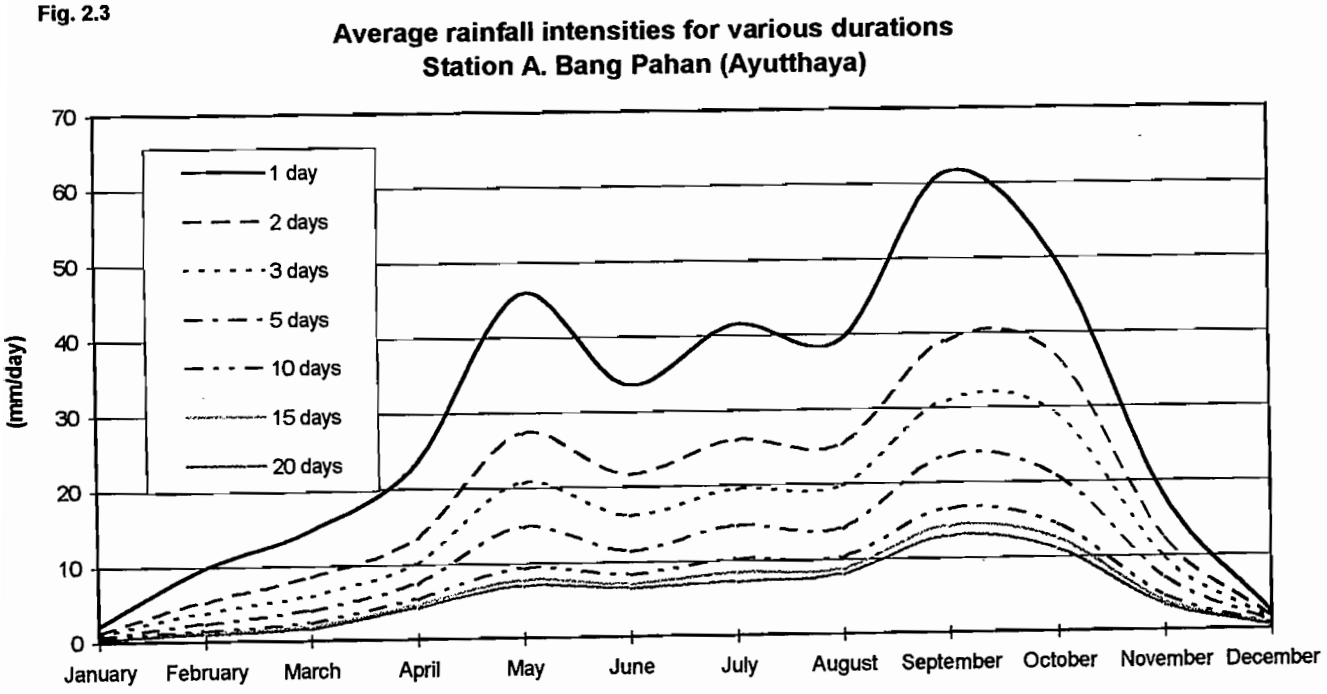

Probability for Rain>Evaporation and Rain>Evaporation/2
(Pan method) - Kamphaengsen 1975-1995
[%]
1
0,8
0,6
0,4
0,2
0
1 2 3 1 2 3 1 2 3 1 2 3 1 2 3 1 2 3 1 2 3 1 2 3 1 2 3 1 2 3 1 2 3 1 2 3 1 2 3 1 2 3
april,10
aug.,20
nov.,1
nov.,20

Fig. 2.3


Average rainfall intensities for various durations
Station A. Bang Pahan (Ayutthaya)
(mm/day)
70
60
50
40
30
20
10
0
1 day
2 days
3 days
5 days
10 days
15 days
20 days
January
February
March
April
May
June
July
August
September
October
November
December

Under such a criteria, only 42 % of the years can be considered as good years whereas the remaining 58 % suffer from some water shortage. In most cases, this will lead farmers to start the rainy season cropping in late July-August, when risk is lower. Only photosensitive rice varieties will be sown from April onward, because of their peculiarity and to take advantage of the first rains.

If the beginning of the rainy season (from May) is quite uncertain, its end occurs quite abruptly in the middle of November. In October and November, with common extension into December, excess of water is experienced in saturated fields and the environment is globally flooded.

Figure 2.3 shows the average rainfall intensities, corresponding to the Bang Pahan station (north of Ayutthaya) and calculated for various durations,: it displays an interesting pattern which shows that May and September are likely to have bigger rainfalls, with daily average values around 45 and 60 mm respectively.

2.2 The Central Plain and its historical background [3]

Little is known about the Chao Phraya delta prior to the establishment of the Siamese Capital in Ayutthaya (1350). Although it had been inhabited for a long time, before constituting the core of the Mon-Dvaravati civilization (6th- 9th century), the region was sparsely inhabited. The delta had been under marine influence in early historical times and still bore features which made it highly unsuitable for settlement : alternting floods and droughts, and malaria are thought to be among the factors which have hindered occupation. In fact, most of ancient settlements are to be found on the margin of the young delta, in locations such as Phetchaburi, U-Thong, Kamphaengsaen, Nakhon Pathom, Lop Buri.

Later, in the apogee of the Angkorean Empire, the Khmer presence also marked the region, up to the west of Kanchanaburi, with some main cities such as Nakhon Chaisi, Suphan Buri and Lop Buri. Although some of these main centres were brought later into the periphery of the Thai Kingdom of Sukhothai, the settlement and development of the Central Plain only started decisively after the foundation of a new capital in Ayutthaya (1351).

2.2.1 The Ayutthaya Period

Historical descriptions of the kingdom of Ayutthaya have often focused on the way the King controlled the production, wealth and trade within his kingdom, and scholars have depicted him as "a great merchant" (Ishi, 1978). In fact, the control of the King was exercised on labour (through the corvée system which obliged subjects to a six month labour, or to the payment of a corresponding tax), on land (with the allotment of rice fields through the *Sakdi na*[4] system), on agricultural production (with a tax corresponding to a tenth of the harvest), and on trade (by taxes and monopoly).

Although the clearing of rice fields in the Ayutthaya region soon allowed the production of some surplus, exported as early as the first half of the seventeenth century, most of the goods traded with other countries - especially China - were produced outside the delta area (spices, aromatic woods, opium, ivory, etc) (Ishi, 1978).

Farmers were mainly self-sufficient, cultivating rice primarily for their needs (about 10-15 *rai*) and relying only to a small extent on help from their neighbours or on bartering, the internal trade being limited by the little widespread use of money (Nartsupha and Prasartset, 1981). Rice lands centred on the flood plain of the old delta and their extension was in accordance with the needs of consumption.

The system of taxation on rice fields, which operated from the late Ayutthaya period through to the early twentieth century, divided rice land in two categories: "*na khukho*" and "*na fangloi*". *Na khukho* land was taxed on the basis of ownership, originally according to the area of rice lands. It was more valuable and corresponded to flooded land cultivated with a broadcasting technique which allowed to bring

[3] Most of the information presented in this section is drawn from Ishi (1978), Takaya (1987), Ingram (1971), Nartsupha and Prasartset (1981), Paitayavat (1978), Johnston (1975).

[4] The Sakdina was a rather complex system including several aspects : political and administrative (assignement, through different titles, of the king's right and authority to his subjects); economic (definition of propriety rights for land according to the rank); social relationship (classification of people among different classes : Prince, Chao Phraya, prai, etc).

larger areas under cultivation. *Na fangloi* were taxed according to the planted area. *Fangloi* lands could rely mainly on rainfall water and were transplanted (Takaya, 1987). Although, in this second case, more investment in labour was required, rice growing has been typified by Ishi as an "agronomic" rather than "technological" adaptation to nature, in that Thai farmers sought to attune their varieties and techniques to the flood regime rather than trying to tame or combat it.

The location of Ayutthaya was ideal for a trading port, as it lies at the junction of the old and young delta, and the excavation of the first canals to ease communication (transport of goods and military) constituted the main task undertaken by the king, through the use of corvée labour. In fact, agriculture in the delta was basically dependant on natural conditions which could hardly be modified and, in the absence of incentive to carry out such heavy investments, it therefore received little attention.

From the Ayutthaya period (1350-1767) dates the dredging of a natural canal linking the Chao Phraya and the Bang Pakong rivers, the excavation of several shortcuts in the meanders of the Chao Phraya and, at the beginning of the eighteenth century, the digging of the first two canals between the Chao Phraya and Tha Chin rivers : Mahachai and Yong canals (see map 2.8).

2.2.2 The Bangkok period and the development of rice production

In 1782, after a settlement of fifteen years in Thonburi under King Taksin, the first king of the Chakri dynasty transfered the Capital of the Kingdom to Bangkok. By moving the centre of gravity of the kingdom - again - towards the south, a new impetus was given to the reclamation of the lower delta.

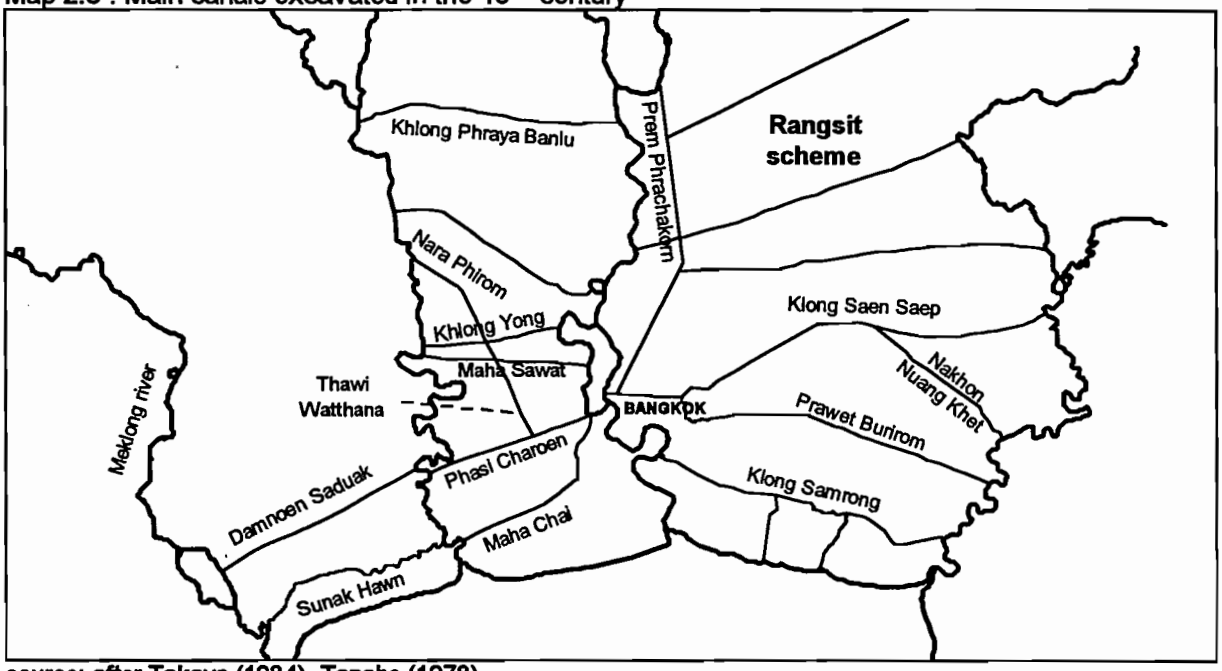
Although with few specific investments, the government had indirectly supported the extension of rice cultivation through tax favours to newly cultivated land, as early as the reign of Rama II who wished "that more jungles be opened up for rice cultivation with a view to increasing the quantity of rice and lowering the price thereof, without prejudice to the interests of peasants and merchants" (cited in Ingram, 1971).

King Monkhut, in 1851, removed the ban on rice exports and reduced ship fees. The population of Siam at that time is estimated to have been between five and six million, meaning that density was as low as 10 habitants/km^2. Approximately 95 % of the cultivated land was devoted to rice and its cultivation followed the ancient patterns of transplanting and - predominantly - broadcasting, little labour being involved.

The impulse on free trade derived from the Bowring Treaty (1855), signed with the English but quickly followed by similar treaties with other western countries, contributed to change Thailand from a self sufficient economy to a more specialized one. Rice appeared to be one of the products most purchased by new traders and, at the same time, the one which production was the most easy to increase and which, because the surplus almost totally originated from the Central Plain, could be easily channelled to the ports for export.

Its development went alongside secondary activities related to rice production : transportation, milling, selling against other imported goods, functions most of the time performed by Chinese middlemen.

Map 2.8 : Main canals excavated in the 19th century



source: after Takaya (1984), Tanabe (1978)

The fourth reign (1851-1868) and the fifth up to 1866, relying more and more on hired Chinese labour, continued the policy of canal excavation initiated in the Ayutthaya period but also turned their attention to the expansion of rice lands, following the Bowring Treaty : the Maha Sawat canal (1857-1861), which constitutes the third link between the Chao Phraya and the Tha Chin rivers, is probably the first main canal to have been dug with the objective to reclaim land for rice cultivation. Adjacent land was in fact claimed by the royal family, which resulted in the constitution of *naa luang* (royal land), cultivated by corvée peasants and bondsmen.

Previously regarded by some observers (Bowring, in particular), as the most promising agricultural activity, the sugarcane industry declined alongside the growth of rice production. Mostly grown in the Chachengsao and Nakhon Chaisi areas, it suffered from several negative factors : high inland transit duties, damage by salty water, price decline, flood damage in 1871, labour cost, competition with rice cultivation, trade and milling, all accounted for the sharp decrease of sugarcane production in the 70's and 80's (Jessadachatr, 1977; Ishi, 1978). By the year 1889, export of sugar terminated. From 1886, most sugar mills had to close down, except a few in Chon Buri and Nakhon Chaisi (Jessadachatr, 1977).

The Damnoen Saduak and Phasicharoen canals, completed respectively in 1868 and 1872, date back to the period preceding the collapse of this activity and are the first canals excavated solely for the development of trade and the progress of sugarcane.

The increase of rice exports, from a few hundred tons in 1857 to a pre-war peak of 1,500 tons, has commonly be credited to the initiative of the Thai farmers themselves, who engaged in extensive land clearing. Although favoured by different incentives (Rama IV extended the tax exemption from one year to three, land taxes remained lower than 10 %) and by attractive market prices, rice and land development were poorly considered by the government as far as capital investment was concerned. In any case, the position of the government about land development and canal digging in the 1870-1920 period is characterized by a quite fluctuating policy.

The Premprachakon canal , heading from the north of Bangkok towards Ayutthaya was dug to create access to new land in the fifth reign, the king preferring to resort to Chinese wage labourers rather than burdening local subjects with corvée. In 1877, the Nakhon Nuang Khet canal, angling down from the Saen Saep canal, was also dug by Chinese labour. Shortly after the completion of these canals at the expense of the crown, the government, aware of the difficulty to control the appropriation of the new reclaimed land by noble officials, modified its land development policy.

"The Proclamation on Canal Excavation" of 1877 reflected a will to ensure that peasants should benefit first from the state investment and, at the same time, that part of the costs should be covered by the settlers themselves. The Prawet Burirom canal, linking Saen Saep canal to the Bank Pakong river, was the first to be undertaken with this new policy : thousands of families were granted land at the rate of 1.5 baht per rai.

After a lull of a few years, the government decided to allow private companies to take over land development in the delta by granting concessions to excavate canals. Influential Chinese, nobles and officials were thus given the right to dispose of the land adjacent to the newly excavated canals and to levy taxes on inland navigation. The most famous of this concessions was the one granted to the *Borisat khut khlong le khu naa sayam,* the Siam land, Canal and Irrigation Company established by two Thai partners and Joachim Grassi, an Italian architect. The contract signed in 1889 gave the company the virtual monopoly on canal and land development projects throughout the Kingdom for the next twenty five years (Johnston, 1971). Deciding that canal digging by Chinese was too slow, they purchased excavating machinery in Europe and started to excavate the Rangsit system which soon had an astonishing success, only one third of the demand being satisfied.

By 1900, 500,000 rai had been made ready for cultivation, and up to 1.5 million a few years later. With this success, numerous land development enterprises were proposed and/or initiated in the 90's and a modification of the monopoly clause had to be accepted by the Siam land, Canal and irrigation company.

However, the euphoria happened to be brief and numerous problems arose within this system : slow work, bankruptcy (with loss of the first payments made by applicants), ill planned projects, short term profit with no concern for maintenance (silting up), land dispute and tensions within the widespread landlord-tenant system, all these factors contributed to compel the government to adopt a new policy.

In 1899, the Department of Canals was established and a Dutch technician, Mr. Homan van der Heide, was appointed as director, with a mandate to elaborate a

master plan for the delta. This plan proposed the construction of an extensive scheme, with a diversion dam in Chai Nat and several trunk canals to distribute water over the delta, where it could be kept in gated canals.

In 1904, the Royal Irrigation Department was established, further to the Departments of Canals. Amidst some internal debate on whether the priority should be given to agriculture or to railway development, RID was granted permission to initiate only minor scale projects and has to postpone the main scheme proposed by Van der Heide. As a result of this new step in state intervention, no private land concessions were granted after 1903.

The 1905-1912 period was marked by recession : some canals silted up to the point that navigation became impossible. The succession of droughts and dramatic floods, animal diseases and a slump in the rice price further depressed the situation; in 1911/12, seeds were missing and even food shortage was looming.

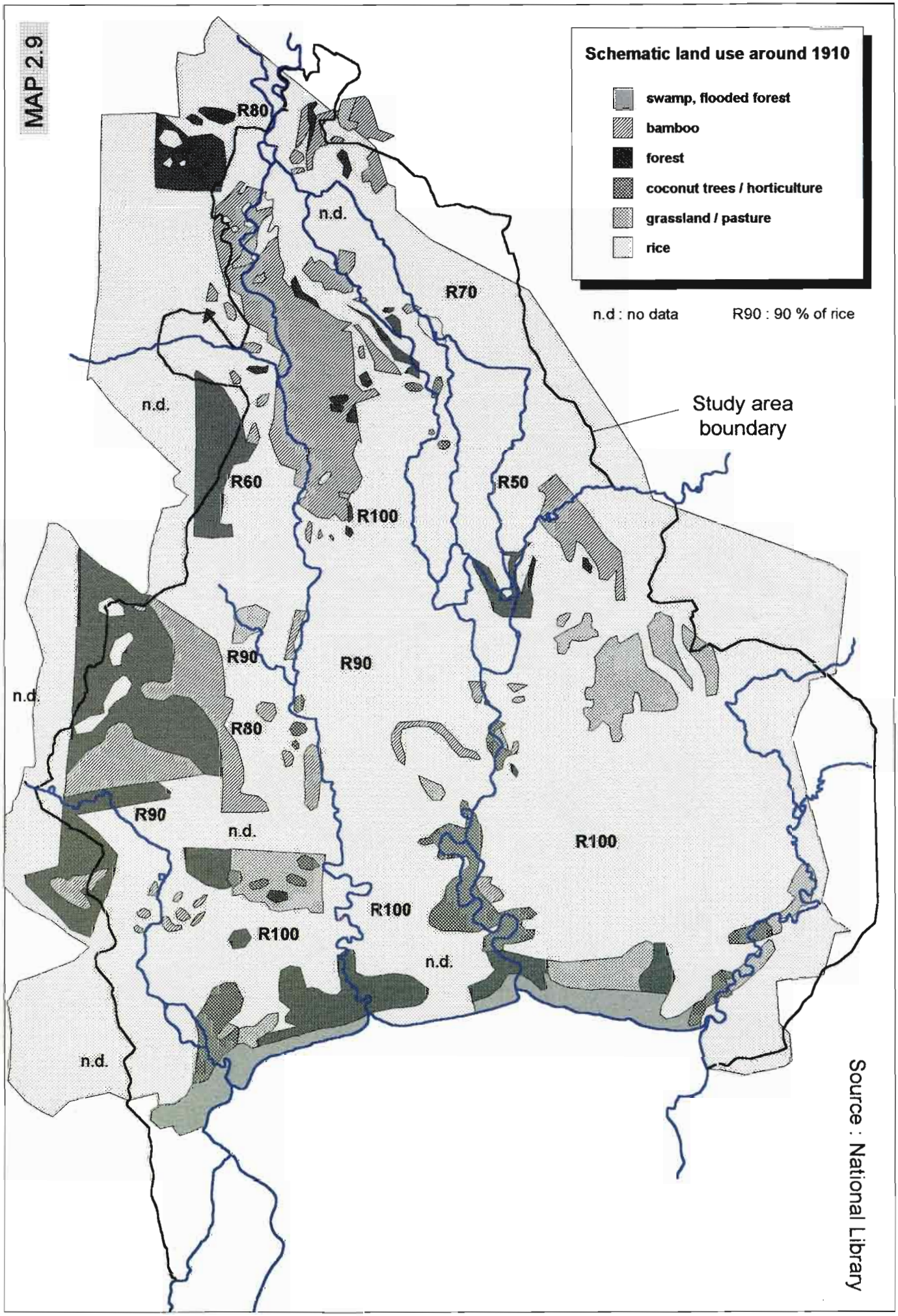
Sir Thomas Ward took over from Van der Heide in 1909 and, emphasizing the still limited population, gave priority to smaller scale projects. At this point, the delta was almost fully populated and cleared out. Map 2.9 shows a sketch of the land use around 1910, in which only the higher parts of the northern delta and the upper part of the Mae Klong fan appear with a cover of florests and bamboo groves.

In early periods, farmers adapted rice cultivation to the water regime and flooding was not considered as a constraint before the necessity to intensify. As Mouhot wrote in 1864 : *The great river Menam [...] is the Nile of this region, the great fertility of which is owing to the annual overflowing of its water, an event eagerly looked for by the inhabitants, and welcomed as a blessing from Heaven* (Mouhot,1992). After World War I, lowland rain fed rice cultivation came up to saturation point. In a second step, mainly between the two World Wars, the forests located on the outer terraces were cut down and burnt for sugarcane, rice and cotton cultivation.

At this point, a preindustrial agriculture (without industrial inputs) is expected to give way to a joint evolution of population density and agricultural intensification (Boserup, 1970). More populated areas is bound to mean less land per family, more work per rai, growing production in order to feed more people, but also a decrease in labour productivity and surplus.

In fact, after the saturation periods, poor water control became a major constraint and land development slowly turned out to be a necessity. Between the two World Wars, three projects were initiated (South Pasak, Suphan and Nakhon Nayok), where diversion dams or regulators delivered water in canals which, for the first time, were fully irrigation canals. Main land development works were eventually carried out after World War II (see § 2.5).

MAP 2.9


Schematic land use around 1910
swamp, flooded forest
bamboo
forest
coconut trees / horticulture
grassland / pasture
rice
n.d : no data
R90 : 90 % of rice
Study area boundary
R80
n.d.
R70
n.d.
R60
R50
R100
R90
R90
n.d.
R80
R90
n.d.
R100
R100
R100
n.d.
n.d.
Source : National Library

2.2.3 The social system, land tenure and labour

The characteristics of the ancient land tenure and social systems have doubtlessly had a marked influence in some actual specificities of agriculture in the Central Plain. For the purpose of emphasizing its impact on agricultural development, the social division during the Ayutthaya period and early Ratanakosin (down to the middle of the last century), can be simplified as follows :

➢ the free peasants, who were allowed to occupy, clear and cultivate unused land, and could sell or mortgage if they wished to do so. These people were obliged to participate to public works and obligations, either for the direct benefit of the King, or for the patron who had received the royal delegation to administrate some of his subjects. In return, the patron was supposed to provide alimentation and protection to his retainers, who could at will change patrons or even sell themselves into slavery. They were also subject to different tax payments as mentioned above.

➢ the so-called slaves, who most of the time were prisoners of war or people who had chosen to attach themselves to a patron : many were obliged to do so because of indebtment, which could in particular result from the climatic hazards linked to rice cultivation. These bondsmen could revert to their condition to freeman at any time by paying back the same amount of money they had received for the price of their subjection.

➢ the nobles and patrons who were granted titles and land within the *Sakdi na* system.

Free peasants constituted the driving force for the reclamation of new land, but they could seldom deal with more than 25 rai per farmer. On the other hand the *Sakdi na* system allowed some people the benefit of areas up to 10,000 *rai*, but the fact that the nobility was not permanent and that land could at any time be requested by the king drastically limited the surge of an independent class of land owners. In a way, although the final ownership was from the King, the tenure status from the free peasant could prove to be more secure than the one granted to nobles and patrons.

Landlords obviously needed a labour force to cultivate the land they were granted : this constraint appears to have been a great regulator of the land tenure pattern. Three labour sources were possible :

➢ *The use of corvée labour for their own benefit*; Predominant in the Ayutthaya period, the corvée system was later progressively dismantled. The six months corvée period was reduced to four and then three months between 1780 and 1810. Whereas payment in money instead of work was already widespread, Rama III reduced the imposition of corvée and started to hire Chinese labour at a fix wage for different kinds of work, a practice which soon turned out to be far more productive than forced labour. The load of the corvée system gradually decreased between 1850 and 1910, which means that the corresponding labour force shifted from the landlords to free initiative, strongly accounting for the dynamics of land reclamation. By the turn of the century, the corvée was abolished and replaced by a capitation tax, later eliminated in 1938.

➢ *The use of bondsmen* ; the progressive emancipation of the Thai peasantry and the abolishment of bondsmanship in the 90's marked the disappearing of this old system of dependency. Even the "royal fields", by the turn of the century, ended up being rented to farmers.

➢ *The use of wage labourers;* hiring Chinese labour became common in the second half of the nineteenth century, but mostly for non-agricultural work such as canal digging. Although the government tried to increase the population (in particular with war prisoners and refugees from neighbouring countries), the labour demand always remained higher than the supply. Hired labour boomed in the 90's, especially with Lao people who were hired for a short period or, more commonly, for the whole year.

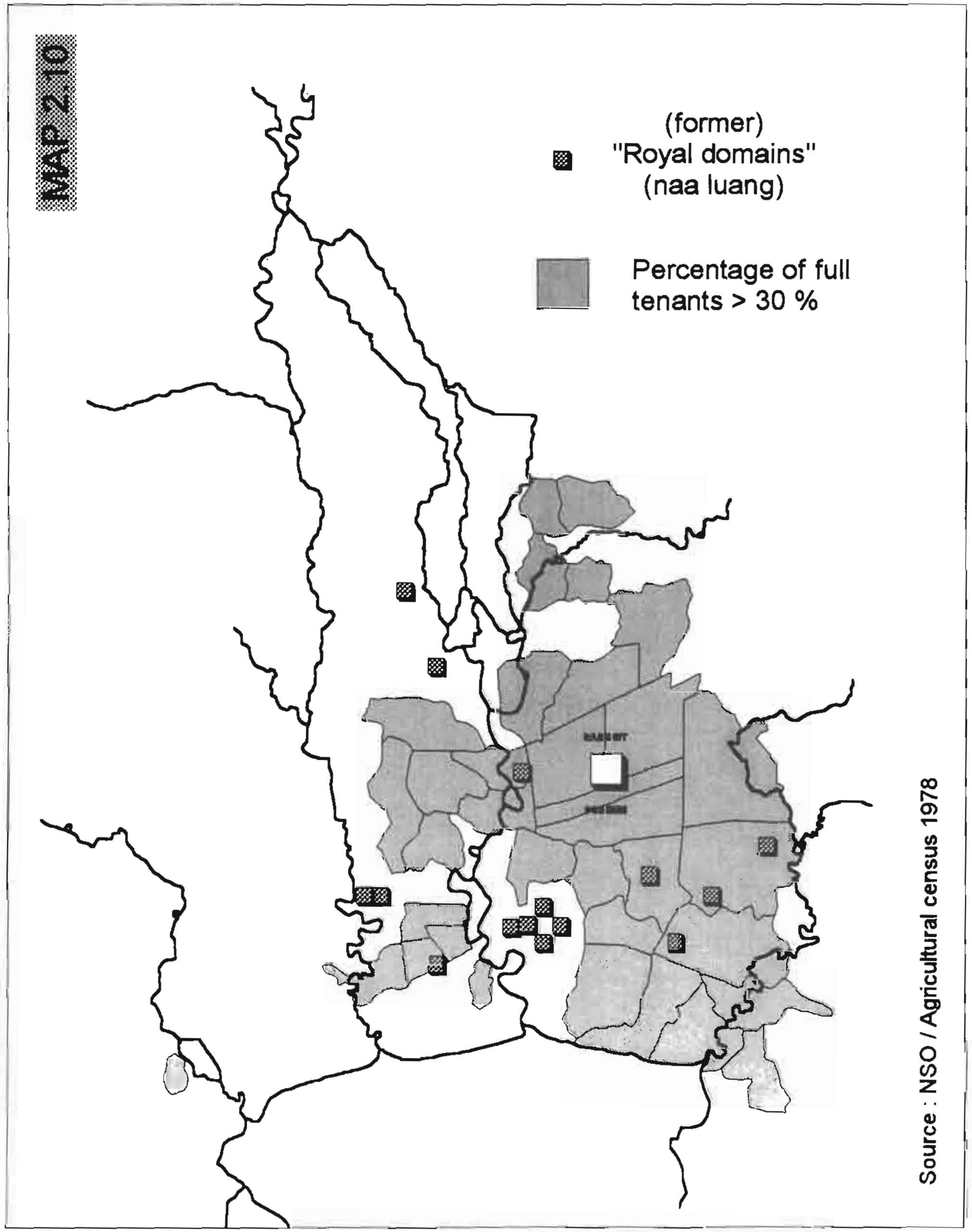
➢ *The renting of the land to tenants;* large scale rice cultivation was nevertheless risky and many landlords soon preferred to rent their land rather than farming it through the use of wage labourers. They often engaged some chief-farmer (nai kong) responsible for the management of tenants and fee collection. A survey carried out around 1930 concluded that the percentage of peasants with no land was thirty-six per cent. The highest proportion of tenancy was to be found in Dhanyaburi, where eighty-four per cent of the farmers were tenants (Zimmerman, 1931).

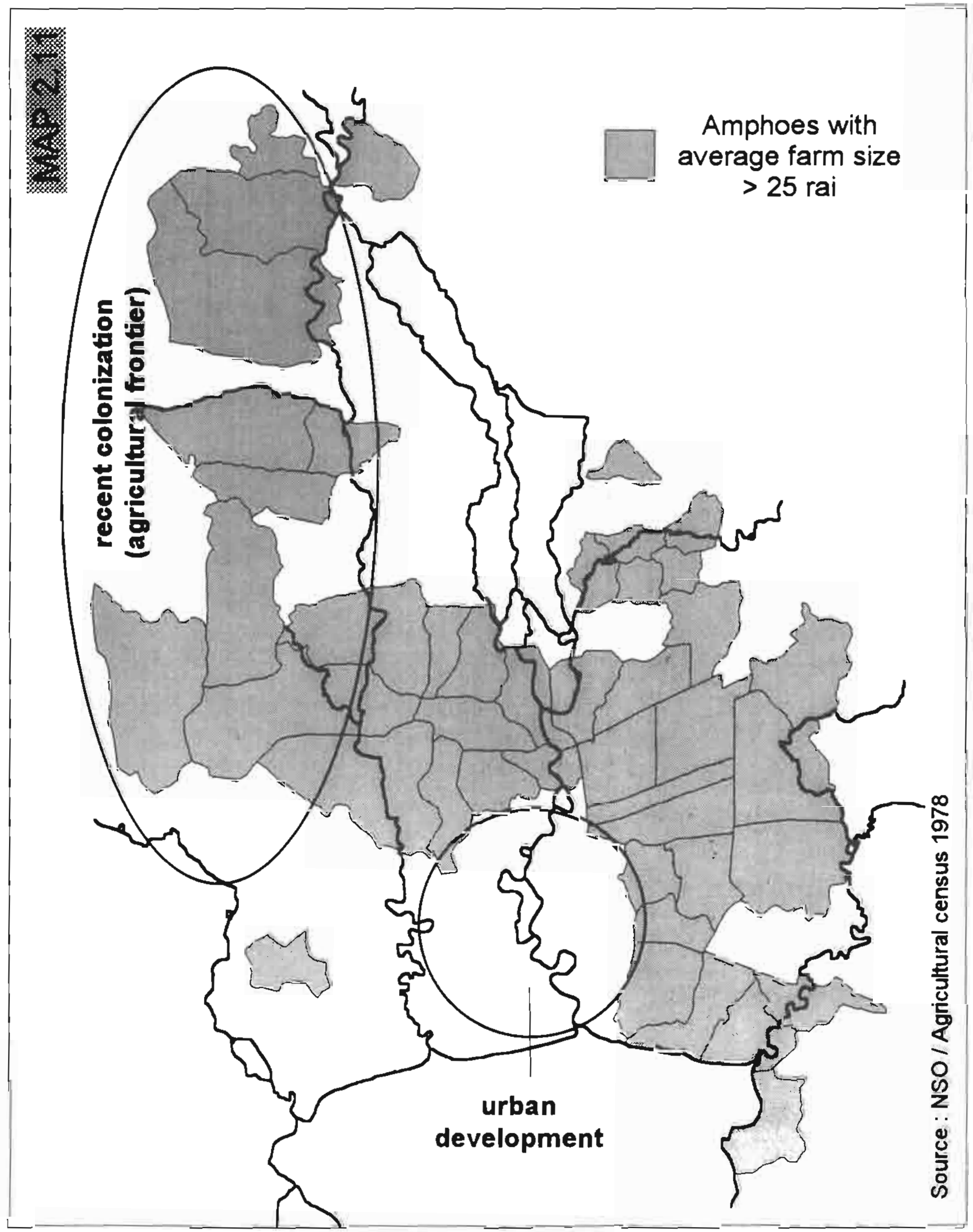
In the course of this century, the landlord-tenant system progressively prevailed and the pattern of land ownership derived from the involvement of the state, nobility and private companies in rice cultivation is still visible today : map 2.10 shows the distribution of *amphoes* with percentage of full tenancy greater than 33 % (agricultural census from 1978), together with some of the main royal domains (naa luang) and Rangsit scheme (derived from Takaya, 1978). This region matches most of the land reclaimed and developed by private interests during the last century. Although no data is available to support this point, tenancy is likely to have been later reinforced by recent speculation on land bought by absentee owners from the capital.

Map 2.11, which shows areas with average farm land over 25 rai, also pinpoints the fact that high tenancy is correlated, in the young delta, with large average farm size, which is also coherent with the historical background of private initiative on large tracts of land. Another region with larger average farm size can be noted on the west of the delta. This is probably related to a most recent extension of the agricultural frontier, in which farmers have been able to settle in larger plots (for this reason, but in contrast with the young delta, this region shows a very high rate of full land ownership).

In summary, the extensive virgin land offered to farmers' colonization in the Chao Phraya delta has constituted the main driving force of land reclamation. This reduced the possibility for landlords to attract enough labour to cultivate large tracts of land. At the same time they were progressively deprived of the traditional labour made available through both the corvée and bondsmanship systems, leading to a development of both wage employment and tenancy.

The reforms carried out by Chulalongkorn proved successful in curtailing the power of the nobility, limiting the benefits they drew from their clients, abolishing the grant of land linked to the *Sakdi na* and only adapting the ranking system to the needs of a new salaried bureaucracy (Siamwalla, 1972).


MAP 2.10
(former)
"Royal domains"
(naa luang)
Percentage of full
tenants > 30 %
Source : NSO / Agricultural census 1978


MAP 2.11
Amphoes with
average farm size
> 25 rai
recent colonization
(agricultural frontier)
urban
development
Source : NSO / Agricultural census 1978

It is worth noting that wage labour has always remained characterized by scarcity and corresponding dearness : as Ingram noted, "since rice cultivation was becoming more attractive, and since few Thai people were willing to become wage labourers, wages tended to rise. Scarcity of labour and a persistent tendency for wages to rise were features of the Thai economy from 1850 until the 1920's (Ingram, 1971)".

In fact, the development of rice cultivation until the second World War was strongly centred on the abundance of land, in conditions of limited labour and capital. This feature, together with natural limitations related to the flood regime, explain the extensive character of rice growing in the delta. Whereas an insufficient availability of labour limited both wage employment and the adoption of techniques of intensification[5], and land development was dependant on the capacity of investment of the state and the richer class, development was bound to be based chiefly on the expansion of the agricultural frontier. The extremely low man-to-land ratio enabled Thailand to export rice in large quantities with competitive low prices (Siamwalla, 1975).

This logic was slightly modified in the 30's and 40's, with the progressive closure of the frontier and a trend towards more intensive techniques and the predominance of transplanting (Hanks, 1972). The huge investments in capital made after the war, in order to increase control over the water regime, laid the basis for a progressive intensification which could rely on labour until the late sixties. Section 3.2 will provide elements on more recent evolution and on how the historical labour constraint again influenced the agricultural development up to the present day.

The Chao Phraya delta has been fully reclaimed only quite recently and remains today a relatively low-populated delta in south-east Asia. The planting area by farm, with an average of 25 rai/family) is by far the largest one, if compared with the Red River and Mekong deltas (Tab. 2.4). This allows surplus and exportation despite a still semi-intensive rice cropping.

Table 2.4 : Some present characteristics of three Southeast Asian deltas

	Population density	Rai per family	Rice cropping	Rice Surplus
Red River	High	2	Highly intensive	None
Mekong	Medium	7	Intensive	Some
Chao Phraya	Low	25	Semi-intensive	High

[5] this is well illustrated by the fact that broadcasted lands (na khukho) were considered more valuable than transplanted ones (na fangloi).

2.3 The population in the delta

2.3.1 Absolute population and human density in 1990

The population of the Central Plain[6] totals almost 14 million habitants (in 1990), that is to say approximately 20 % of the total population of Thailand is concentrated in less than 6 % of the territory. Most of this population (5.9 million) live in the Bangkok Metropolitan Area and, among the remaining 8 million people, two live in the vicinity of Bangkok, defined as the neighbouring provinces of Pathum Thani, Nonthaburi, Samut Prakan, Samut Sakhorn (Tab. 2.5).

This population is therefore distributed very unevenly over the Central Plain : human density culminates in Bangkok and its vicinity (1374 habitants/km2) but has an average of 276 habitants/km^2 in the remaining rural area, which is slightly higher than in other regions (for example 200 habitants/km^2 for the Northeast). This value of 276 is an average of densities by *changwat* which are generally comprised between 120 and 300 habitants/km^2 The less populated ones are Lop Buri (119), Chai Nat (137), Saraburi (153), whereas Sing Buri (269), Ayutthaya (271), Angthong (293), Nakhon Pathom (310) show higher densities. Details at *amphoe* level (map 2.12, data from 1990), show that all the area south of Ayutthaya and the flood plain have densities greater than 200, with growing urban concentration around Nakhon Pathom, Chonburi and Ayutthaya.

Table 2.5 : Population in the Central Plain (1990)

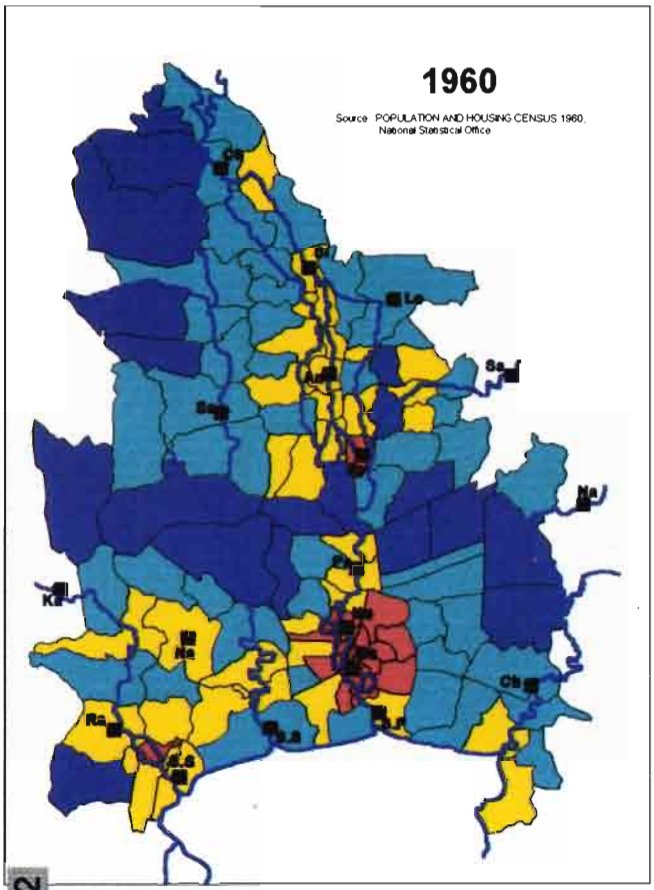
1990	Whole Kingdom	Central Plain	Bangkok and vicinity	Central Plain without BKK and vicinity
Population (thousands)	57,303	13,781	7,692	6,090
area (km^2)	513,115	27,658	5,578	22,080
density (ha/km^2)	111,7	498	1,374	276
Agri ratio	60 %	19 %	-	37 %

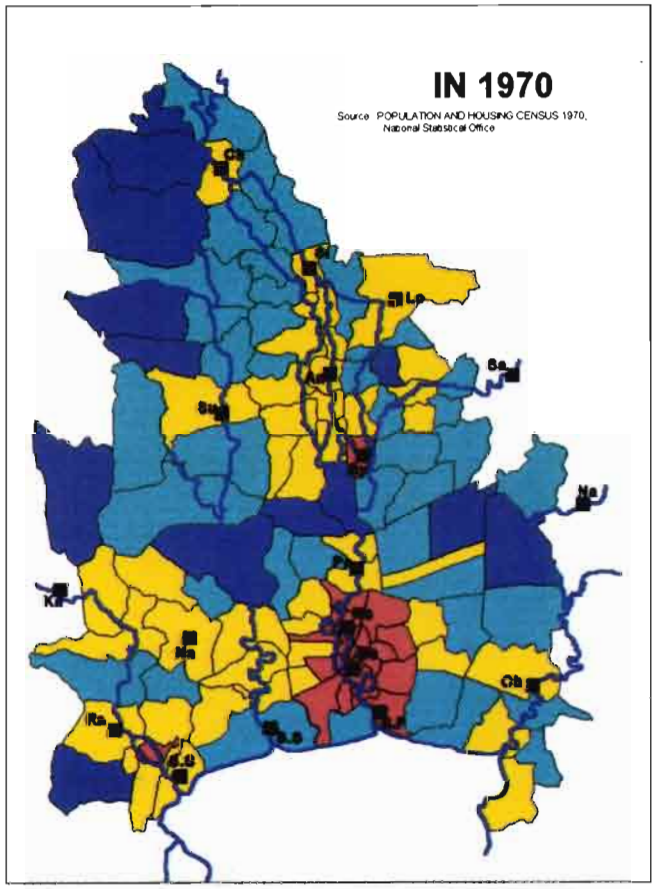
Source : Population census 1990 NSO.

2.3.2 Evolution in the 1960-1990 period

Population in the Central Plain increased more than twofold in the 1960-1990 period. In the same period, population in Bangkok has been multiplied by 2.75 but the growth rate over each of the three decades has shown a significant decline from 44 % to 35 % (Tab. 2.6 and Fig. 2.4). This means than saturation is taking place and the rate for the present decade is expected to decrease even more dramatically. On the contrary, no saturation can be evidenced concerning Bangkok's vicinity area, where the current growth is similar to the one observed in Bangkok for the 1960-1980 period.

[6] As explained in the introduction, the Central Plain considered here corresponds to the amphoes appearing in the administrative map (map 1.2). It is larger than the official Central Region and slightly bigger than the irrigated area which is the scope of this study.



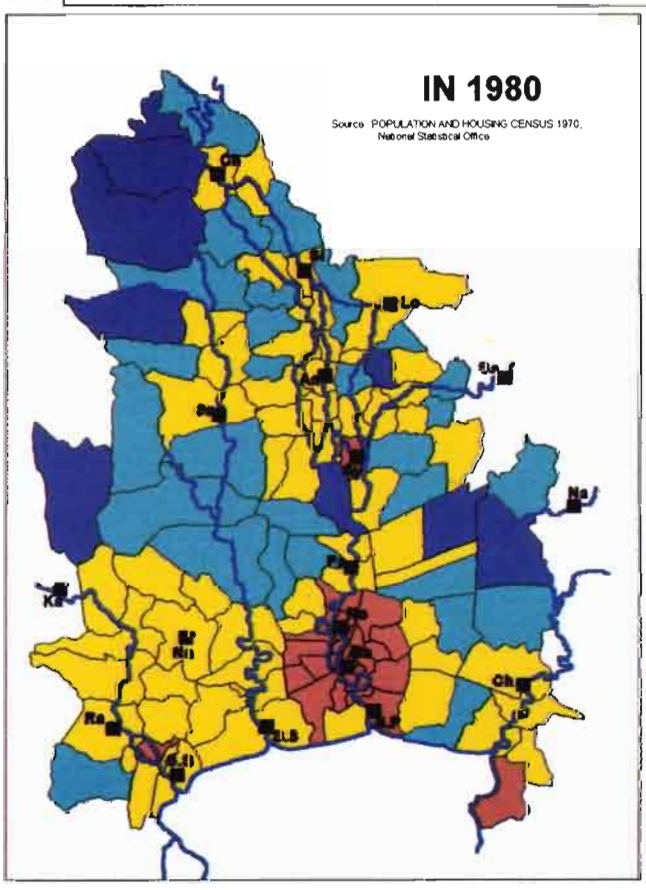


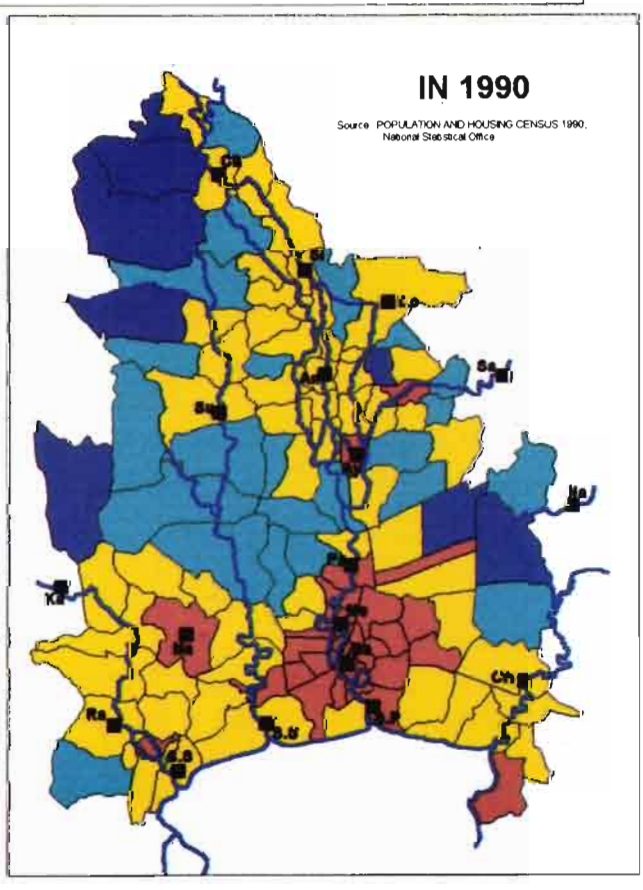
MAP SET : 2.12

EVOLUTION OF POPULATION DENSITY IN THE CENTRAL PLAIN

(1960-1990, habitants per km^2))

- > 500
- 200 to 500
- 100 to 200
- 0 to 100





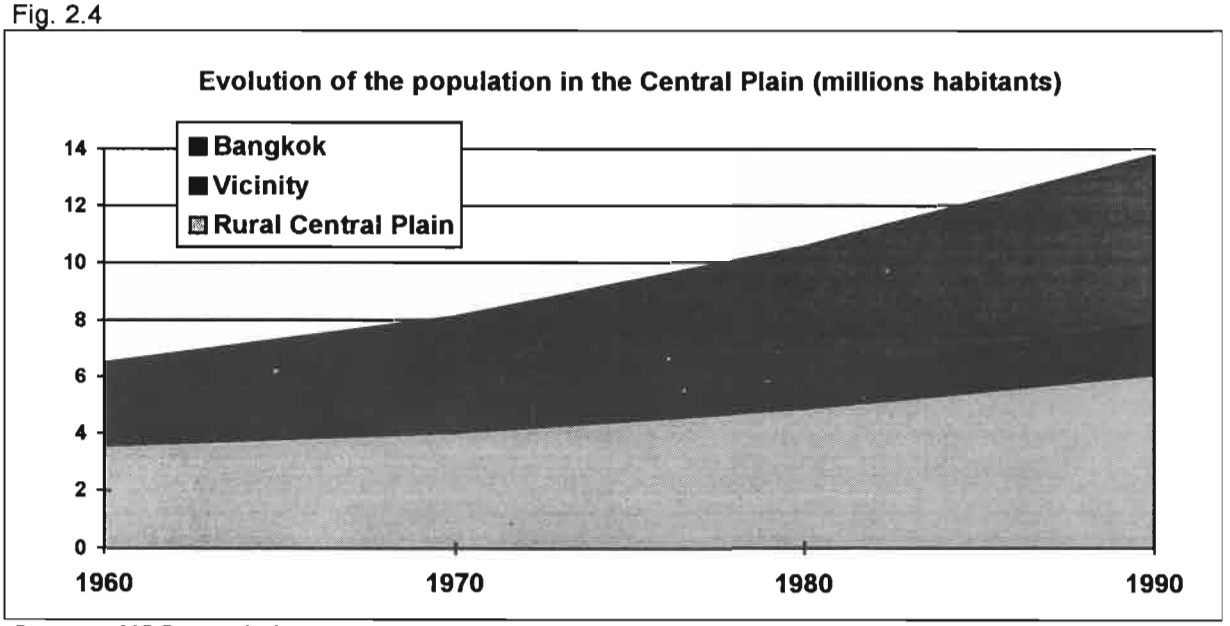
If we now consider the whole of the Central Plain, growth rates by decade seem to have levelled off around a value of 30 %. These growth rates are of course the combined result of natural growth and immigration flows. The annual groxth rate has been declining a lot in Thailand and the yearly average rate of growth - for the whole country - is now as low as 1.5 %. If we consider the Central Plain during the1985-1990 period, with an average growth of 14.2 %[7], the observed overall population increase of 1.68 million habitants can approximately be divided between a share of 673,000, due to net migration flows from outer provinces (see next section), and a share of almost 1 million persons due to natural growth.

Table 2.6 : Population evolution in the Central Plain (1960-1990)

Zone	1960	1970	1980	1990
Bangkok	2,136,435	3,077,336	4,343,074	5,882,411
growth rate by decade	-	44 %	41 %	35 %
Bangkok vicinity	768,953	973,784	1,278,73712	1,809,195
growth rate by decade	-	27 %	31 %	41 %
Total Central Plain without Bkk+vicinity	3,579,052	4,045,236	4,917,598	6,089,852
growth rate by decade	-	13 %	22 %	24 %
Total Central Plain	6,484,440	8,096,356	10,539,409	13,781,458
growth rate by decade	-	25 %	30 %	31 %

Source : NSO population census

Fig. 2.4



Source : NSO population census

Change in population can be specified at *amphoe* level. Map 2.12 shows the evolution of the population density during the 1960-1990 period. It can be observed that, 45 years ago, three areas presented a human density above 500 habitants/ km^2 : Bangkok, the capital of the Kingdom, Ayutthaya, the first large settlement in

[7] which corresponds to a 2.7 % average annual growth rate

the Central Plain and one area near the canal of Damnoen Saduak, in the Province of Ratchaburi.

From this point, three axis successively developed in the Central Plain. The first axis is located in the western part of the Central Plain, from Bangkok to Ratchaburi and Nakhon Pathom Provinces, where urbanization has become important since 1970. The second axis heads towards the eastern part, from Bangkok to Chachaengsao and Prachinburi. At last, a new trend seems to surface, with the development of the hinterland of Sing Buri, Ang Thong and Ayuthaya.

Three areas remain more rural in the Central Plain. The Nakhon Nayok area, where the density of the population is near 100 ha/km^2, the south of Suphan Buri and the south-west of Chai Nat. Not surprisingly, they also correspond to areas with higher ratio of full owner farmers (see chapter 5).

2.3.3 Population and migrations

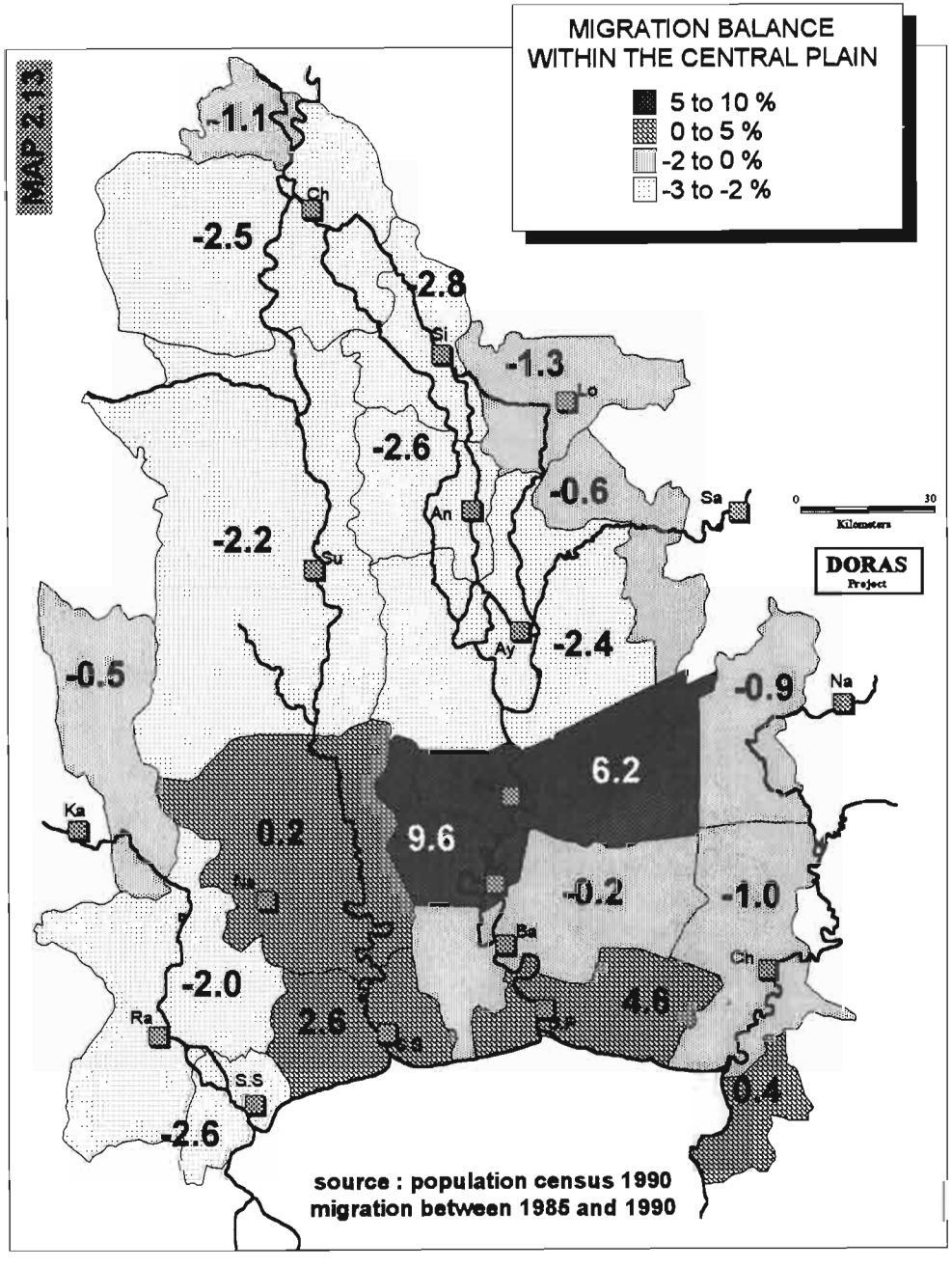
The migration balance in the Central Plain can be approached considering either the flows between the *changwats* of the Central Plain (and only these *changwats*), or the total migration flows between the Central Plain and the rest of the country. We distinguished four successive units for this analysis, namely Bangkok Metropolitan Area (Bangkok), Bangkok vicinity (Samut Sakhon, Samut Prakan, Nonthaburi, Pathum Thani), the "rural" Central Plain (the remaining *amphoes* of our study area; cf § 1.2) and the rest of Thailand (all *changwats* not belonging to the study area)[8].

Table 2.7 displays some of the main features of the migration process in Thailand. Over 1.6 million people moved within the country between 1985 and 1990, that is to say approximately 2.8 % of the total population of Thailand in 1990. At the level of the (whole) Central Plain, 503,960 persons decided to move within this region during the same period, that is to say 3.1 % of the population of this area in 1990. Within these five years, the Central Plain recorded a net gain of 672,918 persons (4.1 % of the total population in 1990). The region stands out as the main pole of attraction in the country. Within the Central Plain, Bangkok and Vicinity received 677,441 more habitants between 1985 and 1990, that is to say 8.5 % of its population in 1990.

Infra-regional migration flows

Map 2.13 shows the migration balance of each *changwat* when only internal flows within the Central Plain are considered. People in the Central Plain clearly tend to migrate to Bangkok Vicinity, but <u>not</u> to Bangkok Metropolitan Area which - on the contrary - shows a slight trend toward return flow.

[8] A small bias has been introduced by considering the flows from outer Jangwats to Jangwats situated in the Central Plain regardless of whether they are fully or not fully included in our study area.


MAP 2.13
MIGRATION BALANCE
WITHIN THE CENTRAL PLAIN
5 to 10 %
0 to 5 %
-2 to 0 %
-3 to -2 %
-1.1
-2.5
2.8
-1.3
-2.6
-0.6
-2.2
-2.4
-0.5
-0.9
6.2
0.2
9.6
-0.2
-1.0
-2.0
2.6
4.6
0.4
-2.6
Ch
Si
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0
30
Kilometers
DORAS
Project
source : population census 1990
migration between 1985 and 1990

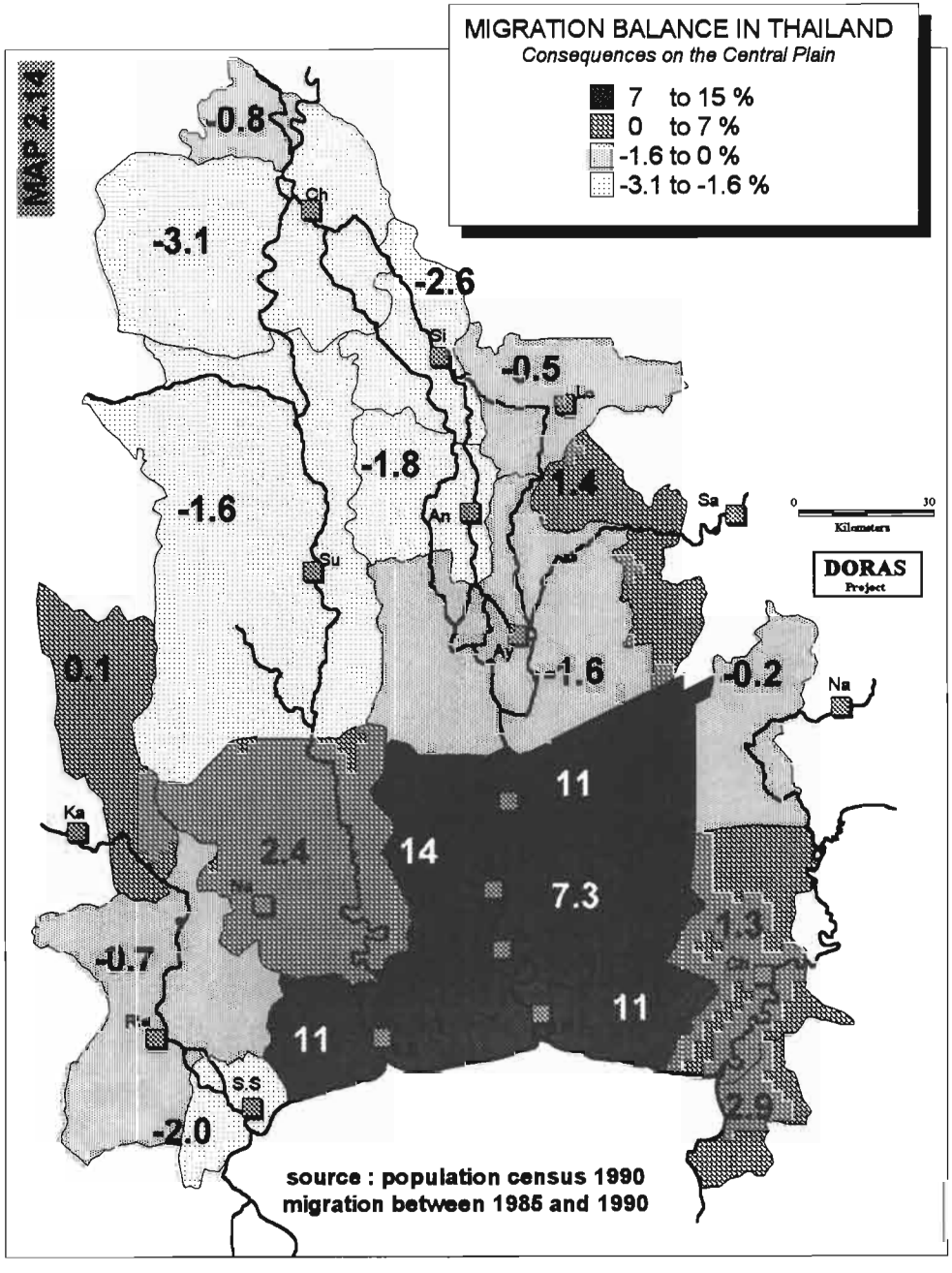

MAP 2.14
MIGRATION BALANCE IN THAILAND
Consequences on the Central Plain
7 to 15 %
0 to 7 %
-1.6 to 0 %
-3.1 to -1.6 %
-0.8
-3.1
-2.6
-0.5
-1.8
-1.6
1.4
-1.6
-0.2
0.1
11
2.4
14
7.3
1.3
-0.7
11
11
2.9
-2.0
Ch
Si
Lo
An
Sa
Su
Ay
Na
Ka
Ra
S.S
0
30
Kilometers
DORAS
Project
source : population census 1990
migration between 1985 and 1990

Table 2.7 : Some characteristics of the migration process

	At the level of the Central Plain	In % of the popula -tion in 1990	At the level of the kingdom	In % of the popula -tion in 1990
Total migrants in Thailand (1985-1990)			1624643	2.84
Total migrants within the Central Plain (number of persons who left their *changwat* between 1985 and 1990)	503960	3.06		
Net migration balance for Bangkok (inflow -outflow)	-11984	-0.2	428831	7.28
Net migration balance for Bangkok and Vicinity	113047	1.35	677441	8.50
Net migration balance for the whole Central Plain			672919	4.09

Source : POPULATION AND HOUSING CENSUS 1990, National Statistical Office

All *changwats* have a negative balance, mostly as a result of migration toward Bangkok vicinity, with the exception of Nakhon Pathom and Prachin Buri, which have enough developing activities to retain their population.

The matrix of the migration flows between each of the 21 *changwat* considered is given in annexe.

Inter-regional migration flows

➢ *Total migration flows in the changwats of the Central Plain*

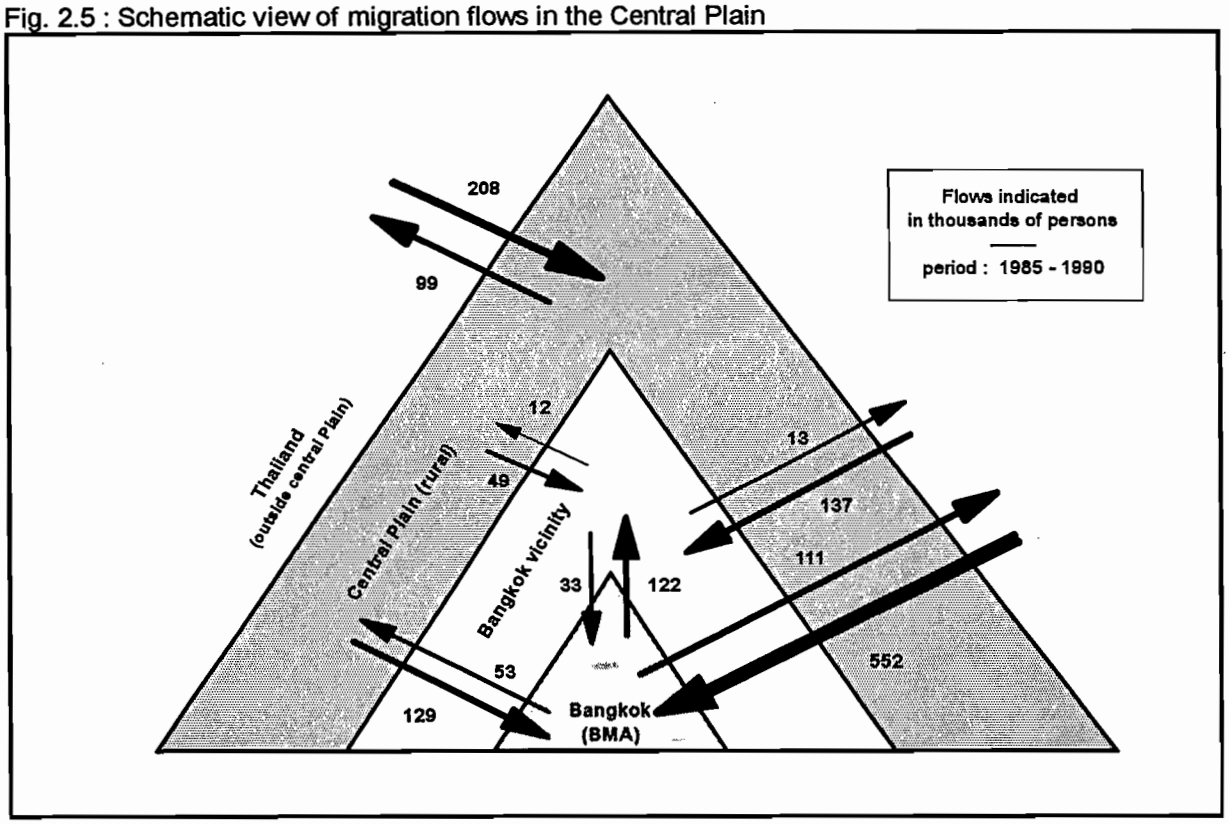
Map 2.14 displays the net migration balance of each *changwat* when all flows within the country are considered. A sharp contrast appears between the old delta in the north and the young delta. The southern part of the Central Plain experienced a net gain of population through migration, during the five year period, resulting in a growth of between 10 and 15 % in four *changwats* (Nonthaburi, Samut Sakhon, Samut Prakan, Pathum Thani). In the north of the delta most of the *changwats*, and especially those which have a high agricultural ratio, have undergone a net loss of population, as high as -3.1 % and - 2.6 % in the case of Chai Nat and Sing Buri respectively. Bangkok and Vicinity continued to swell, with a rate of 7.3 and over 10 % respectively. This phenomena is likely to continue in the future. The map also shows that the migration balances of Chon Buri, Saraburi and Kanchanaburi are positive, which is related to the industrialization of these provinces.

➢ *Migration flows between the zones of the Central Plain and other regions*

If we consider the four zones described above and represented in figure 2.5, we can now summarise their interaction (Tab. 2.8): 285,049 persons have left Bangkok in the 85-90 period but this outflow have been widely offset by an inflow of over 700,000 mainly coming from the outer regions (77 %) and, secondarily, from the (rural) Central Plain (33 %). With an inflow of over 300,000 persons, Bangkok Vicinity received 5

times more than its loss and sticks out as the main target of a migration flow originating in both the outer *changwats* and - more surprisingly - Bangkok City itself.

Fig. 2.5 : Schematic view of migration flows in the Central Plain



The (rural) Central Plain appears to be almost balanced, with an inflow mostly coming from outer *changwats* (76 %) and an outflow directed to Bangkok (47 %), Vicinity (18 %) and outer *changwats* (35 %). Almost 900,000 persons have left the outer *changwats*, trend counterbalanced by only 223,882 returns.

Table 2.8 : migration flows between the regions considered

to / from	Bangkok	Vicinity	Central Plain (rural)	Outer *changwats*	Total outflow from
Bangkok		121,594	52,560	110,895	285,049
Vicinity	33,262		12,366	13,467	59,095
Central Plain (rural)	128,908	48,868		99,520	277,296
Outer *changwats*	551,710	137,046	208,045		896,801
Total inflow in	713,880	307,508	272,971	223,882	

In brief, the (rural) Central Plain has an almost zero net flow, whereas the other surrounding regions have been depleted by almost 673,000 net departures, benefiting both Bangkok (two thirds) and vicinity (one third) (Tab.2.9).

Table 2.9 : Net migration flows between the regions considered

to from	Bangkok	Vicinity	Central Plain (rural)	Outer *changwats*	Net outflow from
Bangkok		88,332	-76,348	-440,815	-428,831
Vicinity	-88,332		-36,502	-123,579	-248,413
Central Plain (rural)	76,348	36,502		-108,525	4,325
Outer *changwats*	440,815	123,579	108,525		672,919
Net inflow in	428,831	248,413	-4,325	-672,919	

2.3.4 Age and gender distribution

The comparison between the pyramid of age of all the population in the Central Plain and the pyramid of age of the agricultural population shows clear discrepancy in the weight of people over 50 years old (Fig 2.6).

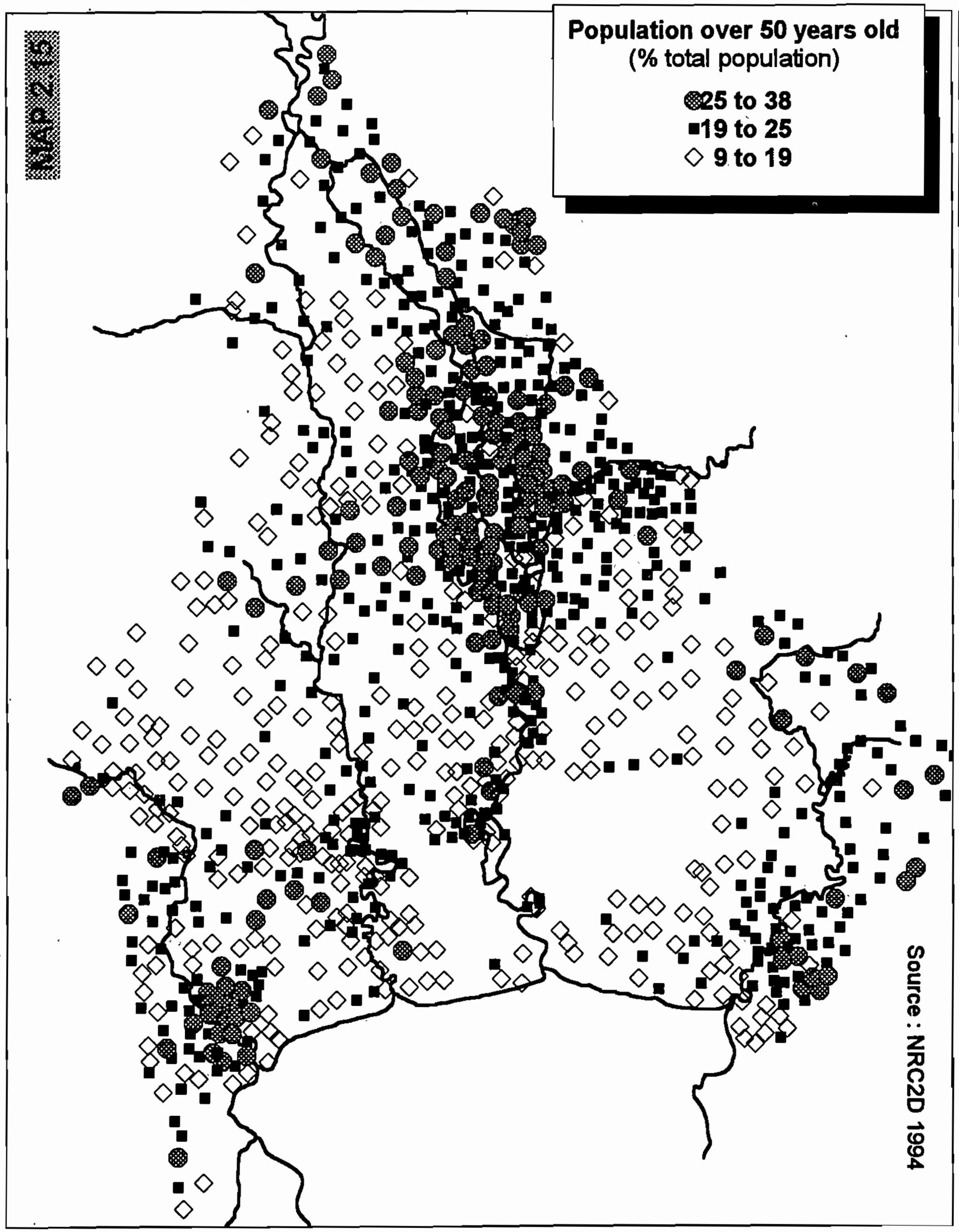
Young people prefer to leave rural areas, but with different intensities according to each region. Map 2.15 describes the population distribution under the criteria of age repartition, considering the percentage of people over 50 years old. The agricultural population is especially "old" between Ayutthaya and Chai Nat and between Ratchaburi and Samut Songkhram. In the same time, the sex ratio (male/female) in these areas is correspondingly really low : map 2.16 displays the percentage of the male population within the total population. It shows that the region with older population also have less men, which suggests that women are less concerned by migration. The percentage of males is lower than 48 % in Ayutthaya and near Samut Sakhon.

Nowadays, the main changes in the structure of the agricultural population occur in the old delta, specially along the Chao Phraya, between Ayutthaya and Chai Nat.

2.3.5 The agricultural population and its dynamics

The rural Central Plain differs from the rest of the country not only because of its higher density but also because of its lower agricultural ratio. Whereas over 60 % of the total population of Thailand is engaged in agriculture, this ratio must be almost halved when considering the Central Plain without Bangkok (37 %) and without its Vicinity (32 %). This means that industry and services also developed out of Bangkok, mainly in its vicinity and around the *changwat* capitals.

Map 2.17 displays the contrasting distribution of the agricultural population ratio, (i.e the percentage of agricultural population in the total population). Areas where the agricultural population is still in majority roughly match the less populated areas (see earlier sections) and follow the axis Chai Nat ⇨ Suphan Buri ⇨ Nakhon Pathom, with more than half of the population engaged in agriculture. The Nakhon Nayok area bears similar feature.


MAP 2.15
Population over 50 years old
(% total population)
25 to 38
19 to 25
9 to 19
Source : NRC2D 1994

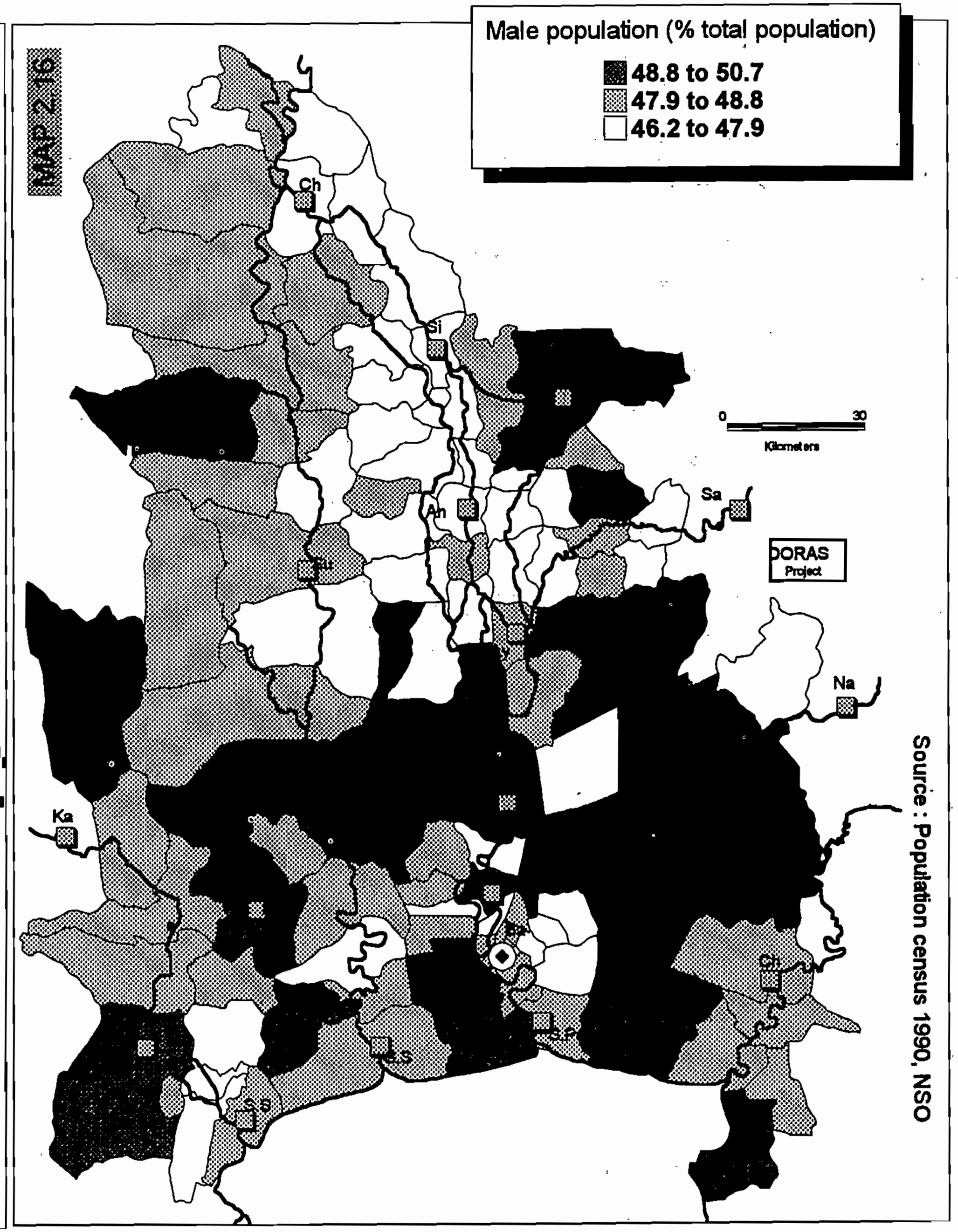
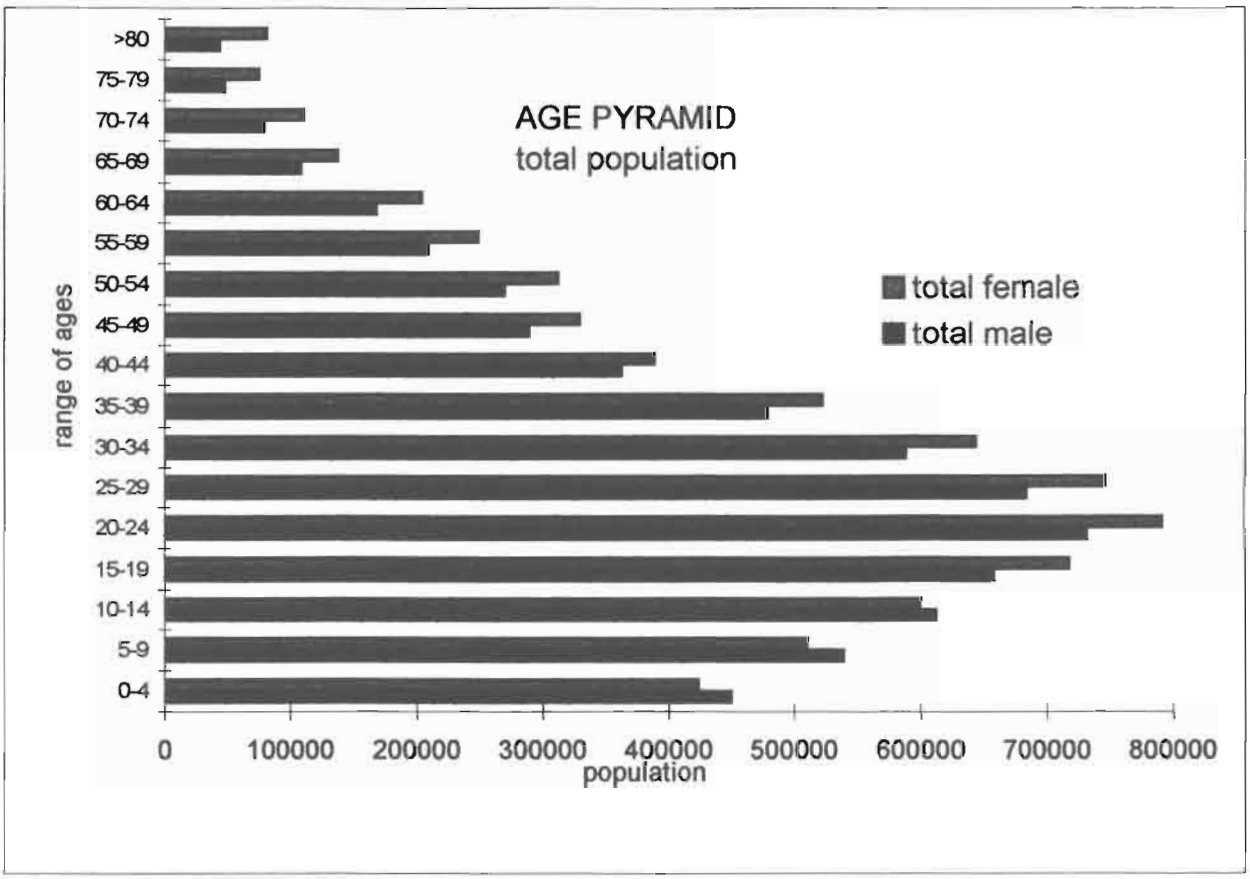
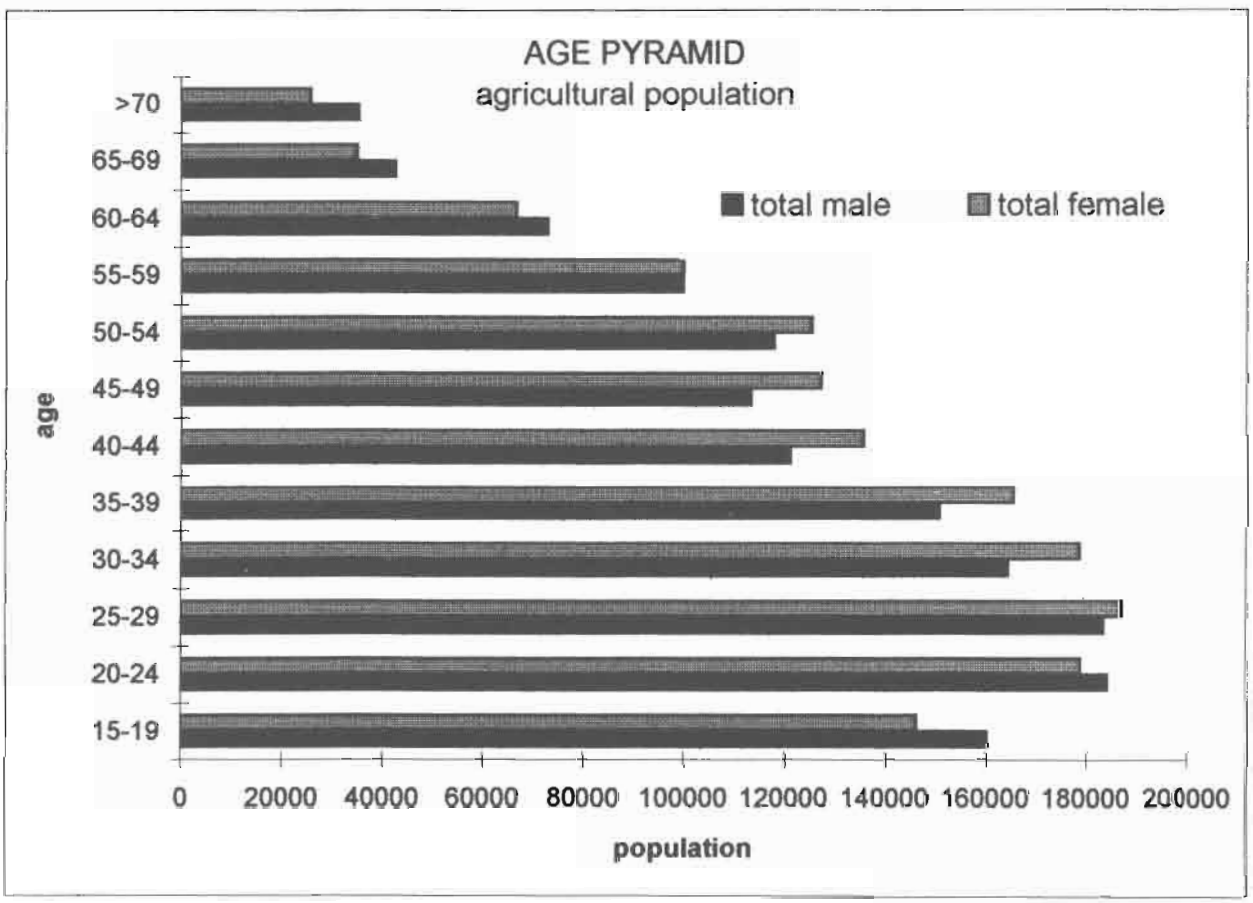

MAP 2.16
Male population (% total population)
48.8 to 50.7
47.9 to 48.8
46.2 to 47.9
0
30
Kilometers
Ch
Si
An
Sa
Na
Ka
DORAS
Project
Source : Population census 1990, NSO

Fig. 2.6


AGE PYRAMID
total population
total female
total male
range of ages
>80
75-79
70-74
65-69
60-64
55-59
50-54
45-49
40-44
35-39
30-34
25-29
20-24
15-19
10-14
5-9
0-4
0
100000
200000
300000
400000
500000
600000
700000
800000
population

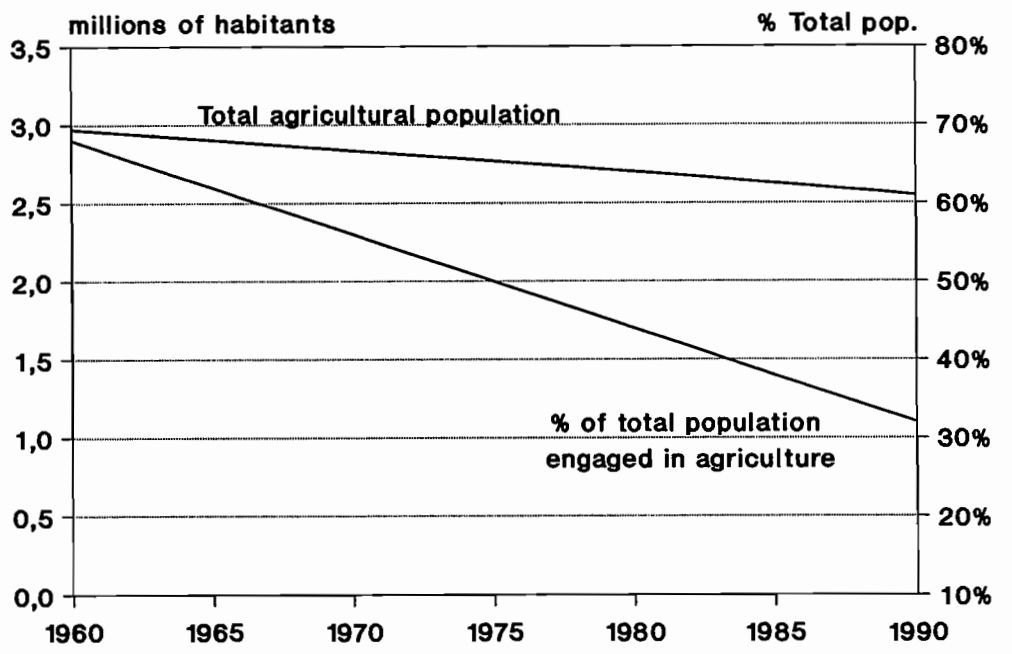

AGE PYRAMID
agricultural population
total male
total female
age
>70
65-69
60-64
55-59
50-54
45-49
40-44
35-39
30-34
25-29
20-24
15-19
0
20000
40000
60000
80000
100000
120000
140000
160000
180000
200000
population

We can also distinguish the area where the industrial and service sectors are particularly developed, roughly the triangle Samut Sakhon - Pathum Thani - Chon Buri, with less than 20 % of the population working in agriculture.

This situation is the result of a rapid evolution since 1960. Figure 2.7 gives the overall evolution of the agricultural population and its corresponding ratio (considering only the area outside Bangkok Metropolitan Area). It reveals that the agricultural population, during these thirty years, has slowly but significantly undergone a decrease of 16 %[9]. If we consider that the average farm size in the Central Plain has also been found to decrease slightly between 1975 and 1991 (OAE), from 26.85 to 24.58 rai (8 %), this evolution also mirrors a decrease in farm land.

As for the agricultural ratio, on the other hand, the decline has been spectacular. In rough terms, the percentage of the population engaged in agriculture has dwindled down from two thirds to only one third between 1960 and 1990. This means that the net gain of population (natural growth + migrations) has been completely transferred to the non-agricultural sectors which now account for two thirds of the activity outside Bangkok. This phenomena is only partly due to the industrialisation of Bangkok vicinity. If we consider the evolution of the ratio outside Bangkok and Vicinity, we find a similar trend from 70 % to 37 %, in the same period. This shows the growth and the importance of non-agricultural activities in the countryside (see § 2.5 for more details).

Fig. 2.7 Evolution of the agricultural population in the Central Plain (without Bangkok)

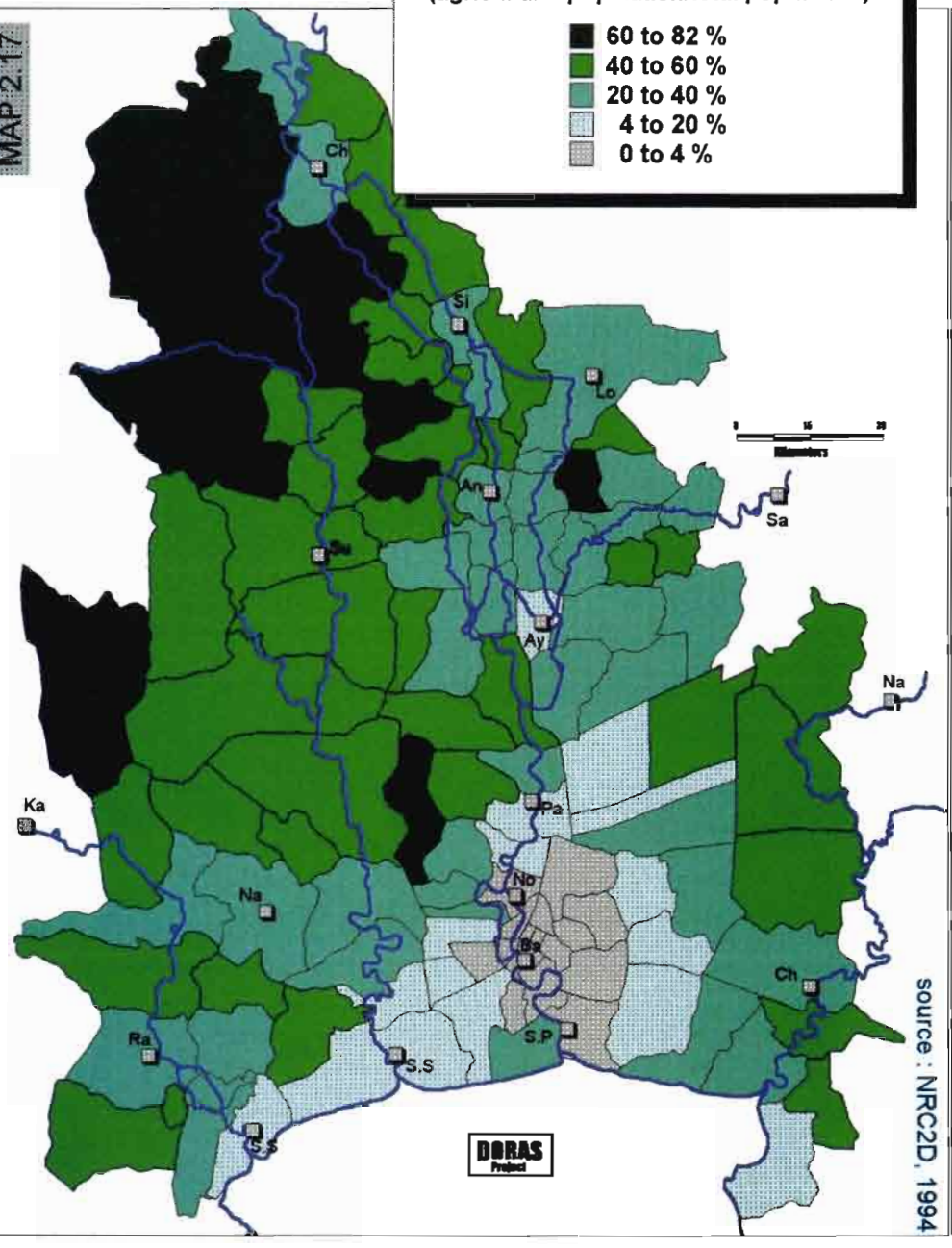


[9] If we consider the Central Plain without Bangkok and its vicinity, this decrease is only 12 %.

MAP 2.17

Agricultural population ratio in 1990
(agricultural population/total population)

- 60 to 82 %
- 40 to 60 %
- 20 to 40 %
- 4 to 20 %
- 0 to 4 %

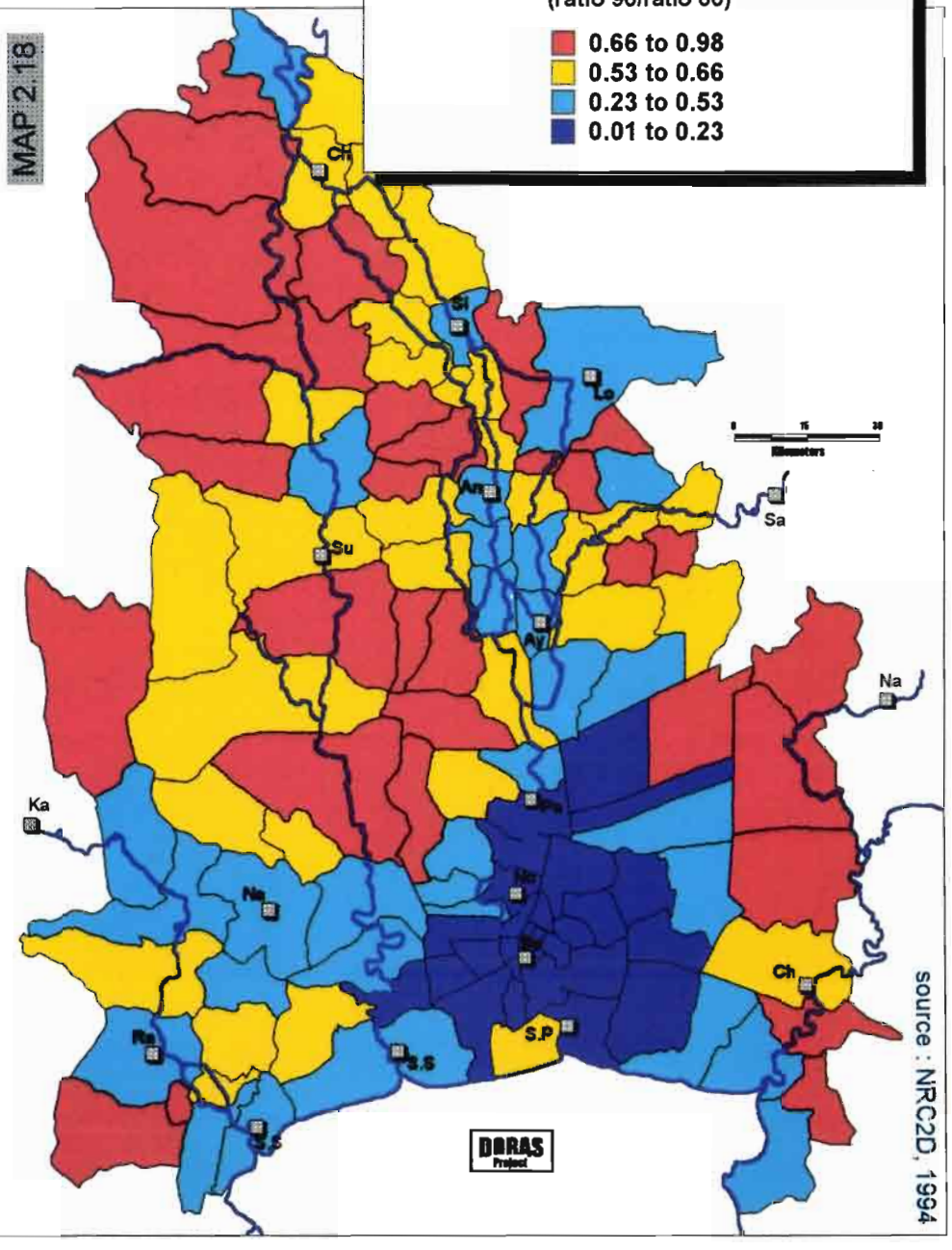


source : NRC2D, 1994

MAP 2.18

Decrease of the agricultural population
(ratio 90/ratio 60)

- 0.66 to 0.98
- 0.53 to 0.66
- 0.23 to 0.53
- 0.01 to 0.23



source : NRC2D, 1994

Map 2.18 shows how this general decrease of the agricultural population ratio in the Central Plain (expressed as the ratio of agricultural population ratios in 1990 and 1960), has affected the different sub-regions. Although the decrease is general (the indice is always lower than one), two zones are specially affected :

- The southern part of the delta, under the influence of Bangkok, with the exception of the fruit and vegetable area around and above the Damnoen Saduak canal;

- The vicinity of the *changwat* capitals located along the Chao Phraya river (Sing Buri, Ang Thong and Ayutthaya), together with Lop Buri.

In these areas, where the density of the population has increased considerably since 1960, the agricultural population rate has been divided by a factor ranging between 2 and 5, and even between 5 and 10 in Bangkok Metropolitan Area. The regions less affected by the (relative) decline of the agricultural sector is, again, the western part of the northern delta.

All these demographic data enable us to draw some general conclusions about their impact on the agriculture of the delta. The first one is that the evolution of the agricultural sector cannot be separated from urbanization and industrialisation. Three factors bring pressure upon the agricultural population :

- The urban growth, which implies a transformation of agricultural land to other purposes, therefore reducing the number of farmers; a significant proportion of idle land can be found around Bangkok (and even in some more remote areas such as the east of Kamphaengsaen Project, Nakhon Pathom Province, or along the Asian Highway), because it has already been acquired for speculation or construction.

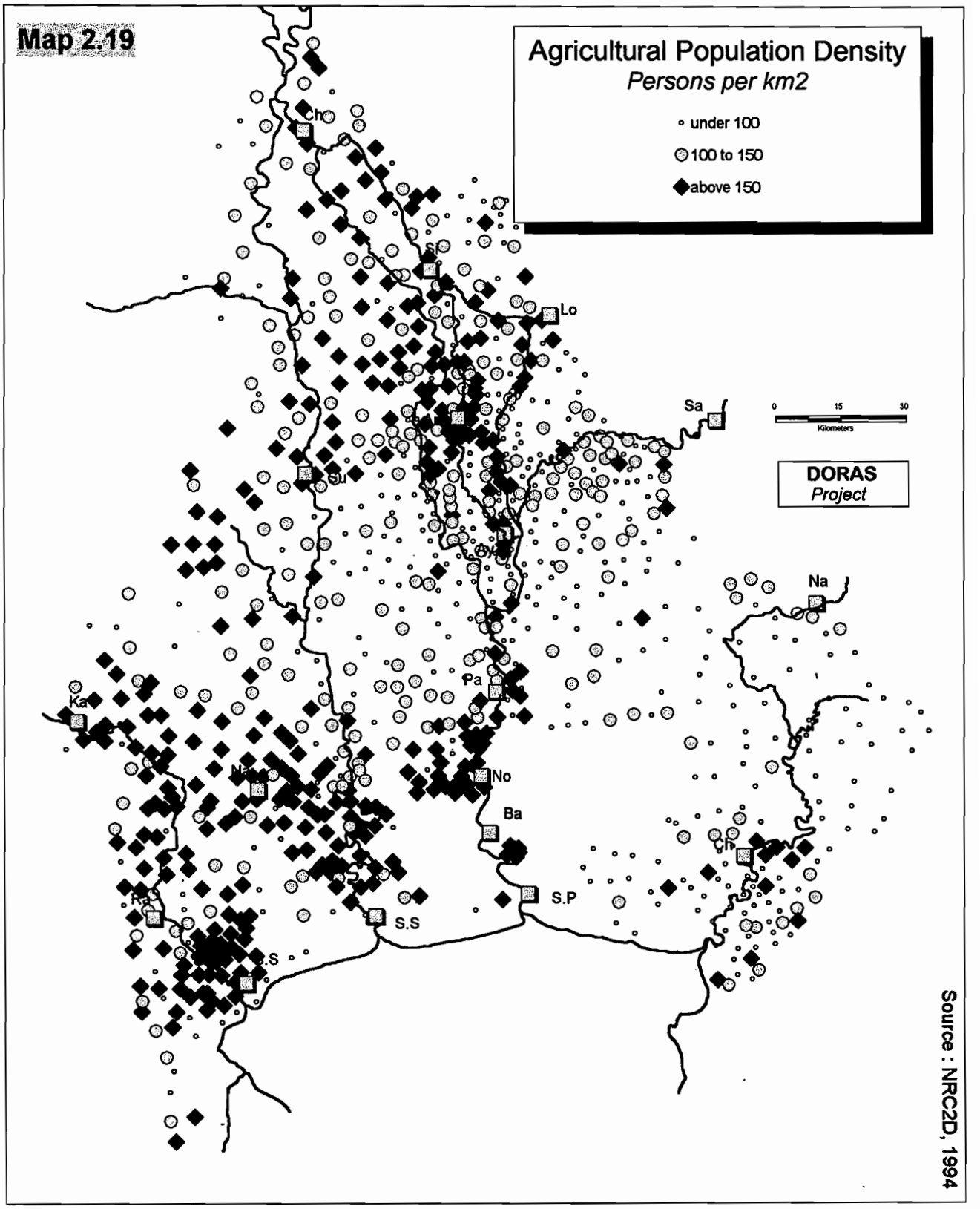
- The industrial and service sectors, which draw the labour force from the fields to factories and offices. Migrations have a clear direct impact on the agricultural ratio, the ageing of the population and the sex ratio. This has brought about drastic change in the structure of the labour force and on labour availability (see later commentaries about the labour constraint; § 3.2.3).

  This impact is more acute in areas where agricultural intensification is impossible or uneasy, principally the flood plain. Pluriactivity also often constitutes a prerequisite of the viability of agriculture in these areas.

  Multiple occupations, migration to urban centres also have a dramatic impact upon farm economics : on one hand, because of additional revenues sent by relatives to the rural households; on the other hand, because of the differential in wages which influences both rural and urban labour costs (see § 2.4).

- The urban demand for new products, with possible new foodstuff production chains, diversification and labour intensive farming, which partly counterbalances the first two trends.

A last map (2.19) shows the current agricultural population density (NRC2D, 1994). Areas devoted to horticulture and the triangle Suphan Buri / SIng Buri / Ang Thong sharply stick out with densities higher than 150 persons/km2. The East Bank, together with some of the areas with extensive rice-farming, show densities lower than 100 persons/km2, which must be linked with larger average farm areas (see Chapter 5).


Map 2.19
Agricultural Population Density
Persons per km2
under 100
100 to 150
above 150
Ch
Lo
Sa
Su
Na
Pa
Ka
No
Ba
S.P
S.S
0
15
30
Kilometers
DORAS
Project
Source : NRC2D, 1994

2.3.6 Aspects of the family structure

To complement this overview of the population in the delta, we may add here some aspects about the family structure. Many studies, and not only in the anthropological field, have emphasized the role of the family structure on historical evolution in different parts of the world (see O. Todd for Europe) and on agricultural innovation[10].

The population census of Thailand distinguishes nuclear and enlarged families, among which we find vertical ones (several generations leave together), horizontal ones (joint siblings' households) and vertical-and-horizontal ones. In each of them, social life, conventions and patterns of authority are different. In a joint family for example, the head of the family concentrates decision, power and capital and the siblings work together. One or various successors to the farmer can be chosen early. In addition, relationship within the village or the social relations of production depend a lot on this basic structure.

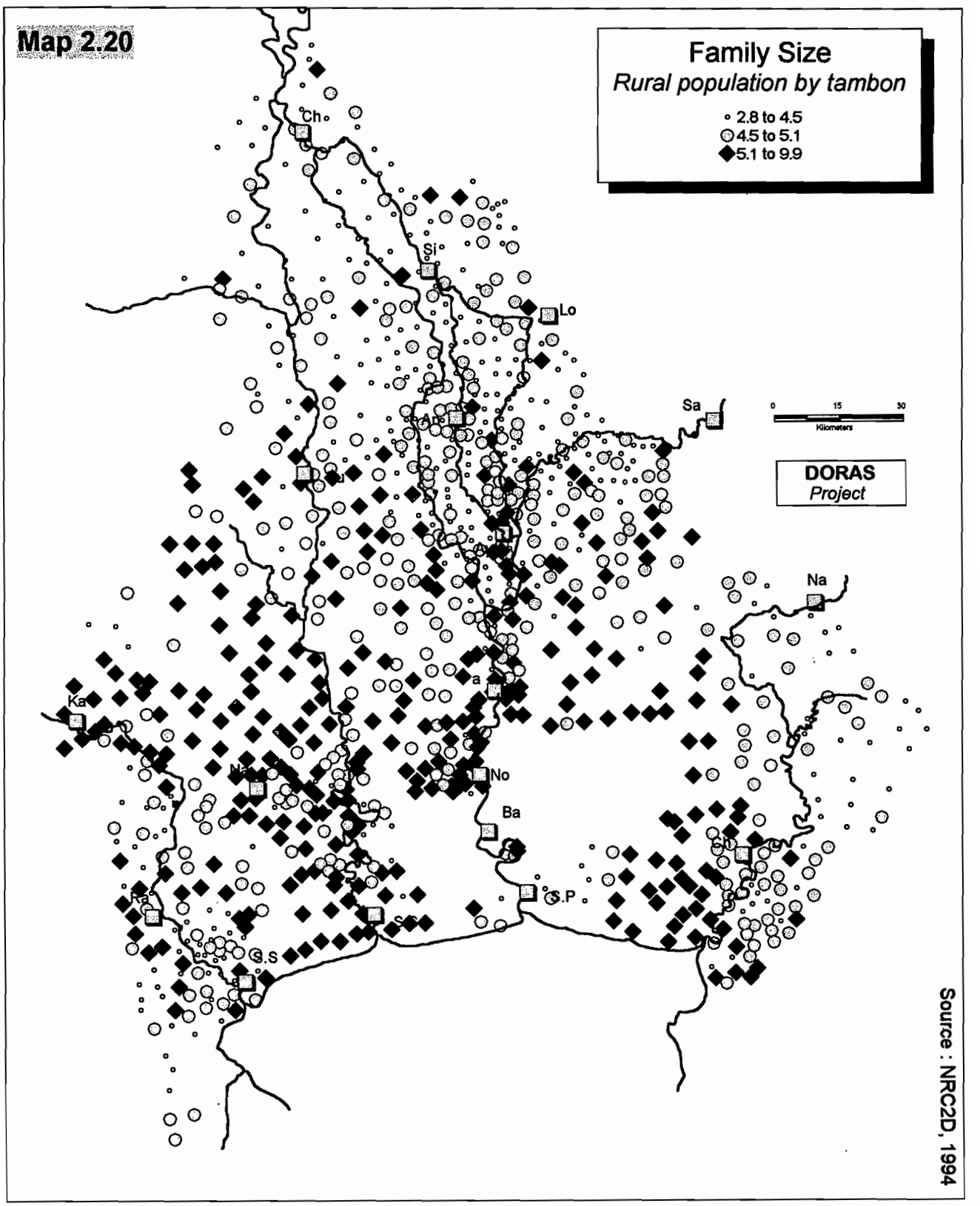
Although the delta has also been populated by Cambodian, Lao or Mon, the main contrast nowadays rests on the ethnic difference between the Thai groups and the Chinese, or their Sino-Thai descendants. For the first ones, the family is nuclear and villages have been defined as loosely-structured. For the latter, the family is enlarged and a high level of internal trust prevails. This enables them to gather money and to lend within the community, as well as to decide the fate of the children. It especially proved efficient to ensure the continuity of a farm. This kind of relationship also favours trading, from retailers to wholesalers, and export companies.

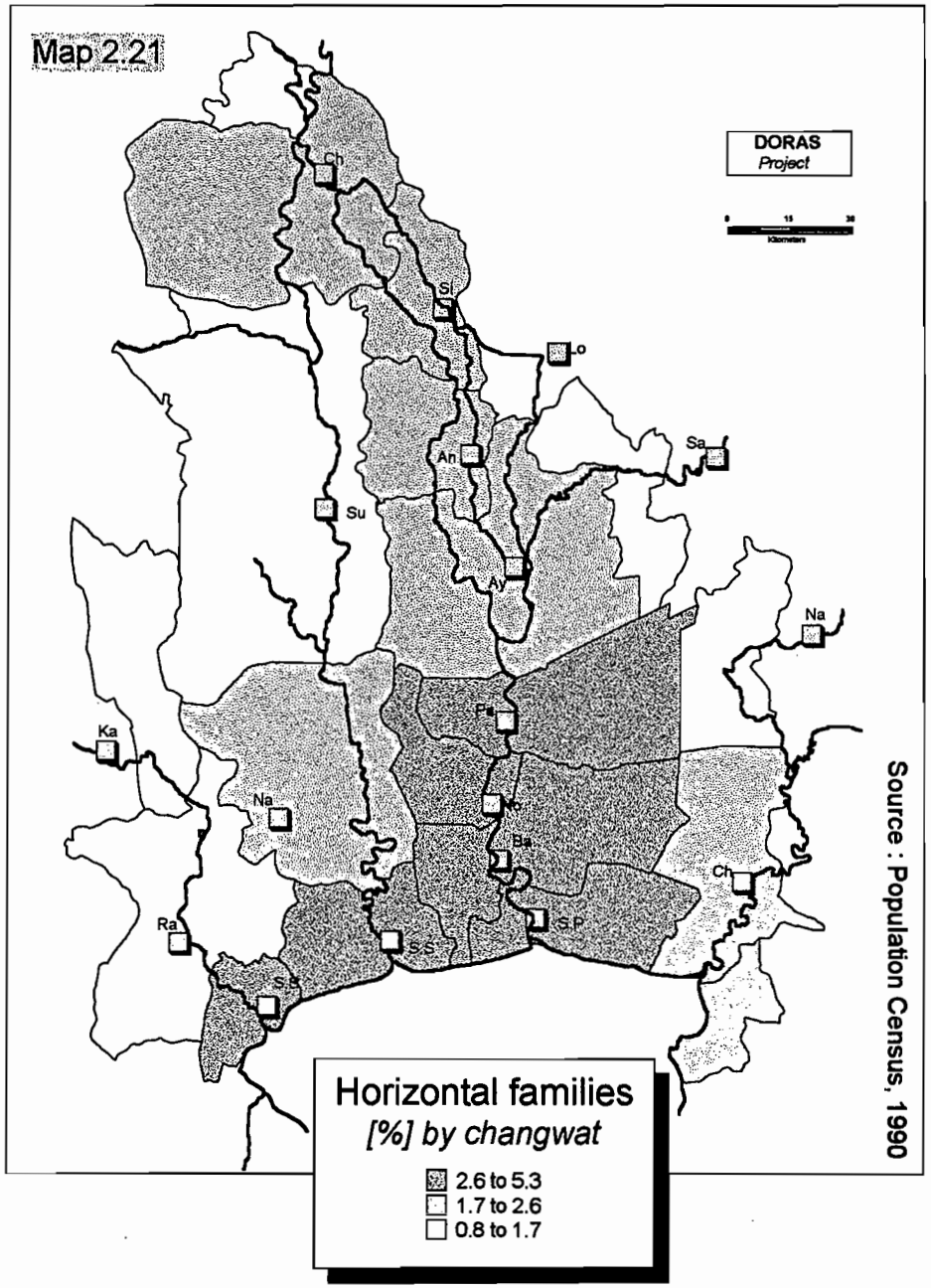
Map 2.20 shows how large are the rural families. This criterion is meaningful in agriculture because it can be linked to the available manpower. There is no doubt that many factors account for differences in the size of families. However, small families are found in the old delta, the flood plain and in the Nakhon Nayok area. This pattern suggests that a poor and extensive agriculture (with high tenancy for Nakhon Nayok), give way to smaller families.

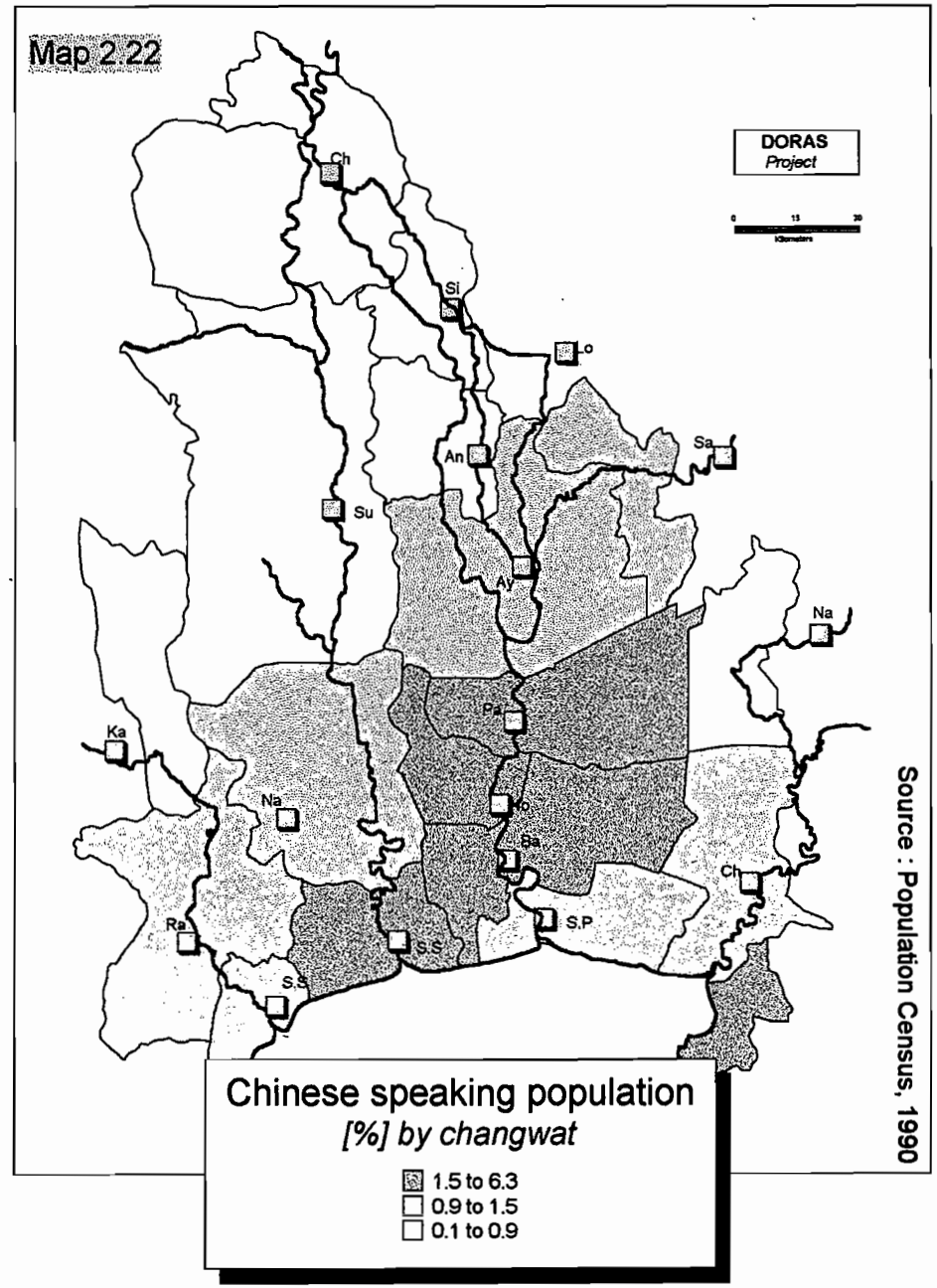
As indicated in map 2.21, horizontal and vertical-and-horizontal families are found in Bangkok and vicinity, but also on the coast, as well as northward along the Chao Phraya. By contrast, vertical families (not displayed) are on the edges of the delta. Map 2.22 tries to localize concentrations of Sino-Thai population. Chinese-speaking ability is a possible indicator, although most persons under 40 years-old do not speak Chinese anymore. Many Sino-Thais live in the southern part of the delta, mainly in Greater Bangkok and in a strip along the coast where coolies settled at the turn of the century. Their location matches the areas with more horizontal families, as seen in the previous map.

Old narratives such as traditional *nirat* show that ethnic Chinese lived in the more remote areas of the country as traders, miners, collectors, etc (Terwiel, 1989). However, the mass immigration of coolies and the settlement of traders, first in Ayutthaya, then in Bangkok, probably explains the present distribution. We will see in chapter 5 how this family structure possibly contributed to induce crop diversification, influenced the family labour force and the formation of credit groups.

[10] see J-P. Deffontaines, for France or J-P. Chauveau for West Africa


Map 2.20
Family Size
Rural population by tambon
2.8 to 4.5
4.5 to 5.1
5.1 to 9.9
Ch
Si
Lo
Sa
Na
Ka
No
Ba
S.P
S.S
0
15
30
Kilometers
DORAS
Project
Source : NRC2D, 1994


Map 2.21
DORAS
Project
Ch
Si
Lo
An
Sa
Su
Ay
Na
Pa
Ka
Na
Ra
Ba
Ch
S.P
S.S
S.S
Horizontal families
[%] by changwat
2.6 to 5.3
1.7 to 2.6
0.8 to 1.7
Source : Population Census, 1990


Map 2.22
DORAS
Project
Ch
Si
Lo
An
Sa
Su
Ay
Na
Pa
Ka
Na
Ra
Ba
Ch
S.P
S.S
S.S
Chinese speaking population
[%] by changwat
1.5 to 6.3
0.9 to 1.5
0.1 to 0.9
Source : Population Census, 1990

2.4 The industrialization process

The delta has always concentrated the bulk of the factories in the country : sugar and rice mills, but also many workshops for consumer goods around Bangkok. However, following World War 2 and above all since the 1970's, the manufacturing sector boomed, taking advantage of low wages and plentiful rural workers, including significant "delocalization" of Japanese factories. The development of this sector, together with services, lured the rural population to such an extent that the agricultural population experienced an effective decrease. This was bound to have drastic consequences on the agricultural sector.

2.4.1 Regional industrialization policies

The policy of industrial decentralization has been targeted as a major objective as far back as the Third Plan (1972-1976), in which the concentration of industries in and around Bangkok was already recognised as a negative factor. The decentralization plan was implemented in three areas : investment promotion through tax incentives (BOI); financial support through the IFCT and SIFCT (Industrial (and Small Industrial) Finance Corporation of Thailand); infrastructure development through the Industrial Estate Authority of Thailand (IEAT). "At the end of the Third Plan, however, 57 % of the country's manufacturing Gross Domestic Product (GDP) was still generated by industries in Bangkok in vicinity" (BOI, 1994).

This policy was further refined and extended during the fourth (1977-1981) and fifth plans (1982-1986). In the latter, the establishment of industrial estates in the regions was given high priority and the Eastern Seaboard Development Program was launched, with emphasis on port facilities.

In the sixth Plan (1987-1991), 24 Regional Urban Growth Centres were defined, among with Saraburi, Chachoengsao, Ratchaburi and Kanchanaburi. The BOI also defined three zones, Zone 3 receiving the maximum benefits from the different forms of incentive.

In the current Seventh Plan (1992-1996), nine Provinces were targeted for development, including Saraburi and Ratchaburi for the Central Region. Regional growth was promoted through two priorities : the development of infrastructure facilities (after demarcating economic zones) and the expansion of public support services for industries (training, marketing information, etc).

Most specifically, the following actions have been undertaken (BOI, 1994):

- *Administration* : establishment of the Committee for Rural Development and Prosperity Distribution, chaired by the Prime Minister and doted with a budget of 55 million bahts for the year 1993.
- *Infrastructure* : upgrading of infrastructure (roads, railways, airports, etc)
- *Finance* : channelling of funds to the region through the various banks and financial institutions.
- *Promotion* : privilege and tax exemption under special regimes of investment (BOI).

The different actions coming under this policy are monitored by the Ministry of Industry, the Industrial Estate Authority of Thailand and the Office of the Board of Investment. The communication with the private sector goes through the Boards of Trade of each Province and the local chapters of the Federation of Thai Industries.

All these policies, although their current dynamics find higher expression in the North and the Northeast regions, have contributed much to the process of industrialization in the Central Plain.

2.4.2 Location of the main industrial areas in the Central Plain.

Map 2.23 was built based on data from the Department of Industry (1990). Three variables are showed on this map :

- Average investment by factory : this variable allows us to localise heavy industries.
- Distribution of Industries : shows the number of factories per *amphoes*.
- Number of workers in industry divided by the total population in 1990 (%) : this variable allows us to evaluate the impact of the industrial sector on the labour market.

The industrial sector is predominant in Bangkok vicinity, especially in three *changwat* : Samut Sakhon, Samut Prakan and Pathum Thani. In some *amphoes*, located near Bangkok Metropolis, more than 30 % of the total population (in 1990) was working in the industrial sector. This area is characterized by a low level of investment by factory and by the high density of factories. Its labour market is marked by the high part of the industrial sector. Nevertheless, although located in Bangkok vicinity, Nonthaburi Province bears different features. In *amphoe* muang Nonthaburi, less than 7 % of the total population of the *amphoe* work in the industrial sector.

Apart from Bangkok vicinity, three other areas of the Central Plain are undergoing an industrialization process:

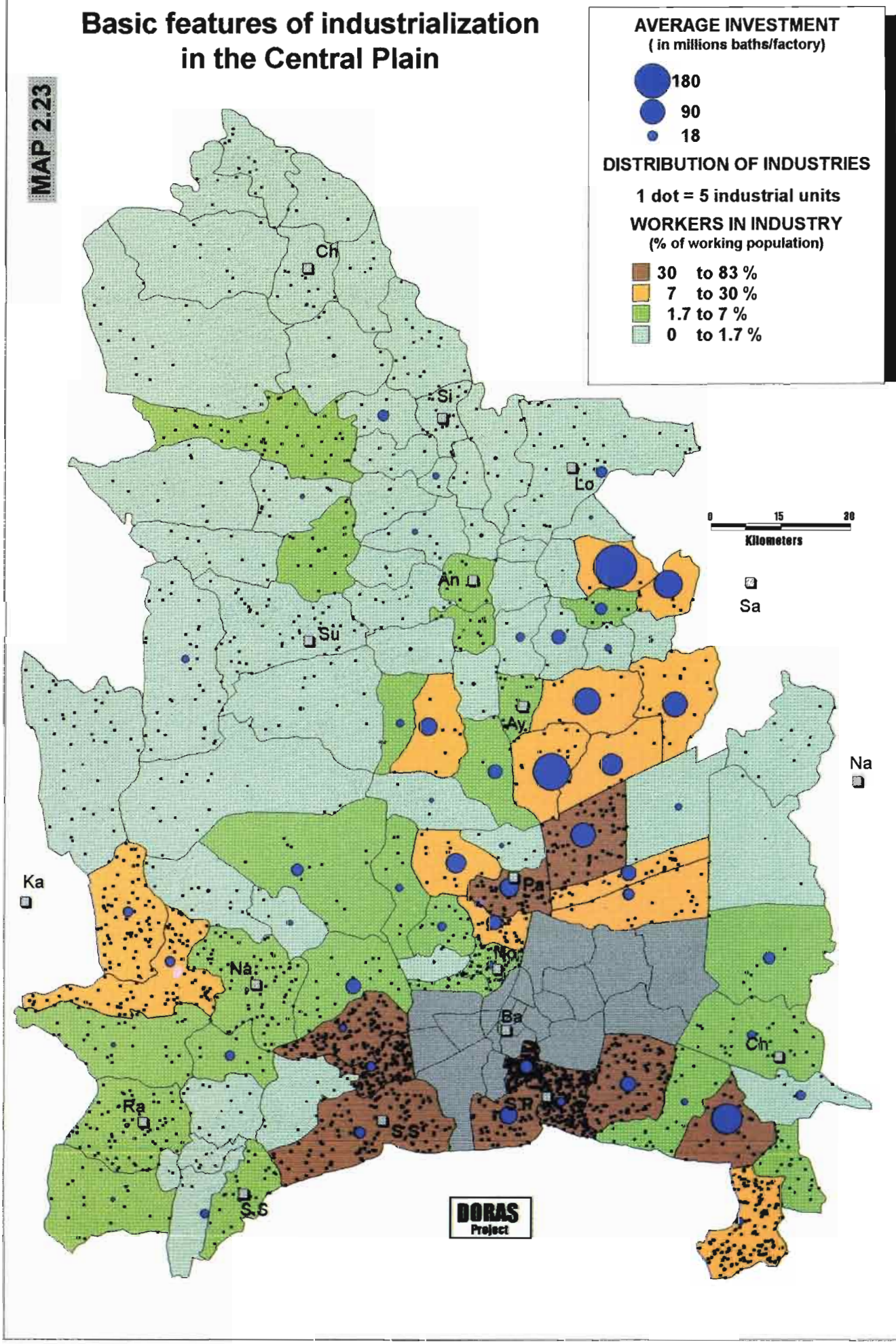
- The east of Ayutthaya and the area between Saraburi an Lop Buri. The density of industries is low : between 32 and 94 factories per *amphoe* for an average of 125 at the level of the Central Plain (without Bangkok Metropolis). In contrast, the average investment by factory is sharply higher than what is found in the rest of the Central Plain (between 253 and 81 million of baths for an average of 24).

  The Provinces of Ayutthaya, Lop buri and Saraburi belong to the Upper Central Region (UCR), in which many areas (with little fertile land and bad water conditions) have been recently developed into factory sites. From 1981 to 1989, the manufacturing sector grew at an average of 9.5 % per year. At the end of 1991, 3,172 factories were established in the UCR.

- The area around Ban Pong, located between Kanchanaburi and Nakhon Pathom, in which between 7 and 30 % of the total population work in the industrial sector. The level of investment by factory is low while the density of factories is high, pointing out a pattern of numerous small industries.

Basic features of industrialization in the Central Plain

MAP 2.23



- The Chachaengsao-Chon Buri area, developed since 1984 by the Eastern Seaboard Development Program. Industry alternates here with agriculture. Heavy industry can also be found in this area.

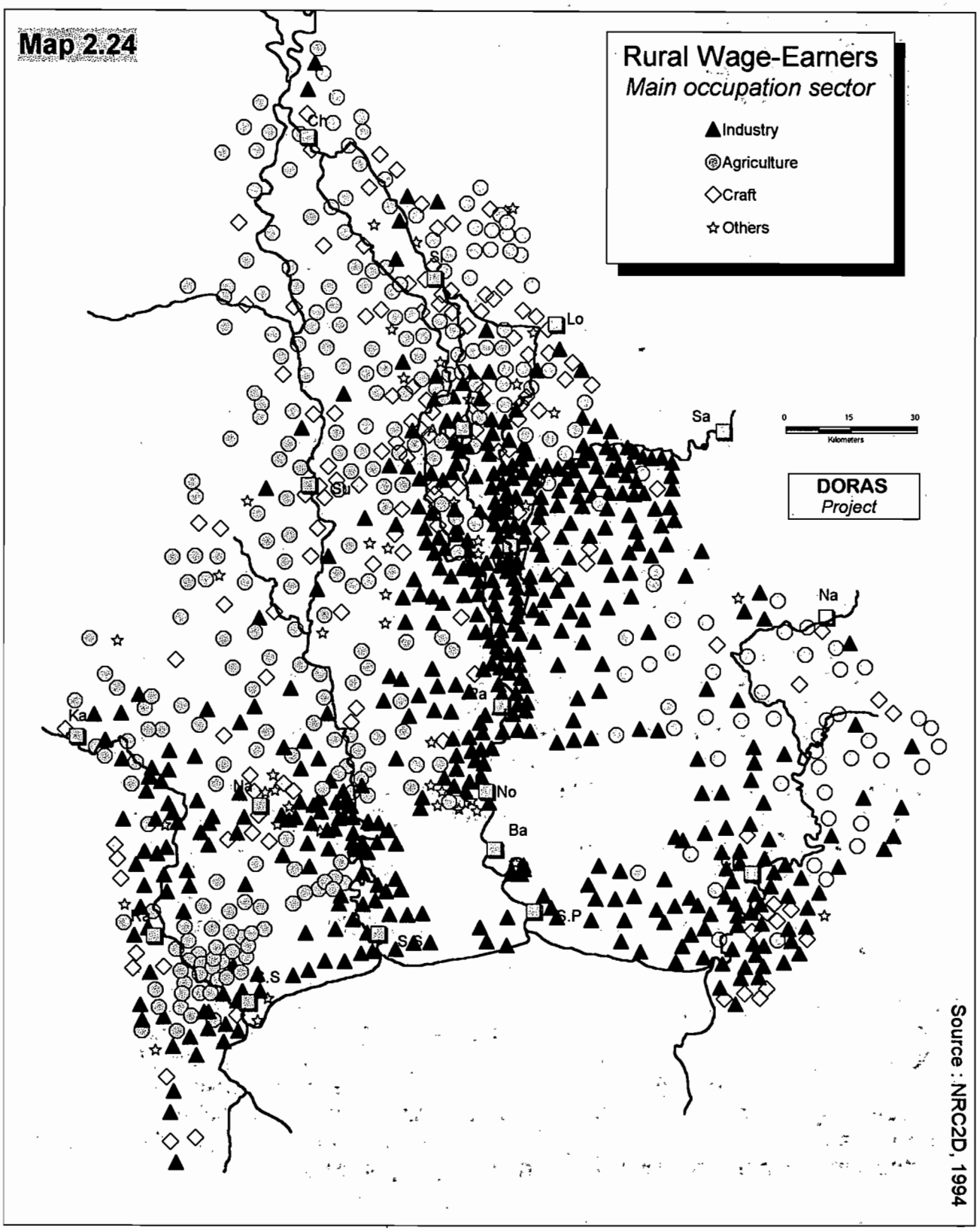
2.4.3 Consequences for the rural population

The dramatic development of the factories under the supervision of the five-year plans has extensively affected the rural population as commented earlier. The relatively higher wages found in the factories drained the working population from the farms, either through residence change or commuter migration (see Chapter 5).

Presently, the delta is divided in two parts : where factory jobs are available and where there are not. Map 2.24 shows the main occupation sector of rural wage-earners. Areas with predominant employment in the industrial sector follow the main traffic axis and match the areas with higher human densities (see § 2.3.2). The first two leave Bangkok northward, firstly towards Ayutthaya and Angthong and secondly towards Saraburi. Eastward is the traffic and industrial axis to Chachoengsao and Chonburi, a region where companies enjoyed tax incentives and infrastructure. Lastly, westward of Bangkok, manufacturing jobs are relatively numerous along the highways to Nakhon Pathom and Ratchaburi as well as around Samut Sakhon and Samut Songkhram.

In the rest of the delta, wage earners mostly find jobs in agriculture and, secondly, in the handicraft sector. The latter is nevertheless predominant in the flood plain and in some spot areas such as the vicinity of Suphan Buri.

The development of the industrial sector in the delta has an evident impact on the labour market (especially the cost of labour, which is increasing, and labour availability). It mostly accounts for the migration flows described earlier and also has impact on land prices and environmental issues. As such, it is of great importance to understand the current transformation of the agriculture in the Central Plain.


Map 2.24
Rural Wage-Earners
Main occupation sector
Industry
Agriculture
Craft
Others
Lo
Sa
0
15
30
Kilometers
DORAS
Project
Na
Ka
No
Ba
S.P
Source : NRC2D, 1994

2.5 The irrigation network

The natural conditions concerning the water regime which was prevailing in the Chao Phraya delta have been slowly but drastically changed in the last two centuries[11]. Beyond the natural conditions and features described earlier, a remarkable *artificialization* of the region has occurred, although the very first land development works were carried out only after the settlement of the Siamese capital in Ayutthaya (see section § 2.2).

2.5.1 The Greater Chao Phraya and Mae Klong Projects

After the Second World War, the huge worldwide demand for cereals led the FAO and the World Bank to support the development of the delta. The Greater Chao Phraya Project was elaborated for the irrigation of the northern part of the delta and was based on the idea of a diversion dam in Chai Nat, first proposed by Van der Heide in the beginning of the century. The Chai Nat dam, or the Chao Phraya diversion dam, is the basis of the irrigation system of the Central Plain and allows the stabilization of its agriculture and to enlarge its cultivated area. This Project encompasses the old delta and the flood plains, together with the fan terraces located on their sides. Branching from the Chai Nat dam, where the water level is artificially raised, several trunk canals make their way to the south, or on the heights constituted by the natural levees of the Chao Phraya and Noi rivers, either on the upper level of the terraces on both sides (see map 2.25). The Project was initiated in 1952 and completed in 1962.

Similarly, the Greater Mae Klong Project was further developed on the western side of the delta, based on the same principle of water diversion by a dam - the Vajiralongkorn dam - located a few kilometres downstream from Kanchanaburi. Initiated in 1972, this project is almost completed with the last construction works in the Phanomthuan and Bang Len Projects. The quality of canal construction has notably been upgraded when compared with the Greater Chao Phraya Project, as the great majority of the canals are lined and design capacities consider full supply requirements for the dry season, as opposed to the complementary irrigation concept of the former. The Mae Klong system has further been fully regulated thanks to the construction of two big storage dams on its two main tributaries : the Srinakarin dam on the Kwae Yay river (1980) and the Khao Laem dam on the Kway Noi river (1984).

In the southern (or young) delta, no gravity irrigation is possible because of the flatness of the area. Water control improvement has therefore consisted in expanding canal excavation, in order to turn water available by pumping to the whole of the area (many of these works, at secondary or tertiary levels being achieved by the farmers themselves), constructing regulators to keep the water in the dry season and to protect fields from salt water intrusion, dredging existing canals, and constructing dikes for flood protection purposes.

[11] Detailed information on the history of land development can be found in particular in Takaya (1987), Tanabe (1977), Tomosugi (1966) and Kaida (1978).

Table 2.10 : Main characteristics of irrigation sub-projects

		Year	Year	(rais)	(ha)	(rais)	(ha)	Land consolidation (rai)		Ditch and dike (rai)	
PROJECT	PROJECT	const.	funct.	ProjAREA	ProjAREA	IrrigAREA	IrrigAREA	Intensive	extensive	Indirect	direct
Bangbal	บางบาล	1970	1983	160000	25600	144200	23072			32900	
Bang Len	บางเลน	1983	1989	351500	56240	316350	50616				
Bang Pakong LB	ฝั่งซ้ายแม่น้ำบางปะกง	1950	1963			65000	10400				
Borommathat	บรมธาตุ	1952	1963	405000	64800	365000	58400	143007	5120		212179
Chanasutr	ชัณสูตร	1952	1963	527000	84320	475000	76000	125830	27680		321490
Chao Ched Bang Yeehon	เจ้าเจ็ด-บางยี่หน	1939	1950	437850	70056	406000	64960	1119			
Chong Kae	ช่องแค	1953	1963	292500	46800	238000	38080			31800	206200
Damnoen Saduak	ดำเนินสะดวก	1902	1917	348000	55680	230500	36880				
Don jedee	ดอนเจดีย์	1961	1964	162500	26000	133000	21280	26538	9600		96862
Khamphaengsaen	กำแพงแสน	1965	1975	316000	50560	252800	40448		3250	9320	241227
Khlong Dan	คลองด่าน	1921	1933	569000	91040	525000	84000				
Khok Katiem	โคกกะเทียม	1953	1963	208119	33299	196000	31360	41100	24023		130877
Klong Priew	คลองเพรียว	1955	1973	122500	19600	91900	14704				91900
Kra Siew	กระเสียว	1966	1982			130000	20800			105274	
Maharat	มหาราช	1952	1964	513900	80448	476300	76208				422000
Manorom	มโนรมย์	1952	1962	264113	42258	236250	37800	83006	5700		103294
Nakhon Pathom	นครปฐม	1966	1973	468435	74950	364200	58272				221057
Nakhonchum	นครชุม	1966	1972	338750	54200	265000	42400				156905
Nakhon Luang	นครหลวง	1960	1964	301844	48295	220000	35200				220000
Nakhon Nayok	นครนายก	1933	1954			574000	91840				144308
Pasak Tai	ป่าสักใต้ (ท่าหลวง)	1915	1924	272000	43520	240600	38496				225800
Pasicharoen	ภาษีเจริญ	1902	1907	350000	56000	200000	32000				
Petchaburi	เพชรบุรี	1937	1956	494563	79130	336000	53760				330000
Phak Hai	ผักไห่	1952	1963	206000	32960	185000	29600				94138
Phan Tong	พานทอง	1956	1965			40500	6480				
Phanom thuan	พนมทวน	1977	1988	332000	53120	295800	47328		34864		
Pho Phaya	โพธิ์พระยา	1921	1933	415938	66550	370000	59200			50234	233300
Phra Ong Chai Ya Nuc	พระองค์ไชยานุชิต	1921	1933	510000	81600	510000	81600				
Phrapimol	พระพิมล	1939	1950	266000	42560	266000	42560				
Phrayabanlue	พระยาบรรลือ	1939	1950	437500	70000	437500	70000				325962
Pollathep	พลเทพ	1952	1963	103000	16480	95000	15200				95000
Rangsit Nua	รังสิตเหนือ	1915	1924	504400	80704	454000	72640				416772
Rangsit Tai	รังสิตใต้	1921	1933	578000	92480	450000	72000				115000
Ratchaburi LB	ราชบุรี (ฝั่งซ้าย)	1967	1972	233725	37396	190500	30480		73122		175900
Ratchaburi RB	ราชบุรี (ฝั่งขวา)	1973	1985	303600	48576	258800	41408				
Roeng Rang	เริงราง	1952	1963	211200	33792	164375	26300			25835	137165
Samchuk	สามชุก	1935	1955	372100	59536	305000	48800	56055			248945
Sao Hai	เสาไห้	1970	1981			271250	43400			43430	
Song Pee Nong	สองพี่น้อง	1981	1988	416106	66577	342615	54818		90921		
Tha Lard	ท่าลาด	1950	1973			123125	19700				
Thabote	ท่าโบสถ์	1952	1963	218356	34937	161000	25760				161000
Thamaka	ท่ามะกา	1970	1980	314400	50304	283800	45408	2390	202415		
Yangmanee	ยางมณี	1952	1963	242400	38784	210000	33600	2660			179340
TOTAL					**2009152**	**11895365**	**1903258**	**481705**	**476695**	**298793**	**5306621**

Because retaining fresh water coming - through rivers and canals - from the upper delta is the main task to ensure water supply, this area is often referred to as the "conservation area", in opposition with the gravity area (see chapter 4 for further details).

In order to allow regulation throughout the year, the Sirikit dam was constructed in 1972 on the Nan river, thus complementing the Bhumibol dam constructed in 1964 principally for energy generation purposes. This regulation capacity made dry season water allocation possible and allowed rice double cropping to expand, alongside the use of High Yield Varieties.

Map 2.25 shows the layout of these different irrigation projects, with the diversion dams and main canals. Map 2.26 indicates the name and location of the sub-project of each main Project, which here total 43 units. 13 sub-projects belong to the upper Chao Phraya, 12 to the lower Central Plain, 10 to the Mae Klong project, in addition to the Sao Hai/Klong Priew, Kra Siew, Wat Sing and Nakhon Nayok Projects, which can be considered independent from the main system. Four sub-projects located on the left bank of the Bang Pakong river have also been considered[12].

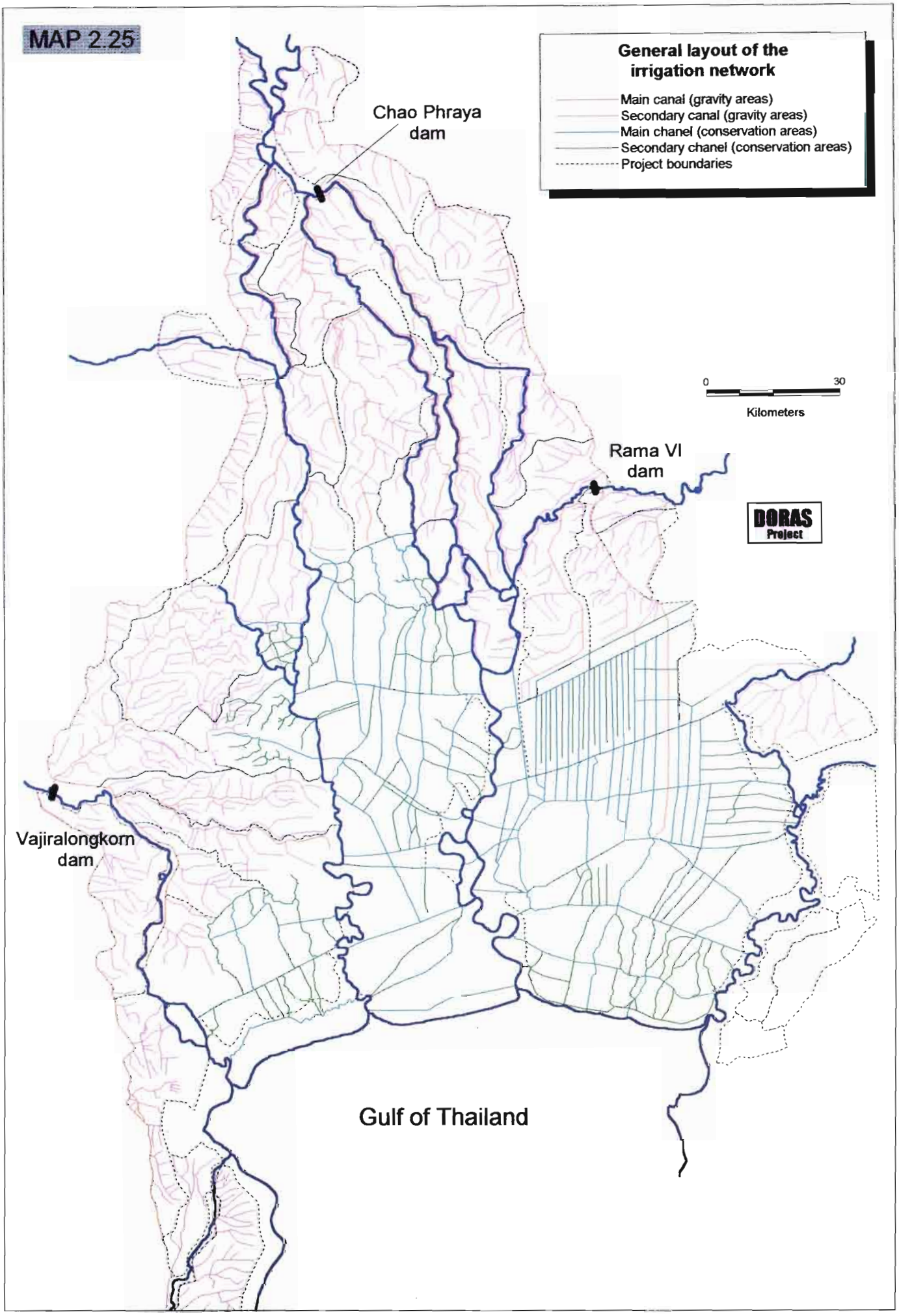
The principal characteristics of these sub-projects are summarized in table 2.10.

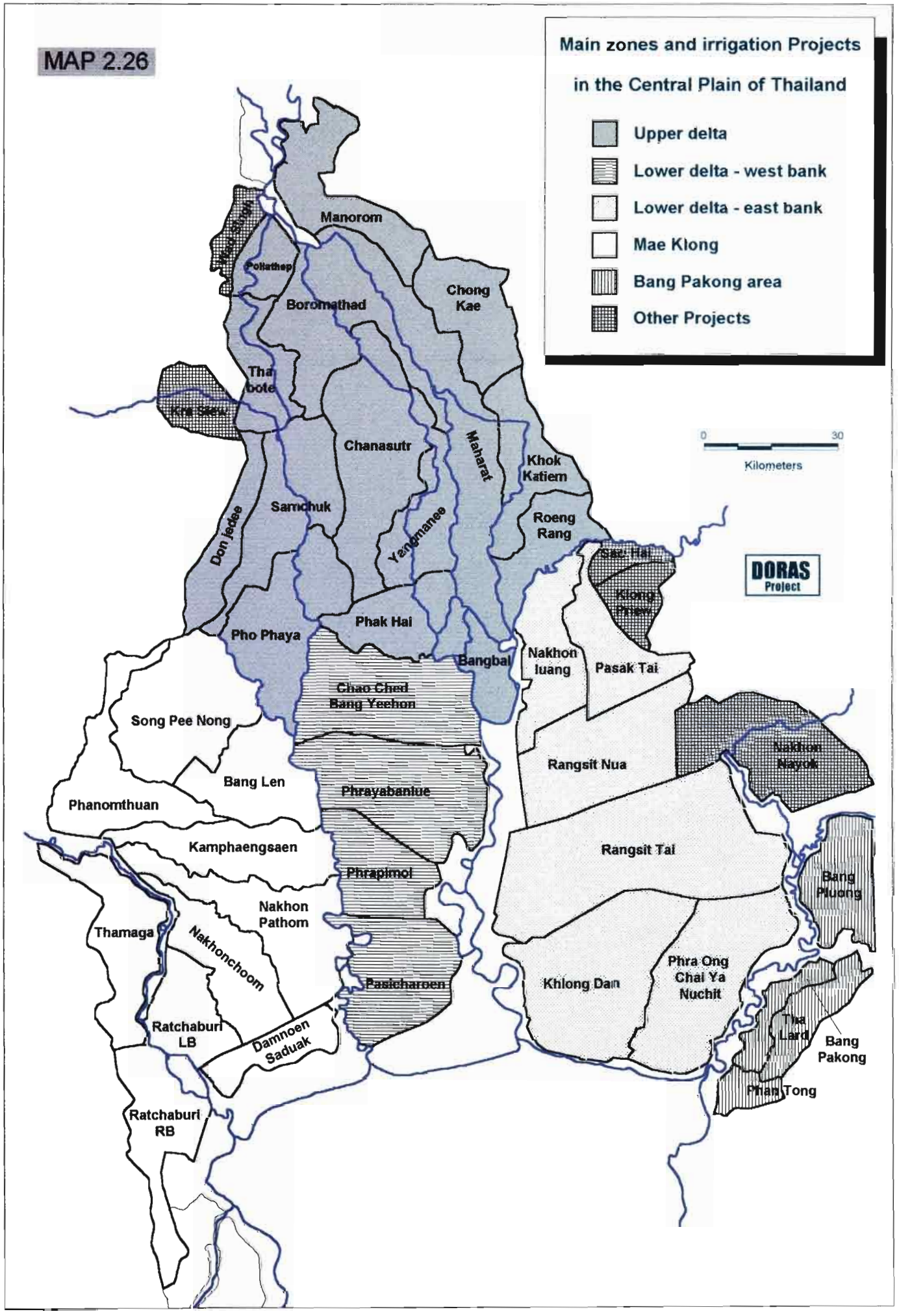
2.5.2 On farm development

The rapid completion of the Greater Chao Phraya Project indicates that work had actually concentrated on only the main and secondary distribution network. As the budget was insufficient to ensure both main and on-farm development, priority was given to the former, under the assumption that the latter would partly be carried out by the farmers themselves.

This however did not turn out to be satisfactory enough, as water access or control was reported low in many places, leading the Royal Irrigation Department to launch the so-called Ditches and Dikes programme between 1963 and 1969. Through this initiative, on-farm conditions were improved, with the participation of farmers, by the digging of tertiaries and drainage farm ditches together with field bunds, enabling thus a better use of the water distributed by the main irrigation system. According to the results of the study carried out by Pongsatorn (1989), not all the plots considered in the Ditches and Dikes Programme have been able to benefit from the drainage system. Only farmland located near main drainage waterways are able to drain directly. The 400-500 m interval between ditches has been found to result in uneven water distribution, because of the irregularity of the land. The layout of ditches also caused an increase in land fragmentation.

[12] Although not belonging stricto sensu to the Central Plain, these Projects are considered in order to specify conditions prevailing along the Bang Pakong river. Therefore, only the western part of Bang Pluong Project is shown on the maps.


MAP 2.25
General layout of the irrigation network
Main canal (gravity areas)
Secondary canal (gravity areas)
Main chanel (conservation areas)
Secondary chanel (conservation areas)
Project boundaries
Chao Phraya dam
0
30
Kilometers
Rama VI dam
DORAS Project
Vajiralongkorn dam
Gulf of Thailand

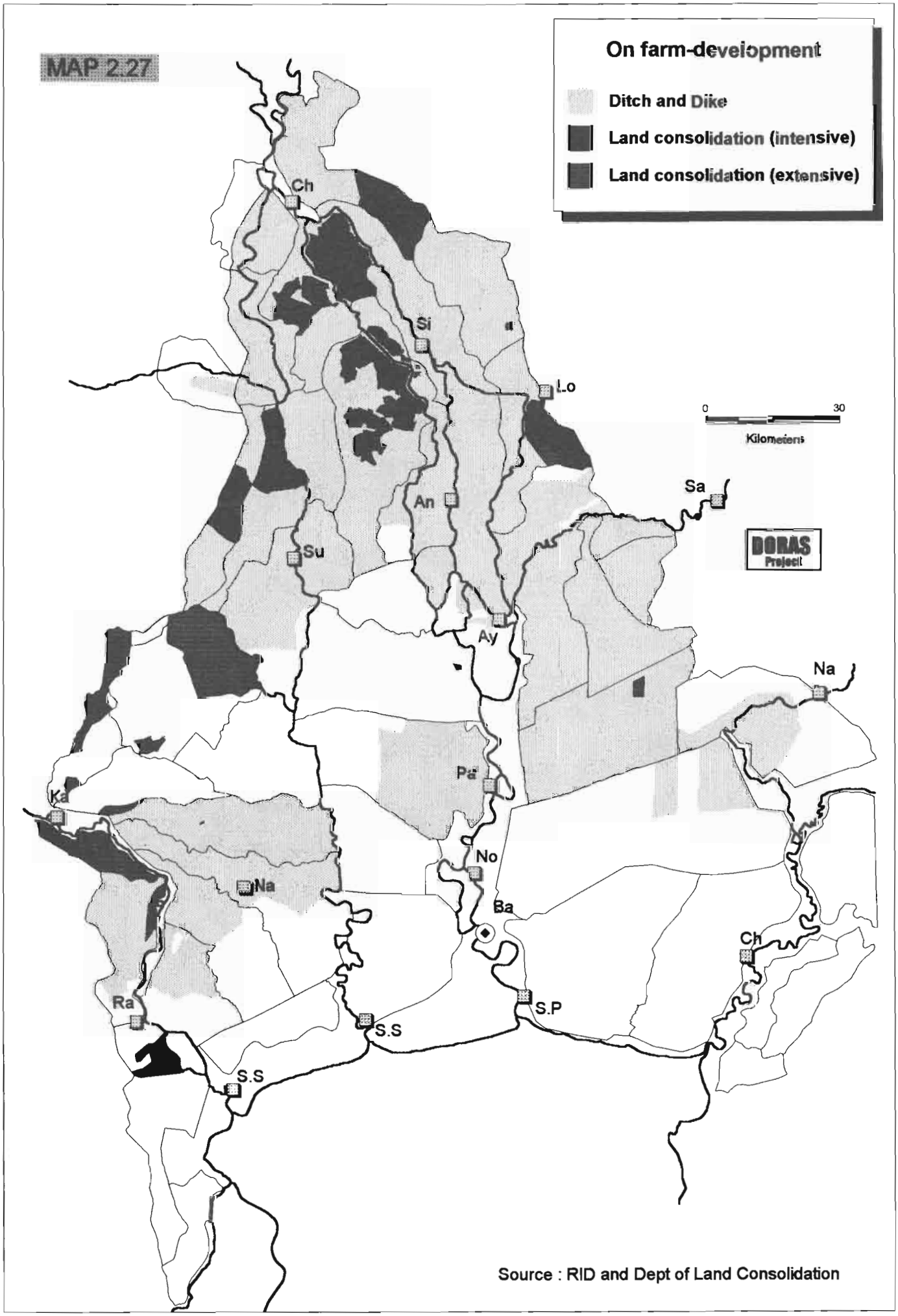

MAP 2.26
Main zones and irrigation Projects
in the Central Plain of Thailand
Upper delta
Lower delta - west bank
Lower delta - east bank
Mae Klong
Bang Pakong area
Other Projects
0
30
Kilometers
DORAS
Project
Manorom
Pollathep
Boromathad
Chong Kae
Tha bote
Khok Katiem
Chanasutr
Maharat
Samchuk
Don Jedee
Yangmanee
Roeng Rang
Phak Hai
Pho Phaya
Bangbal
Nakhon luang
Pasak Tai
Chao Ched Bang Yeehon
Song Pee Nong
Bang Len
Phanomthuan
Phrayabanlue
Rangsit Nua
Nakhon Nayok
Kamphaengsaen
Phrapimol
Rangsit Tai
Bang Pluong
Nakhon Pathom
Thamaga
Nakhonchoom
Pasicharoen
Khlong Dan
Phra Ong Chai Ya Nuchit
Tha Lard
Bang Pakong
Phan Tong
Ratchaburi LB
Damnoen Saduak
Ratchaburi RB

Further to this programme, a land consolidation programme has been promoted in 1974, under the responsibility of the Agricultural Land Consolidation Office (ALCO), in order to achieve full development of the production potential. Several initiatives promoting different forms of land consolidation were proposed and tested, while governmental budget was used to consolidate almost one million of *rai* (half with the extensive pattern, half with the intensive one, which also consider redesign and realotment of plots). In the last fifteen years, however, less or little attention seems to have been paid to on-farm development, although many areas still suffer from improper water control (irrigation and drainage) at plot level, with impact on the level of yield.

The present situation in our study area is shown in map 2.27 and summarized in table 2.11. It can be noted that 40 % of the Central Plain has no on-farm development, but most of such areas are to be found in the conservation area of the lower delta, where it is less relevant because of direct access to water by pumping. However, it is worth noting that in many places of the Ditches and Dikes area, which constitute half of our zone, water control still ranges from insufficient to poor. This must be taken as a general statement, as little is known of the on-farm improvement achieved by the farmers themselves or funded by local authorities (Ko-So-Cho programme and others).

Table 2.11 : On-farm development in the Central Plain (distribution by types)

Land Consolidation - intensive	481,705 *rai*	77,073 ha	4.5 %
Land Consolidation - extensive	476,695 *rai*	76,271 ha	4.5 %
Ditch and dike	5,605,414 *rai*	896,866 ha	51 %
No, or poor, on-farm development	4,373,561 *rai*	699,770 ha	40 %
Total	**10,937,375 *rai***	**1,749,980 ha**	**100 %**


MAP 2.27
On farm-development
Ditch and Dike
Land consolidation (intensive)
Land consolidation (extensive)
0
30
Kilometers
DORAS
Project
Ch
Si
Lo
An
Sa
Su
Ay
Na
Pa
Ka
No
Na
Ba
Ch
Ra
S.P
S.S
S.S
Source : RID and Dept of Land Consolidation

Chapter 3

Actual cropping systems and recent evolution

3.1. General land use

This section describes the current main cropping systems in the Central Plain. It remains mainly descriptive as some of its determinants (recent evolutions, water control, farm characteristics) are developed in following sections.

The region is dominated by widespread rice cultivation, which is here detailed according to land use intensity, variety, cropping calendar and techniques. The second most important crop is sugarcane. Fruit tree cultivation, vegetable cropping, aquaculture and animal husbandry constitute the most predominant aspect of a diversification process which stands out as the main feature of current evolutions in the region.

Map 3.1 displays the location of the main cropping systems which are described and commented on below. This map has to be considered in accordance with its scale and purpose. It focuses on the main cropping patterns and cannot always mirror their internal variability. In some cases, this variability is high and mixed cropping patterns cannot be geographically distinguished. Scattered activities, such as occurrence of fruit trees or fallow land along main roads, cannot always be represented at this scale. Commentaries given in the text will provide additional information on this internal variability.

3.1.1 Rice based cropping systems

a) Main characteristics

Most (flooded) rice cropping techniques and ecological situations can be found in the Central Plain. Our zoning distinguishes major contrasts among varieties (High Yield Varieties (HYV), deep water and floating rice (often referred to as Traditional Varieties : TV), land use intensity (one, two or three crops per year), cropping techniques and cropping calendars.

** Rice classifications*

High Yield Varieties are short stemmed (< 50 cm), non-photosensitive improved varieties derived from the Green Revolution or locally developed. They present a [maximum] yield potential between 7 and 10 t/ha (100 to 130 thangs/rai). They are generally sensitive to weed pressure, water stress and to excessive flooding (especially at the tillering stage); in addition, they generally require *a high level of inputs* (around 150 to 200 units of fertilizer, especially nitrogen), to allow a good expression of their potential. Rice grown in the dry season is always of this type.

Traditional varieties can be conveniently classified in two groups[1] : **deep water rice** varieties, which are suitable for flooding depths between 40 cm and 100 cm, and **floating rice** varieties which have the ability to elongate and to grow in deeper water (from 1 to 4 m). Both are photosensitive and can be cultivated only during the rainy season. The term Traditional Varieties does not necessarily mean that these varieties are old local strains. Instead, it implies that, most of the time, these varieties are grown in "traditional" situations, with limited or no water control.

In fact, it is worth noting that some of these deep-water and floating rice varieties have been improved by the rice research stations (see map 3.9 and commentaries). In some (still marginal) cases too, these traditional varieties are cultivated in areas with good water control, because of the quality of their grain (farmer's preference for consumption, flavoured rice of high quality for new markets,..).

Another classification is also used which considers the duration of the cycle : "light" rice has cycles from 3 to 4 months, "medium" varieties from 5 to 6, and "heavy" ones from 7 to 8[2]. HYV are "light" rices whereas floating rice is - but for rare exceptions - always "heavy". Deep water rice can belong to all categories (but is generally "medium" or "heavy").

** Crop establishment*

➢ The first traditional technique is known as **dry broadcasting** (*wan samruai*) : nowadays, the land is prepared and ploughed by 4 wheel-tractors before or at the beginning of the rainy season. In case of insufficient rainfall, two or even three sowings are sometimes required, under the risk that the flood come before the plants are well established. In case of early and abundant rainfall, such as in 1996, seeds may also be lost and ponding water prevent land preparation.

It is worth noting that the dissemination of four-wheel tractors also allowed farmers to conduct their ploughing in dry (or dryer) conditions than in the past, when buffaloes were used for land preparation, allowing a better control of weeds.

➢ **Transplanting,** another traditional technique, is still to be found in some restricted areas. The land is first soaked, ploughed and then puddled in muddy conditions. Transplanting requires much labour but decreases the necessity to use herbicide to control weeds. This technique is nevertheless necessary when no drainage is possible.

➢ The last technique, more recent, is **wet broadcasting** (*wan nam tom*): Land preparation is similar to transplanting, but more care is required as for the levelling. Two wheel or small four-wheel tractors are used in all cases. The pounding water must then be drained out of the plot (by gravity or pumping) to allow pregerminated seeds to be broadcast on the mud bed ; the water level is then controlled according to the growth of the seedlings. Wet broadcasting is generally used for HYV but sometimes for deep water rice (see § 4).

[1] Several classification exist for rice varieties : in the one proposed by Huke, for example (Huke, 1982), deep water rice is referred as "Intermediate rainfed wetland" (water depths of 30-100 cm), whereas floating rice is called "deep water rice".

[2] these values can be increased in case of early sowing of photosensitive varieties; for example a floating rice variety sown in April and harvested in February may exceed 9 months.

** Cropping calendars*

Because of the mild temperature prevailing all year round, rice can be grown at any time without major climatic restrictions. Moreover, dry season cropping gives better yields because of increased solar exposure (almost 50 % more than the rainy season).

Constraints are therefore generally linked to water availability : lack or excess of water (unavoidable flooding) or bad quality (pollution, saline intrusions), as detailed in next chapter. The "normal" period for dry season cropping, as defined by the calendar of water delivery in the irrigation network, is from February to May. Nevertheless, advanced calendars are frequent. Differences in cropping calendars are indicated with superimposed symbols on the map and summarized in Figure 3.1:

➢ Dry season cropping starting in October-November (marked with stars * and +)

These areas start the dry season at the very end of the rainy period. They take advantage of better water availability in the canals and of the existing field wetness.

- In the Phophya Project and in the West Bank - more precisely in the areas where water recedes first or where the dike system protects the fields - , this shift allows to start the rainy season in April-May and to harvest before the end of September, in order to avoid the flood period (marked with plus +).

- In the East Bank, the area near the Bang Pakong river has adopted a similar calendar but, there, the purpose is to avoid the end of the dry season in which water becomes scarce and saline (marked with stars *). Thus the rainy season starts as soon as the salt dilution by new rainfalls allows it and the dry season is carried out straight forward.

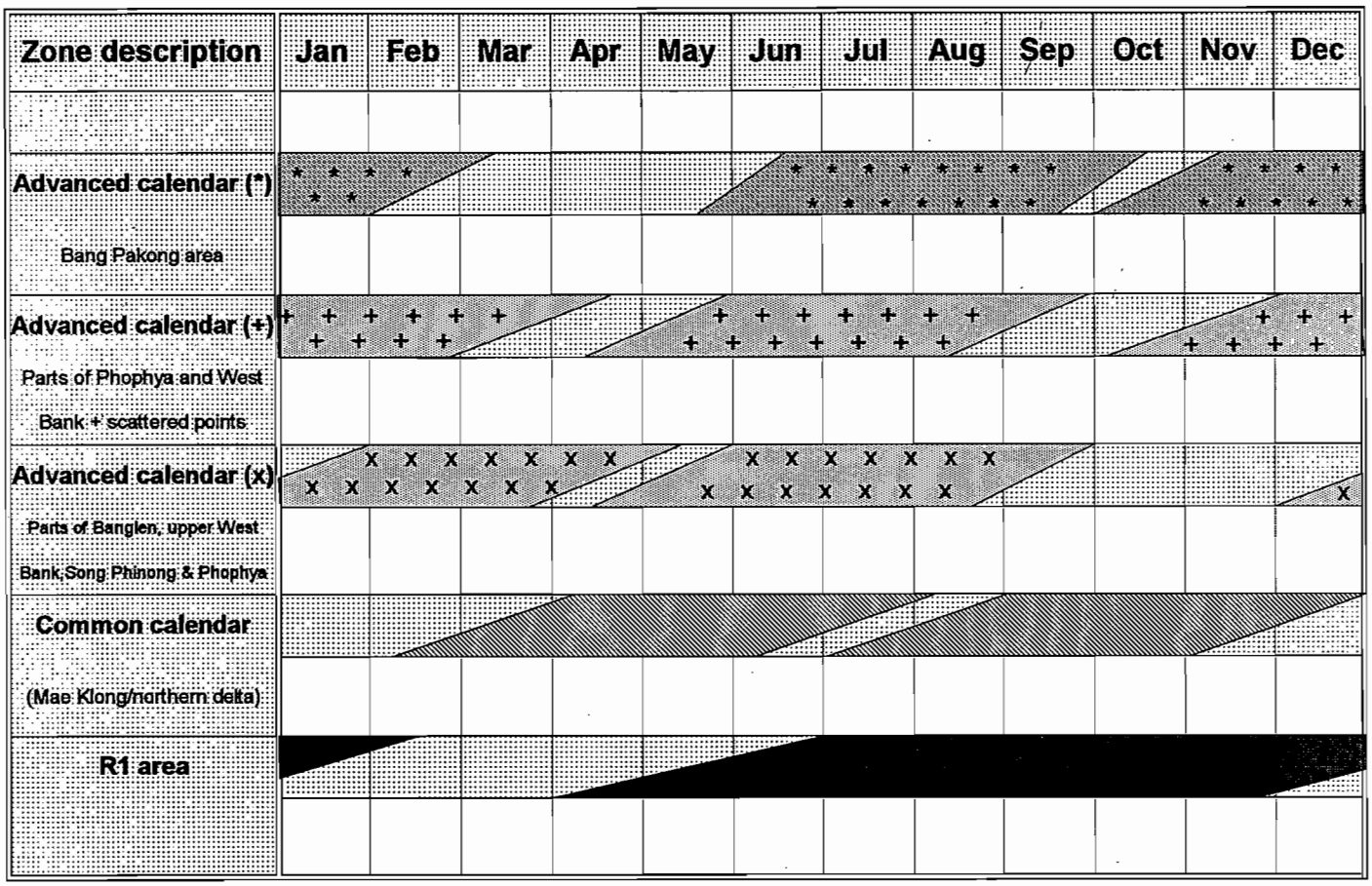
➢ Dry season cropping starting in December-January (marked with x)

These areas also advanced their calendar to take advantage of better water conditions. They do not begin earlier mostly because they must wait for the receding of the flood or because they had to wait for water deliveries to establish their major rice (August).

➢ Dry season cropping starting in February-March (no marks)

This calendar is the most common and corresponds to the "official" period of water distribution by RID. Areas located at the tail end of the network will generally get water as late as the end of March, which may preclude farmers from planting dry season rice.

Figure 3.1 : Differences in rice-cropping calendars



b) Rice based cropping systems subdivisions

The following subdivisions among rice based cropping systems can be observed in main map 3.1.

➲ **RICE R1**

In these zones, deep water and floating rice are predominant and only one crop a year is planted.

The main area spreads along the flood plain of the Chao Phraya and Lop Buri rivers, from the middle of the Central Plain (Ayutthaya and Sena), towards Lop Buri and Chai Nat. A few other areas of extensive rice are also located between Nakhon Pathom and Ratchaburi but these are being progressively transformed into raised beds systems; others can be found in the low lying areas of the old delta or near Nakhon Nayok and the Bnag Pakong river.

Dry broadcasting is most common, especially on the flood plain, rice being generally broadcast between May and July.

Nevertheless traditional (but often improved) medium cycle varieties (*khaw khlang*) are also planted with the *nam tom* technique, where water availability allows this type of land preparation and where the risk of early submersion is low.

We therefore distinguished three categories in Rice R1 :

- **R1a** : deep water and floating rice planted with dry broadcasting technique

The separation between deep water and floating rice is rather uneasy because it has no fixed boundary and for several other reasons which are detailed in the next chapter.

This category represents most of the flooded area of the Central Plain; bad water availability in the beginning of the rainy season, poor or no on-farm development, lack of labour or appropriate equipment are some of the factors which impede the use of *nam tom*.

- **R1b** : deep water rice (often improved varieties) planted under *nam tom* technique

R1b is concentrated in Sing Buri Province, where 17 % of the deep water rice is sown with *nam tom* (Charoendham et al.; 1994), in Nakhon Nayok Project (10 %) and in Chao Chet Project.

- **R1c** : deep water rice (often improved varieties), with transplanting

These areas, indicated on the map with superimposed letters : (tp), generally correspond to depressions deprived of drainage. Ponding water results from the very first rain and transplanting is the most suitable technique.

➲ RICE R2

In this category, double cropping is found with low to very low intensity, in any case less than 50 % of the area and often less than one third. These thresholds must be considered rather qualitative because it has not been possible to consult maps showing the situation year by year and because the first three years of the decade can be considered specially dry, with much less double cropping than in the precedent decade.

Here again, it is possible to distinguish between areas where traditional varieties are planted during the rainy season, with wet broadcasting technique (*nam tom*), and areas where only HYV are grown (also with *nam tom*). In both cases, they are associated with HYV planted in the dry season (*nam tom*).

- **R2a** : deep water rice (often improved varieties) with *nam tom* + HYV < 50 % in the dry season, alternate with single cropping (rotation)

  R2a type is mainly found in the Chanasutr and Khok Katiem Project. In years with dry season water deliveries, traditional varieties (rainy season) and HYV (dry season) are planted with the *nam tom* technique. In other years, only a traditional variety is planted in the rainy season, with dry broadcasting.

- **R2b** : double cropping of HYV, with dry season cropping less than 50 % (often <1/3).

In R2b areas, double cropping can be observed, especially along main canals or near their head reaches, but it always amounts to less than 30 % of the area. This is the case of the eastern part of the upper delta (along the Chai Nat-Pasak canal), and the lower eastern parts of the Mae Klong area.

➲ RICE R3

In this zone, double cropping with medium to high intensity is the rule but it can involve different associations of techniques and varieties :

- **R3a** : double cropping of HYV, with dry season cropping over 50 % (often >2/3) every year.

This area comprises most of the Mae Klong Project and the young delta. It includes nevertheless a wide range of cropping calendars, as detailed earlier.

- **R3b** : double cropping of HYV, with dry season cropping over 50 % (often >2/3) but only one year out of two because of the rotational system within the Project[3].

In the Mae Klong area and most parts of the young delta, water is available in the dry season[4], whereas in the northern delta (Chao Phraya Project), water is delivered to only one half of each Project, with rotation between halves every year (see § 4.4 for more details).

Therefore, this class is found in the northern delta, most specially in its western part and along the head reaches of the main canals in the eastern part.

The rotational system, however, does not produce the contrasted cropping pattern which one might expect from this kind of allocation, and some areas succeed in maintaining an average of over 50 % of dry season cropping (see § 3.2.2 and 4.3.1 for discussion).

- **R3c** : deep water rice (often improved varieties) with *nam tom* + HYV > 50 % (in dry season)

This class corresponds to a succession of traditional varieties and HYV, both with *nam tom* and without rotation constraint. It is found in the Phak Hai Project, along the main canals, along the Bang Pakong river and in some depressions of the Mae Klong project.

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[3] The distinction between R2b and R3b must be regarded as somewhat qualitative. No precise yearly data is available which would show the distribution pattern of each dry-season. In addition the situation observed in the nineties is quite different from the one in the eighties, when dry season cropping was more widespread. Therefore, the two areas have no strict limits and the distinction only mirrors the fact that dry season rice cropping is getting scarce in the eastern side, apart from upper reaches of the main canals.

[4] apart from some specific years with drastic water shortage

Such a cropping pattern is only possible with medium cycle deep water rice and is not common because of possible overlapping between the two rice cycles. In Phak Hai, wet season rice is mostly harvested in the end of December.

In all these three categories, some limited cases of transplanting can be observed; they are indicated with superimposed letters (tp).

3.1.2 Sugarcane

Sugarcane can predominantly be found in the upper Mae Klong Project and in the western part of the old delta (mainly in Chanasutr and Samchuk Projects).

These regions are characterized by higher and better drained soils, often with insufficient or poor access to irrigation water (crops rely on underground water and rainfall) and proximity of sugarcane mills. In fact, especially in some areas such as the upper Mae Klong, irrigation has only partly supplanted rainfed cropping associated with well supply, most of the time because of a poor or non-existent ditch system combined with higher topographic location where gravity irrigation is difficult.

Yields are, in the average, about 75 t/ha in the old delta area and 60 t/ha in the Mae Klong area, mostly because water supply in the former is superior. Ratooning is done during an average of two years, before plants are renewed (see § 3.3 for more details).

3.1.3 Fruit cultivation

Two kinds of fruit cultivation exist in the Central Plain : the first one is the traditional backyard orchard which can be found typically along the main rivers, on their natural bordering levees : the Noi and Chao Phraya rivers have some old orchards whose total area is large enough not to be overlooked : in the Yangmanee Projects, for example, these orchards are said to total approximately 5,000 ha.

The second kind is the cultivation of trees in irrigated orchards. These orchards generally go together with the construction of raised beds and additional dikes around the plot. Both are necessary to ensure non-flooded conditions for the trees. Nevertheless, in some higher plots, trees can be planted without such investment, but this situation is less frequent than the first one.

The main - and older - fruit growing areas are located in the lower Mae Klong Project, around khlong Damnoen Saduak, and in the western bank of the Chao Phraya river, close to Bangkok (see map 2.9). More recently orchards have spread to the eastern part of North Rangsit (Kono and Kumar, 1995), and near Chachoengsao. At present, given the increasing value of land, some of these fruit growers are selling their land and moving further north to continue their activities (e.g Chanasutr, Khok Katiem).

The most common fruits are mango, citrus (orange, pomelo, lemon, lime, tangerines), durian, coconut (around the lower part of the Mae Klong river), guyava, rose apple, grapes, betel nut, banana, etc. Some areas specialize in particular kinds

of fruits : citrus (Rangsit and Nakhon Chaisi), coconut (Samut Songkhram), grapes and mango (Damnoen Saduak), etc.

Map 3.2 and 3.3 display areas with higher concentration of fruit trees and vegetables according to the NRC2D database.

The orange pattern (V1) indicates areas where orchards are predominant, sometimes with some secondary vegetable cropping, or miscellaneous, as indicated. Apart from these main areas, fruit plantations are to be found scattered all over the delta. Additional areas where orchards are significant are dotted in orange. In the case of the stripes along rivers, which represent the traditional backyard orchards on the levees of the river, these fruit trees are associated with small home gardening and housing.

3.1.4 Vegetables, field crops and flowers

Several kinds of vegetable and field crop farming can be distinguished. The first one is the permanent farming, which can be found either on raised bed systems or on normal plots. The second is the dry season cropping, which is generally carried out after the major rice.

- Raised beds systems

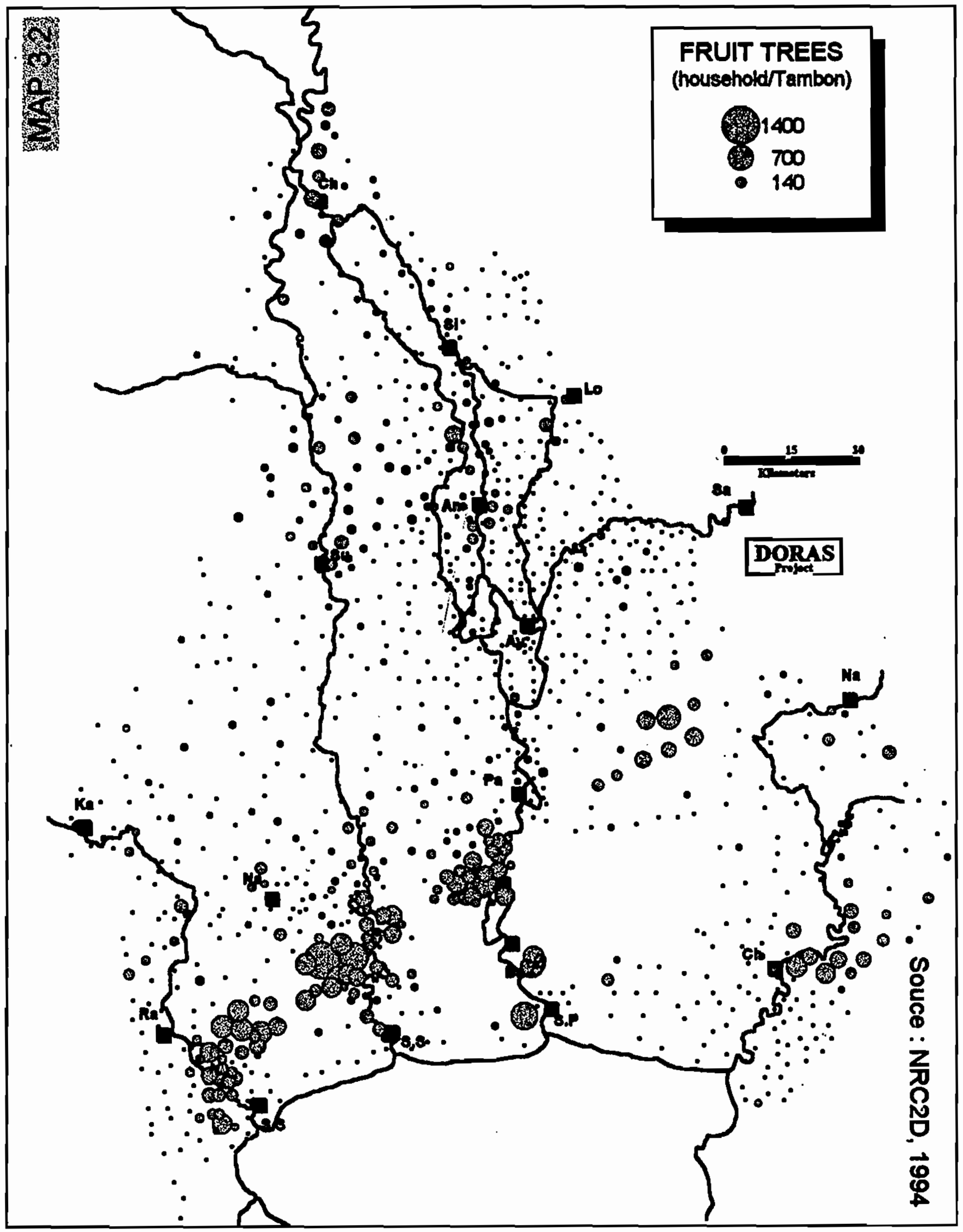
The lower Mae Klong and lower West Bank stand out as the main vegetable cropping areas on raised beds. Provided with good water access all year around and non flooded (high or poldered) land, their proximity to Bangkok has turned them into the major areas for diversified products, with production geared towards national and international markets. Although generally mixed with other crops, predominant vegetable growing can be found in some areas such as the lower Ratchaburi Left Bank Project (part of the raised beds of Damnoen Saduak area), around Nakhon Pathom and west of Bangkok (Phrapimon Project).

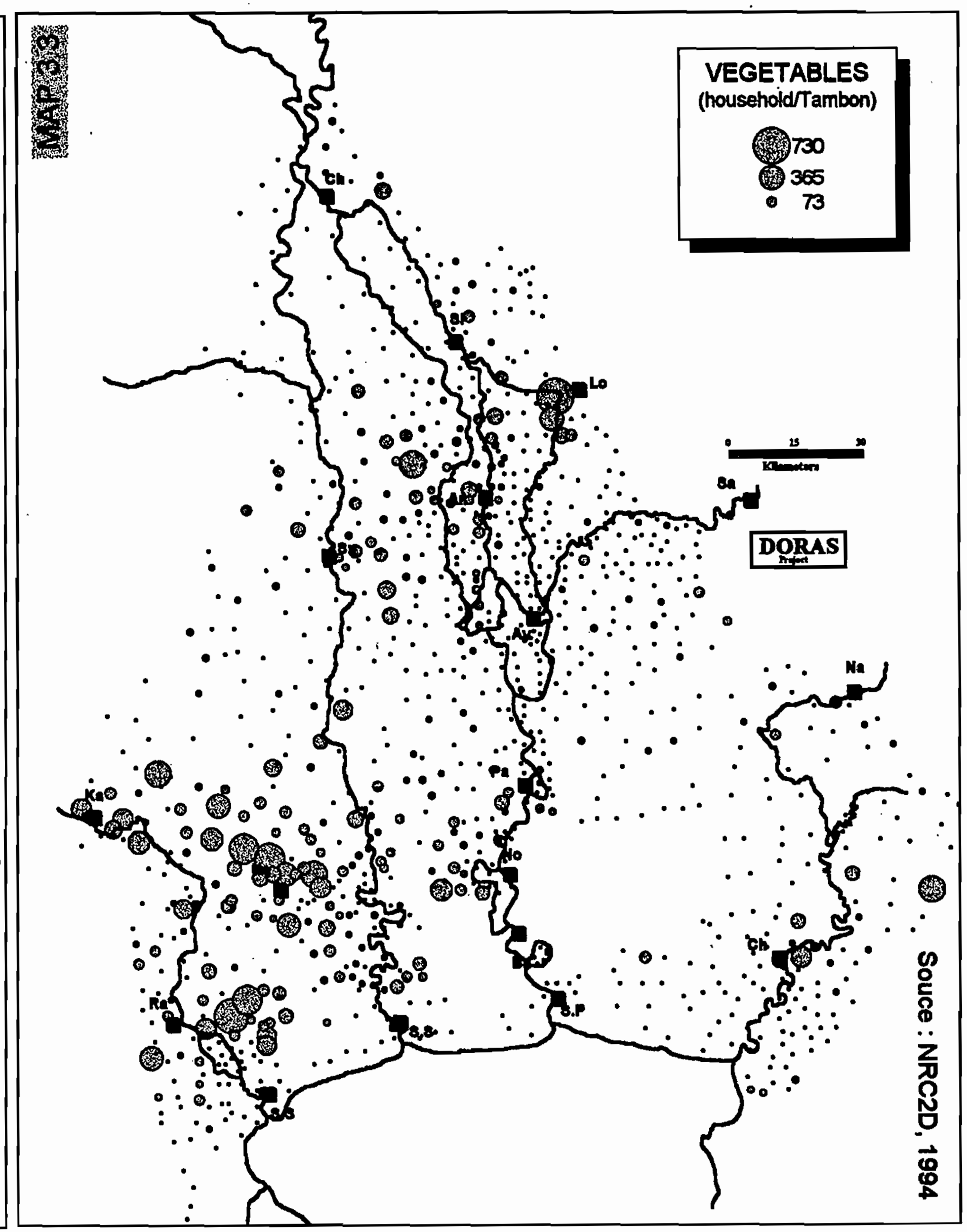
Vegetable cropping on raised beds can nowadays be found all over the (non flooded) delta.

The main crops are asparagus, coriander, different kinds of cabbage and cauliflower, baby corn, sweet potato, etc. Cropping is intensive with a high level of input (fertilizer, pesticide, lime, etc) and irrigation must be provided up to twice a day during the hot season. Pesticide overuse is frequent with negative impact on the health of workers and the environment.

- Normal plot

Some field crops or vegetables are also cultivated all year round in normal plots. This is the case for baby corn (irrigated by furrow) and for *cha-om* (Acacia nnata), near Nakhon Pathom.


MAP 3.2
FRUIT TREES
(household/Tambon)
1400
700
140
DORAS
Project
Ch
Sl
Lo
An
Su
Sa
Ay
Na
Pa
Ka
Na
Ra
Ch
S.S
S.P
Souce : NRC2D, 1994


MAP 3.3
VEGETABLES
(household/Tambon)
730
365
73
DORAS
Project
Ch
Sl
Lo
Sa
Ay
Na
Pa
No
Ka
Ra
Ch
S.S
S.P
Souce : NRC2D, 1994

➢ Aquatic farming

Some popular aquatic leaf vegetables are also grown in flooded fields or in drains : water mimosa (*phak krachet* (Neptunia reptans)), water crest, lotus flowers, etc

➢ Dry season farming

Apart from these intensive cropping systems, which often constitute the major or unique activity of the farmer, many scattered areas also grow field crops during the dry season, in rotation with wet season rice. However, it is somewhat difficult to pinpoint these areas because they are not constant over the years and they often correspond to scattered plots, preferentially located along the main waterways : rivers, canals and drains. Decisions concerning the cultivation of vegetables in the dry season is, in such cases, very flexible and depends much on labour availability, access to water and crop price. Main field crops are groundnut, mungbean, sesame (favoured for their short cycle and low water requirement), chilli, asparagus, water melon, soya, taro, etc. but some vegetables can also be found (cucumbers). Crops are grown either with the residual soil moisture, or with some additional irrigation done by lifting water from small ditches dug at regular intervals, or by furrow (taro, corn, chilli, asparagus).

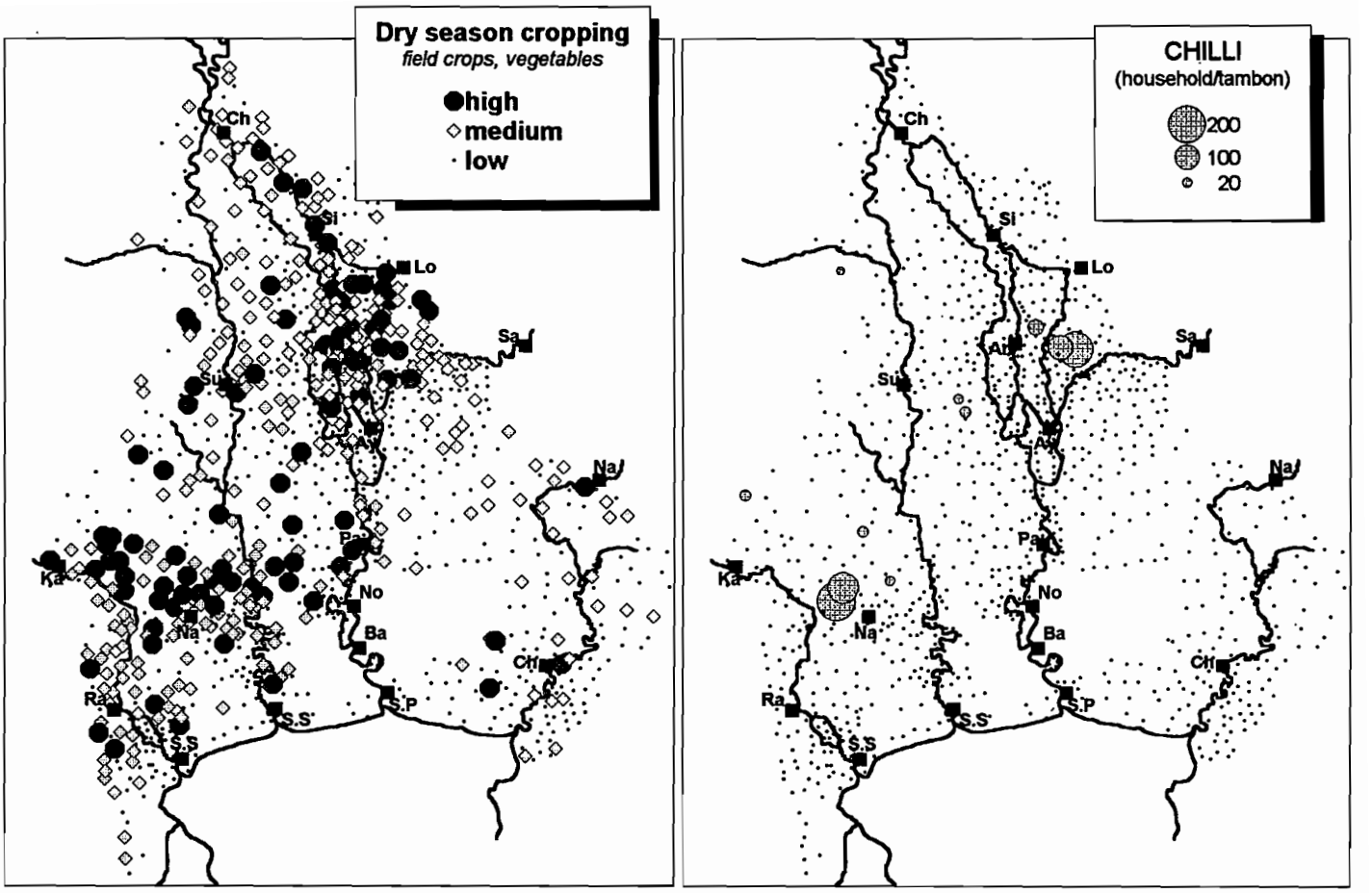
Because of its fluctuating character, this activity does not appear on the main map. In the northern delta for example, which is subject to the year to year rotational system, field crops are often grown alternately with rice. Some areas, nevertheless, can be cited as regular dry season production sites : the north of Pasak Tai Project, Boromathad and the centre of Maharat, where mungbean has been encouraged, the Roeng Rang Project, where taro can be found up to 4000 *rai*, the Song Phi Nong and Kamphaengsaen Project with significant area of water melons, etc.

The set of maps 3.4 gives an idea of the geographical distribution of some of the main field crops cultivated in the dry season (for the year 1994). The first map shows areas with higher rates of field crops and vegetables cultivation in the dry season; the next three maps specify the distribution of chilli, mungbeans and tubers, as given by the NRC2D database (number of households per *tambon* cultivating each crop).

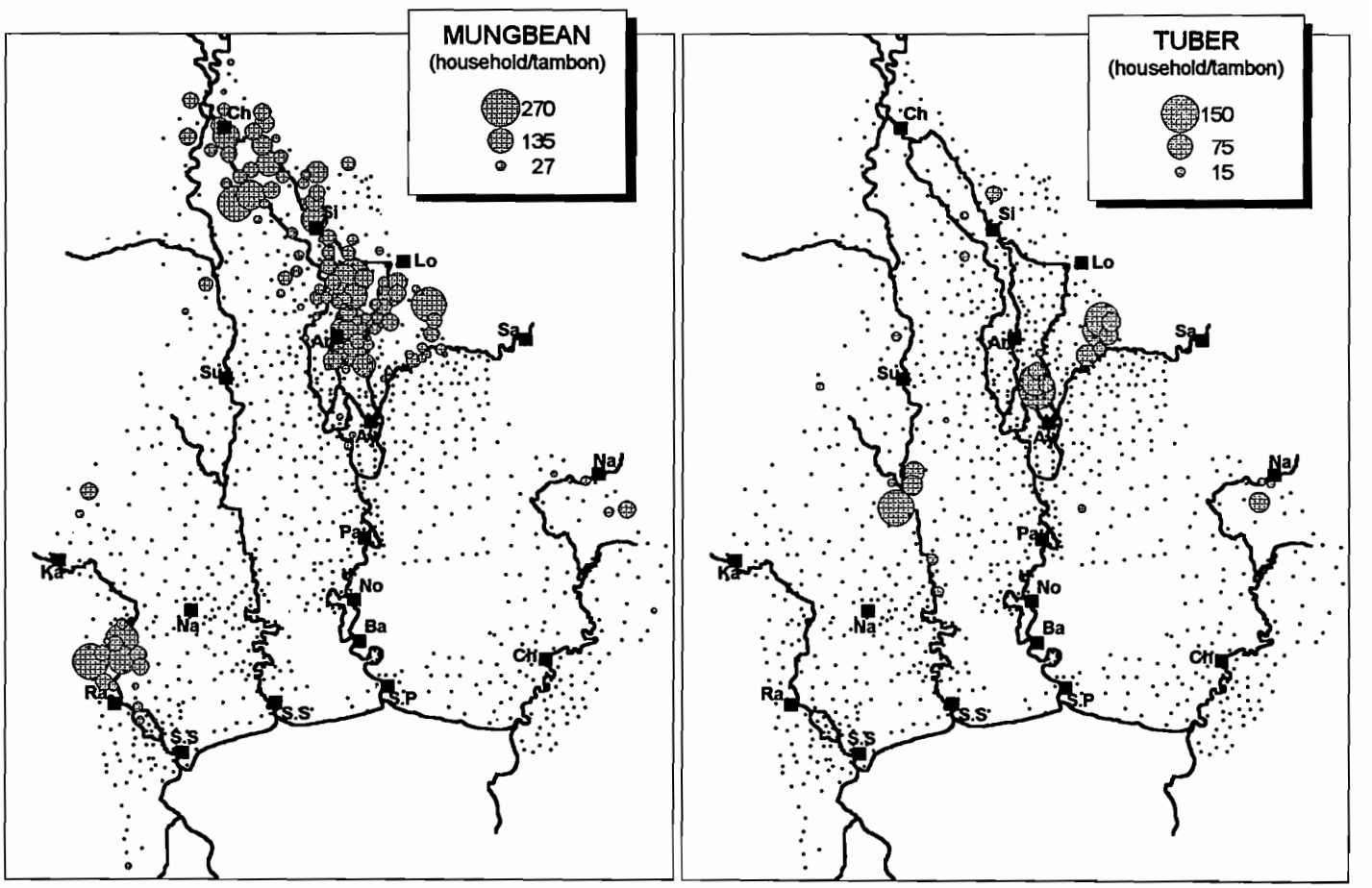
Other diversification activities can also be observed. About one thousand hectares of orchid farms are located in the west of Bangkok (Phasi Charoen). Orchids are grown in suspended coconut husks and watered by sprinkler.

Another example includes mushroom cultivation, traditional in the flood plain.

The green pattern (V2), named horticulture, indicates areas where vegetable cropping is predominant, usually with some secondary tree cultivation and miscellaneous, as indicated.



Set of maps 3.4 : examples of field crop and vegetable production



3.1.5 Mixed cropping patterns

Diversification (towards fruit trees and vegetables) is also partly developing amid cropping systems based on rice and/or sugarcane. In that case, it is difficult to separate their respective cropping areas. Such mixed cropping patterns are to be found mostly in the lower West-Bank and in Nakhon Pathom Province. We distinguished :

- **V3** : Mixed cropping pattern : association of fruit and vegetable cropping, with rice and secondary land use (pasture, sugarcane, idle land, etc. as indicated), predominant in Nakhon Pathom Province and in the lower West Bank.
- **V4** : association of rice fields and fish farms with miscellaneous as indicated, in Khlong Dan and one strip of land south of Nakhon Pathom.
- **Other** associations are indicated with dots bearing the colour of tree (orange), horticulture (bright green), mixed pattern (red), sugarcane (rose) or aquaculture (blue). This indicates that theses activities are significant but correspond to less than one third of the area.

3.1.6 Aquaculture

Aquaculture (W1), mainly freshwater fish and shrimp raising, is also an important activity in the delta, especially in its southern part and scattered in Suphan Buri Province. Main areas are located in the Khlong Dan Project and in the south of the Mae Klong Project. Around 3,000 and 1,500 ha of aquaculture can also be found in the upper West Bank (Chao Chet and Phraya Banlue Projects [1991]). Nevertheless, due to water quality problems, this activity is being abandoned and is moving to the north in search of better water conditions. Bang Len and Phophya Project also present a large increase of this activity. The area lying between Bangkok and Prachin Buri is by far the main area for fresh-water aquaculture.

Aquaculture needs protection from floods, security in water supply and a large amount of water, especially shrimp farms in which water must be flushed with high frequency.

Aquaculture areas are shown in blue (W1), or associated with rice (V4). Along the sea shore, on both sides of the delta (between the last protection dike and the ocean), water is brackish : shrimp farms predominate and are associated with salt production. This association (W3) is sometimes dominated by one of these two activities, which is indicated by superimposed letters : **Sa** (salt) and **Sh** (shrimps).

3.1.7 Urban areas and others

- *Mangroves - Marsh land*

In the eastern side of the delta, near the seashore, some mangroves also alternate with aquaculture or coconut trees. These areas (W4) are decreasing but are still significant in the north of Petchaburi, where palm trees are also present, and in the Phasicharoen and Damnoen Saduak Project.

These mangroves are an association of marshes, grass land and aquatic vegetation such as atap palm trees (*nipa*, used for roofing).

➢ *Urban areas, built-up, industrial parks*

Urban areas (W5) are expanding and - in addition - speculation, is also often responsible for significant idle land (I) in their surroundings, especially along the main roads. Such areas, corresponding to the capitals of *changwat* or industrial parks, are indicated in light grey. Projects close to Bangkok, like Khlong Dan or Phasi Charoen have undergone a drastic decrease of their cropped area : the latter, for example, lost 30 % of its agricultural land between 1986 and 1992.

➢ *Tree plantations (wood)*

Some little areas with plantation of trees such as eucalyptus or casuarina can sometimes be found. According to RID data, 11,500 hectares of such land use exist in the Central Plain with 57 % of this area for the sole Project of Ratchaburi Left Bank. Such plantations are cut every 7 to 10 years and the wood sold for posts or to paper mills.

➢ *Other*

Other activities are also responsible for significant encroachment on agricultural land. These include in particular the development of golf courses, real estate large scale projects and sand pit excavation (e.g Kamphaengsaen, Yangmanee and Bangbal Projects, east of Bangkok). Golf courses are indicated in the main map (green squares) and are naturally scattered around and near the capital.

Other specific large areas are also indicated : Kasetsart University (Kamphaengsaen campus : **K.U**), the aeronautic training camp (**Aero**), Puthamonton Park (**P.M**), the future Bangkok airport (Bang Phli) : **F.A**.

➢ *Specific spot activities*

In order to specify some particularities observed in the land use patterns, the map also bears some scattered letters to indicate occurrences of spot activities. The following conventions are used :

- **v** : vegetables, **bc** : baby corn, **as** : asparagus, **or** : orchids farms
- **t** : trees (orchards), **Co** : coconut trees, **ci** : citrus
- **h** : horticulture (vegetable + orchard + secondary rice)
- **f** : fresh water aquaculture
- **p** : pasture land (cattle breeding)
- **w** : tree plantations (for wood)
- **sh** : brackish water aquaculture (shrimps)
- **s** : salt pans
- **u** : urban areas, built-up; industrial park
- **i** : idle land or fallow
- **tp** : areas with transplanted rice

3.1.8 Animal production

Numerous kinds of animal breeding can be found in the Central Plain. Areas with concentration of such activities are not indicated in the main map but, for reasons of clarity, are displayed in secondary maps (set of maps 3.5).

Animal production is first of all a marked feature of the upper delta and concerns cattle, pigs and poultry. Cattle is also found along the border of the irrigated area and in Nakhon Pathom province where it is often associated with baby-corn cropping. This constitutes one of the few examples of an association between agriculture and breeding : the stems and leaves of the plant are given to the animals and the corns sold to foodstuff companies. In these areas significant agricultural land is kept as pasture.

Small scale pig production units are famous in Nakhon Pathom Province and are also well developed between Ang Thong and Lop Buri and near Chachengsao. They occupy little land but are responsible for water pollution.

Ducks are common in the upper delta and are sometimes raised in the paddy fields, where they take advantage of the rice leftover after the harvest. Impressive flocks gathering more than 10,000 animals are sometimes seen swarming in the fields.

It is worth noting the striking absence of animal production in the young delta, where pasture is scarce due to hydromorphic conditions.

Other more peculiar animal breeding include crocodile breeding (such as inBang Len and Thonburi areas - around 300 crocodile farms can be found in the Central Plain) and exotic fish (for collection). Some buffaloes still remain in the area but few herds are to be seen as they seem to be mostly raised for donation to temples.

3.1.9 Overall schematic vision

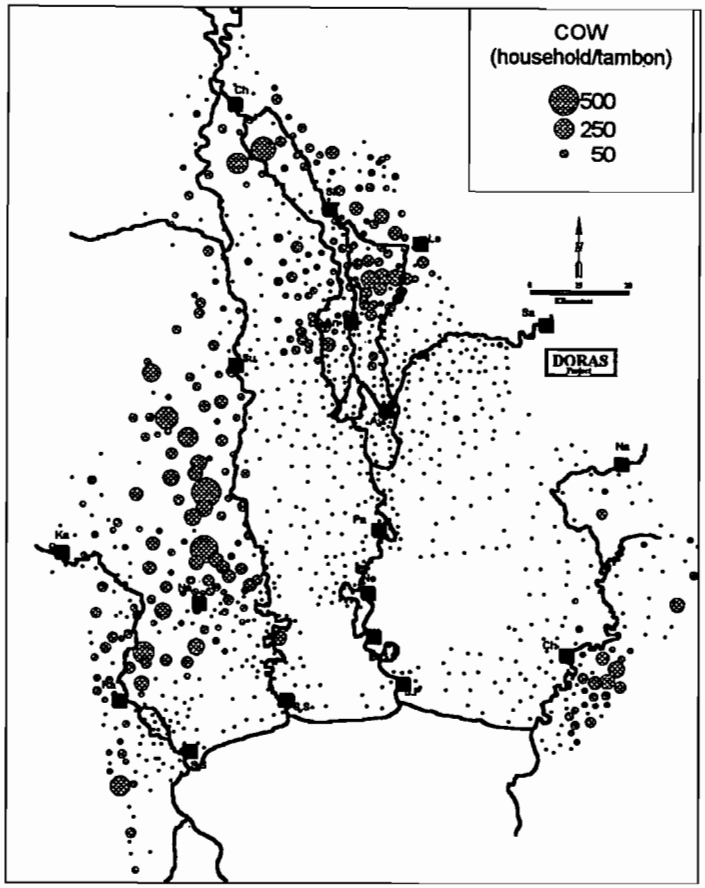
The cropping patterns of our study area, as detailed above, can be briefly summarized by the following charts[5] (fig. 3.2):

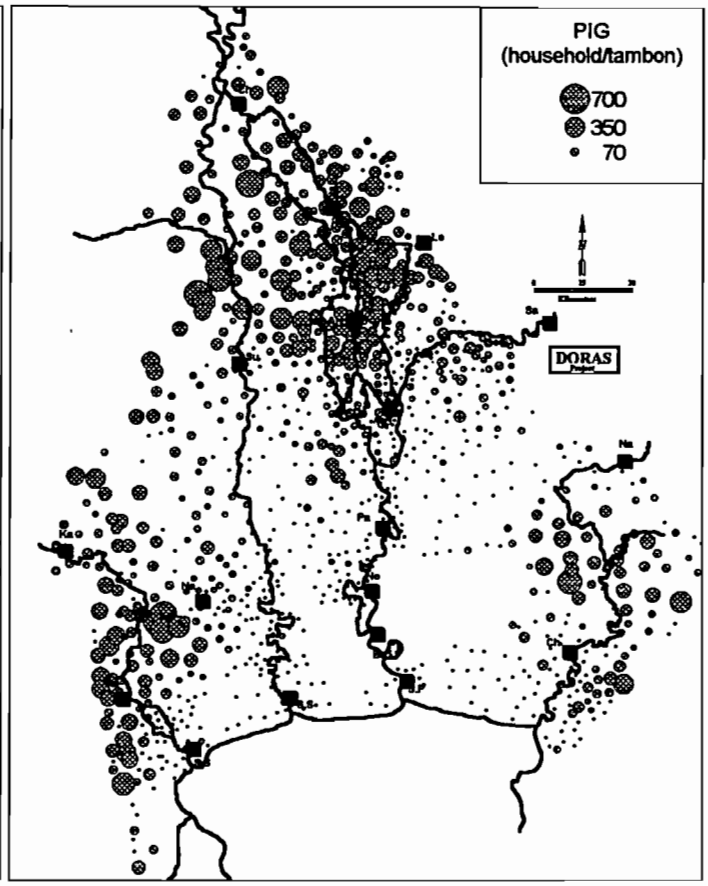
Rice cultivation is overwhelmingly predominant, in terms of cropped area, with about 1.2 million hectares cultivated in the wet season and around 450,000 ha in the dry season. A little more than two thirds of the area is planted with High Yield Varieties (68 %), whereas the remaining area is cropped with Traditional Varieties. Half of the corresponding area is in the northern delta, half in the eastern projects, the Bang Pakong area and the lower Mae Klong.

Sugarcane covers an area of approximately 120,000 ha, the bulk of which belongs to the Mae Klong area (73 %). Fruit cultivation can be estimated at around 140,000 ha, considering plantations on raised beds (concentrated in the Damnoen Saduak and North Rangsit areas) and traditional orchards on the levees along the rivers.

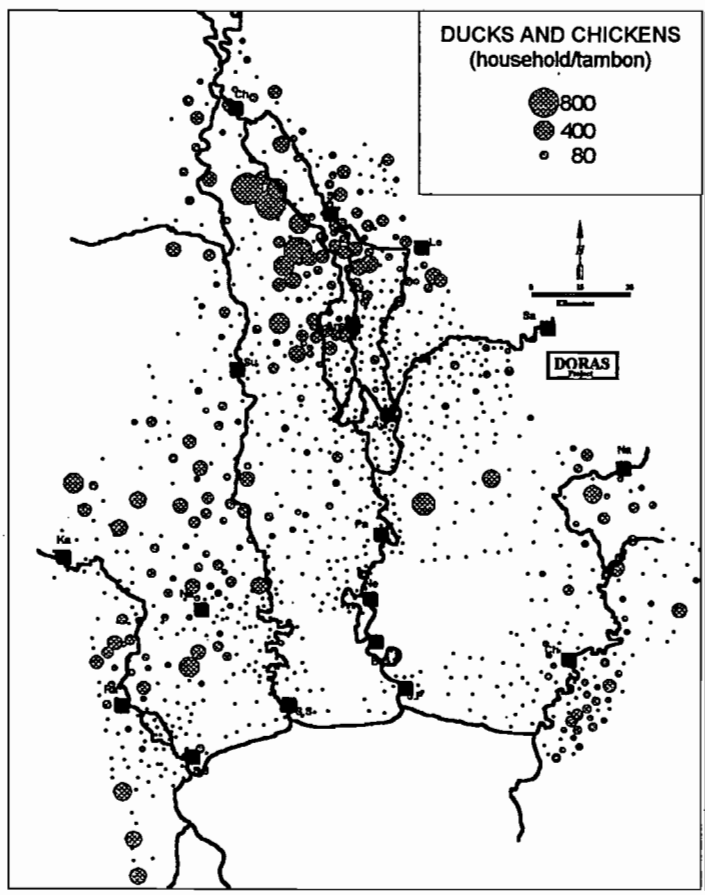
Fresh water aquaculture represents a growing area of about 30,000 ha.

[5] The given values are rough and approximate ones given for the sake of schematization. They are estimated based on the rice acreage given by RID and on the mapped area reduced by a factor 0.68, found to be the ratio between gross and net rice cropping areas.





Map set 3.5 Animal production



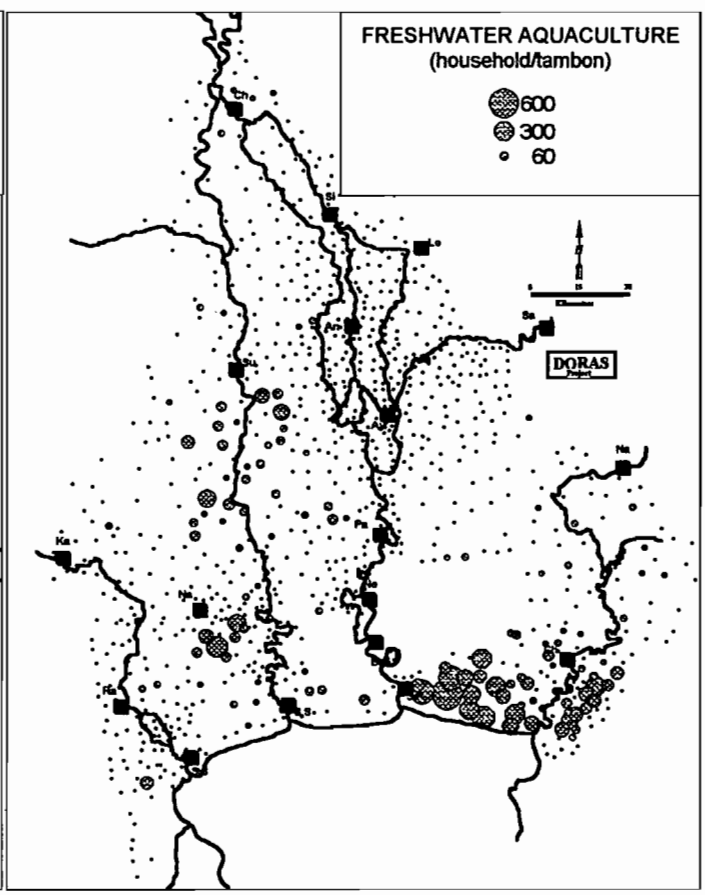
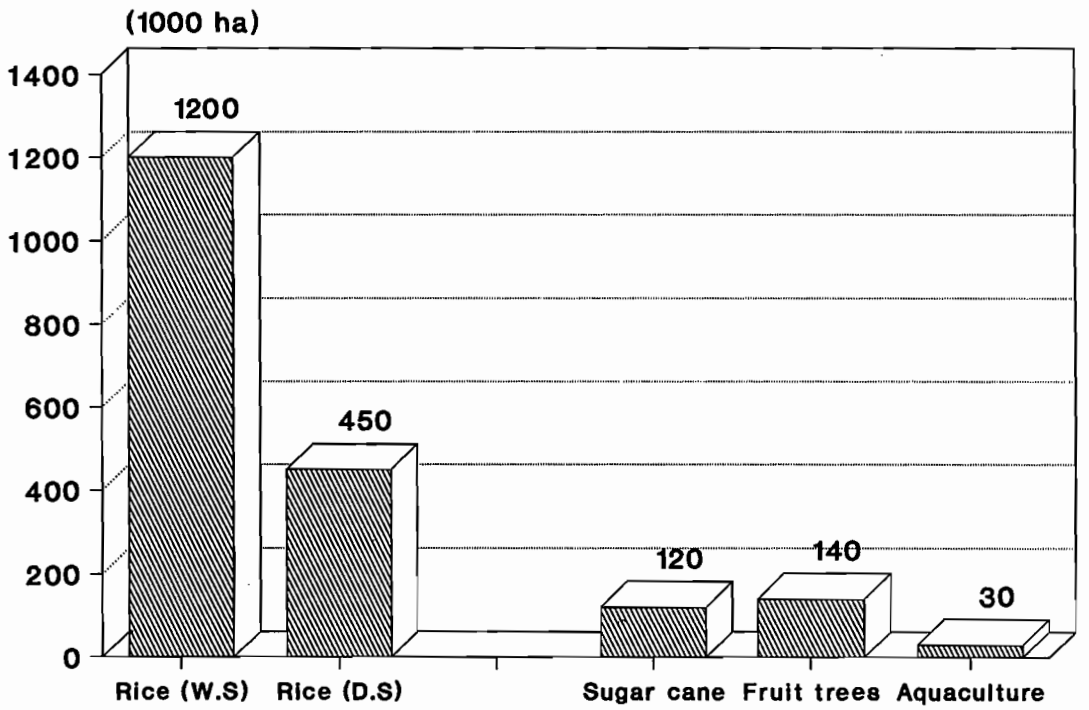


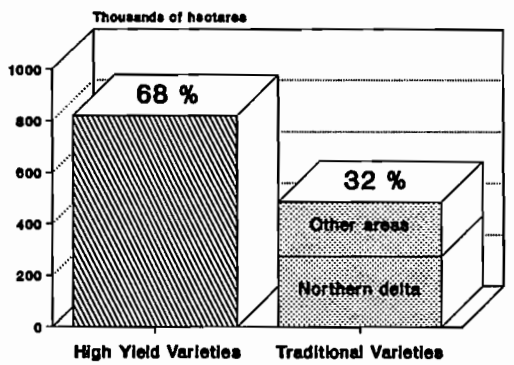
Figure 3.2

Schematic vision of the land use in The Central Plain

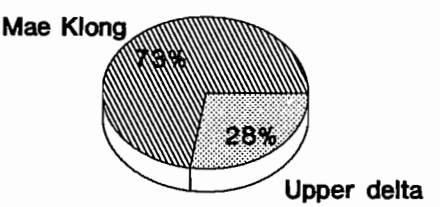
Overall land use distribution
(approximate values)



Rice types



Sugar cane areas
Total of 120.000 ha



3.2 Features of rice cultivation and recent change

3.2.1 Average yields

Rice yield in the delta varies widely and mirrors the also varying degree of intensification. The lower yields, of course, are to be found in areas planted with deep water and floating rice. Most of the time - but not always -, there is no use of fertilizer and pesticides. In addition, some of these areas also have acid sulphate soils which demand the use of lime (Ayutthaya region, where the lowest yields occur). Common average yields range from 20 to 30 thang/rai but for some traditional varieties - with partial water control - it may increase up to between 30 and 50 thang /rai.

High Yield Varieties generally go together with a quite uniform pattern of fertilization (typically one bag [50 kg] per rai, with two applications of mixed urea (46-0-0) and 16-20-0). Whereas herbicides are generally used after sowing (sometimes just before), the number of pesticide applications depends mostly on pest pressure (between zero to four or five). Common average yield is 75 thang/rai but varies between 60 and 100 thang/rai.

Under similar pest pressure, yields in the dry season are higher than during the rainy season, due to significant increase in light intensity and photosynthesis activity.

Map 3.6 shows the distribution of average rice yields, according to NRC2D database (*tambon* level). The points corresponding to lower values (blue) obviously overlay the **R1** rice area. On the other hand the highest yields are observed in the old delta (consolidated areas) and in the poldered plots of the lower delta (West Bank and Rangsit). Phophya Project also stands out as a productive area.

Medium yields are obtained in the gravity irrigated areas along the Chai Nat-Pasak canal and along the main western canal of the lower Mae Klong Project. Although this may be partially due to the encroachment of some *tambons* in the rainfed areas, it may also point out some difficulties of regulation in these very long trunk-canals.

Other data relative to 1993 yields has been issued at *amphoe* level by the Office for Agricultural Economics of the Ministry of Agriculture. This data evaluates yields by a sampling at farm level but, giving an average for the *amphoe,* it therefore often covers different kinds of rice cropping. This data, given in annexe, allows one to calculate a weighed average yield for our study area of 3.05 t/ha and 4.27 t/ha (488 and 684 kg/rai) for main and second rice, with corresponding cropped areas of 1.04 and 0.33 million hectares (6.5 and 2.5 million of *rai*).

Average yields over 4 t/ha (64 thang/rai) in the rainy season are few and are encountered in the Pathum Thani area, in *amphoe* Bang Buathong,Bang Len, Nakhon Chaisi and in the Sing Buri Province. Around Ayutthaya and Ang Tong, average yields can be lower than 2 t/ha (32 thang/rai), such as in *amphoe* Bang Pahan and Pa Mok.

Data from the Royal Irrigation Department must be handled carefully because it has been calculated at the Project level, that is to say considering units larger than

amphoes. It is little demonstrative of differences, given that most values range between 2.8 t/ha and 3.8 t/ha. An estimation with average yields for the 1985-93 period weighed by corresponding Project areas gives an overall productivity - for main rice cropping - of 3.3 t/ha (528 kg/rai). Projects with higher yields are Thabote (4.3 t/ha) and Samchuk (4 t/ha), whereas at the bottom end we can find Phak Hai (2.4 t/ha) and Nakhon Luang (2.7 t/ha), both having bad soils and largely predominant deep water/floating rice.

3.2.2 Multiple cropping and land use intensity

Due to dam regulation in the upper basin, double rice cropping has developed since the early seventies. However, insufficient and fluctuating stored water resources together with insufficient canal flow capacity have not allowed double cropping to stabilize. These aspects are commented in the next chapter.

Double rice-cropping

➲ *The development of dry-season rice cropping*

In 1964, the construction of the Bhumiphol dam, although principally designed for power generation, was also expected to allow some development of dry season rice cropping. In 1967, however, the rice acreage for the dry season was only 3.7 % of the irrigable area in the Greater Chao Phraya Project, reaching 27 % in the West Bank[6] but only 1.7 % in the south-Rangsit Project (FAO/UNDP, 1968).

In 1972, a second storage dam, the Sirikit dam, was constructed on the Nan river, in the upper part of the water basin of the Chao Phraya (see map 2.6). It allowed a quick development of dry season rice cropping. From almost no area in 1970, the dry season cropping totaled 190,000 ha in 1974, leveled off to 500,000 ha during the beginning of the eighties, before collapsing in the 1990-1993 period. Last year (1994) data showed that "normalization" (370,000 ha) was on the way, while the 1995 acreage is expected to reflect another sharp progression (see map 3.7). Figures 3.3 and 3.4 show the rice acreage in the Chao Phraya Project (upper and lower) in the last twenty years, for both major and second rice.

While dry-season acreage may show irregularities (gaps in 1980 and 1991, decrease in the last ten years), major rice acreage is regular and only decreased by 10 % over the last twenty years, mostly because of diversification and urbanization.

In the Mae Klong area, much better water storage and regulation capacities have maintained dry season cropping close to its potential of 150,000 ha[7], with the exception of 1994, when restrictions have also had a negative impact (Table 3.1).

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[6] this higher value was due to the choice of premonsoon cropping imposed by flooded conditions in the rainy season

[7] considering an estimated area for the Bang Len Project

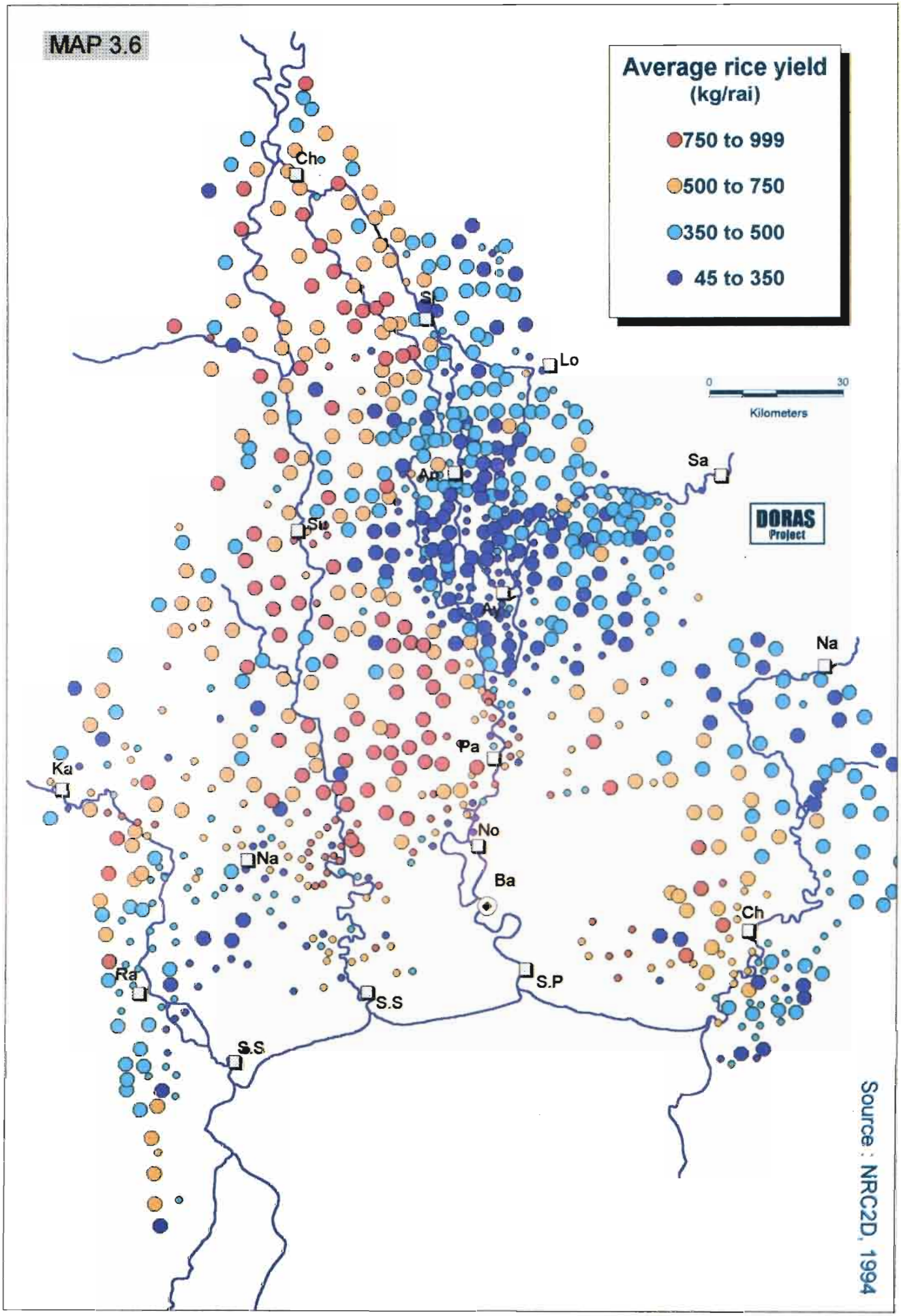
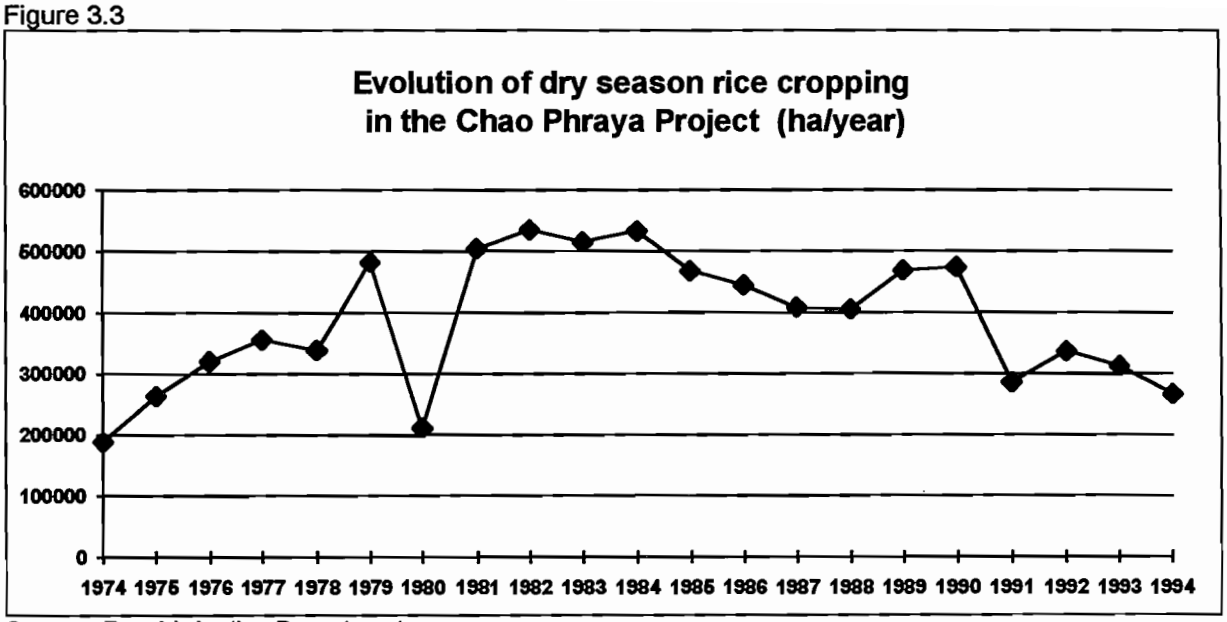
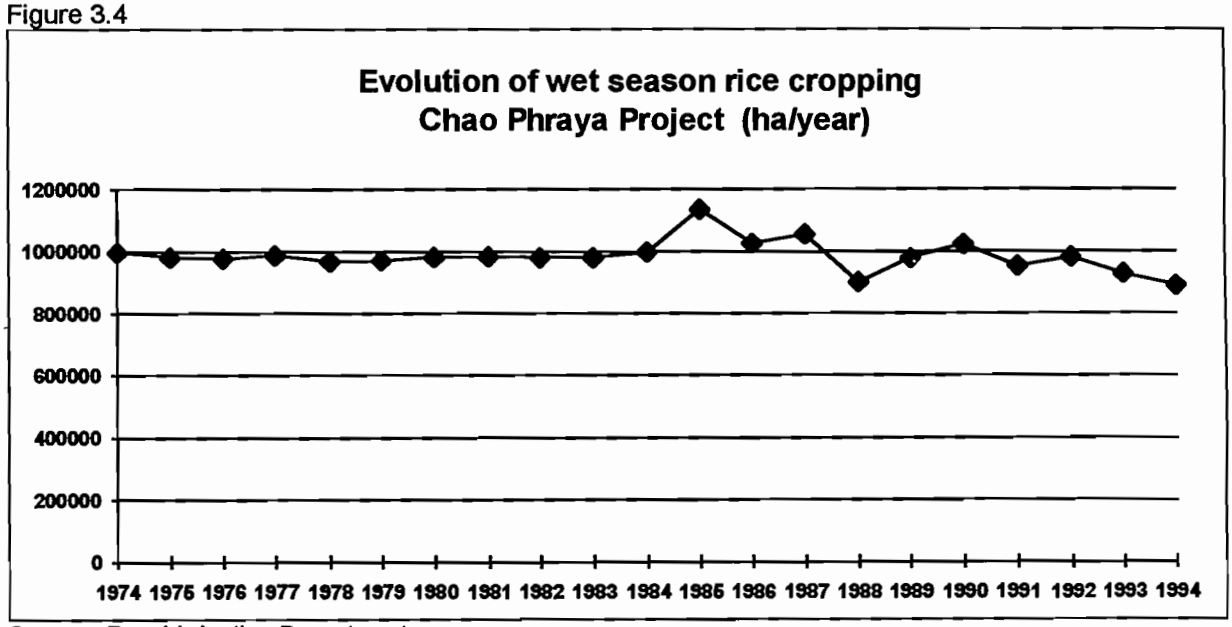

MAP 3.6
Average rice yield
(kg/rai)
750 to 999
500 to 750
350 to 500
45 to 350
0
30
Kilometers
DORAS
Project
Cho
Lo
Sa
Su
Na
Pa
Ka
No
Na
Ba
Ch
Ra
S.P
S.S
S.S
Source : NRC2D, 1994

Figure 3.3



Source : Royal Irrigation Department

Figure 3.4



Source : Royal Irrigation Department

Table 3.1 : Dry season rice cropping in the Mae Klong Project (ha/year); (source RID)

DS88	DS89	DS90	DS91	DS92	DS93	DS94	DS(average)
107338	148386	160118	134731	156355	141615	96607	124586

➲ *Example of the 1994/1995 dry-season*

The 1994/1995 dry season can be considered as a good year regarding dry season rice cropping. It follows four years where water shortages have drastically reduced the cropping area during the dry season.

Map 3.7 shows a rough distribution of the area under rice cultivation during the first half of 1995[8]. The eastern and western parts of the upper delta, not considering the flood plains where traditional varieties are grown, stand in sheer contrast, with the overwhelming prevalence of the western side.

Several reasons can be raised to explain such a contrast : the western part benefits from better water conditions, especially with the Tha Chin river in its middle where a significant flow is maintained in order to satisfy downstream requirements (West Bank, navigation, combating salt intrusion), thus allowing water diversion. In the eastern part, water can only be diverted from the secondary canals on which RID has full control. In addition, the water level in the Chai Nat-Pasak canal is often insufficient in some of its reaches (Roen Rang, Chong Kae) because discharge falls under 110 m^3/s, minimum value to ensure proper regulation. The control of water allocation is also stricter than in the west because downstream areas mainly rely on its supply, whereas the West Bank can count on deliveries coming from the Mae Klong system.

The western side is also a traditional region of rice cropping where agricultural strongly prevails. The east, on the other hand, can be said to be influenced by the situation prevailing in the neighbouring areas of extensive traditional rice : there, worker migration is prevalent - both for long periods and seasonally - because the single rice crop demands only a short labour period. Pluriactivity is the rule and opportunities for work are much more numerous, including the urban areas of Lop Buri, Sing Buri, Saraburi and Ayutthaya (see § 3.3.4). This difference can be noted as well in the land tenure patterns, the western region showing a high rate of full owner farmers in contrast with the east where tenancy is predominant (see map 5.2). The demand for a dry season water supply is therefore less strong in the eastern side than in the western one, where it may also get political backing.

The case of triple rice-cropping

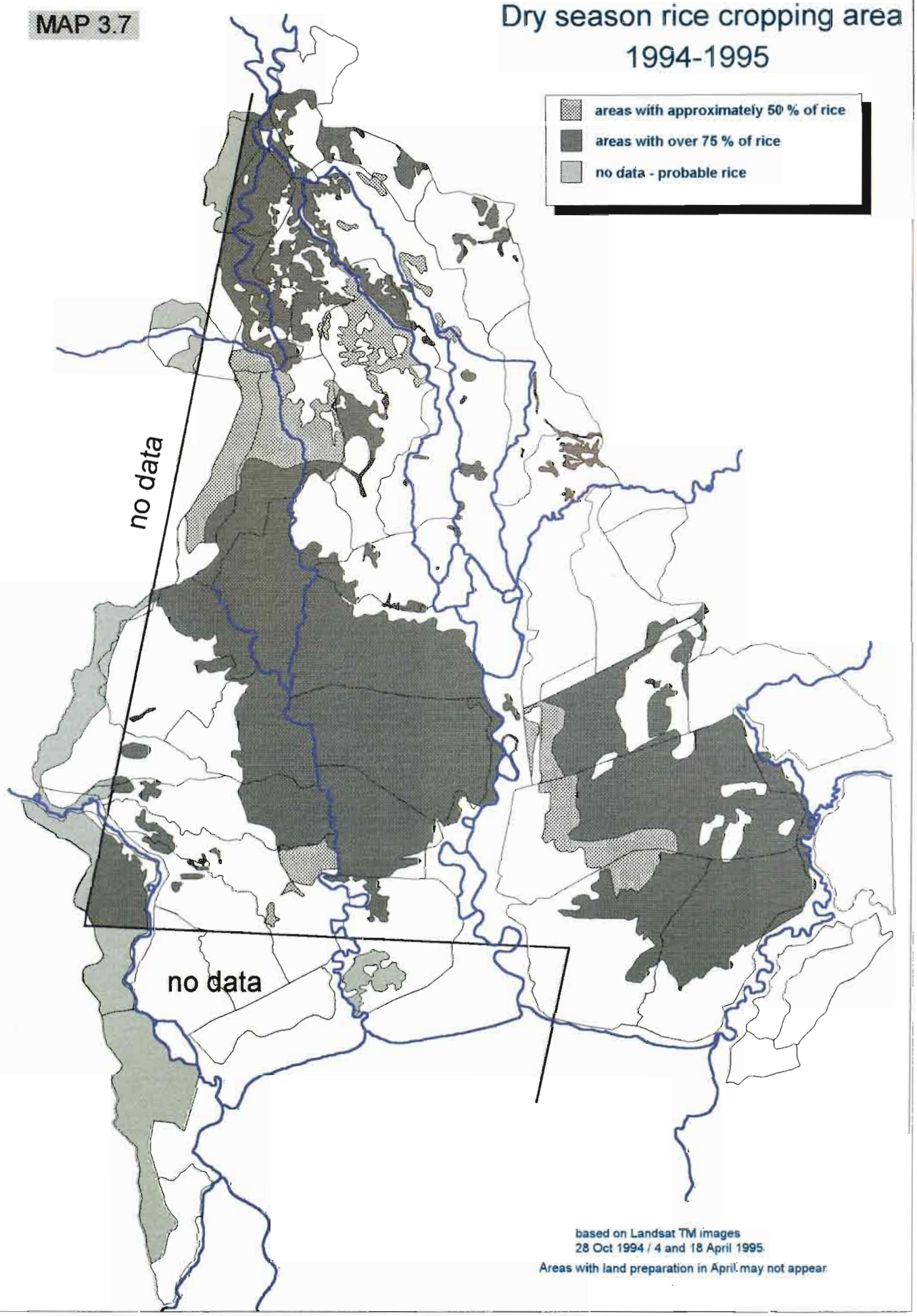
Triple cropping of rice is also not rare in the delta. Map 3.8 shows some of the areas where three crops of rice per year can be observed in some plots, namely parts of the conservation area (Rangsit Tai, West Bank, eastern tip of Kamphaengsaen Project, etc) and spots of the gravity area (Samchuk land consolidated area, Phophya Project,...).

In most cases however, there are no fixed or compact areas growing three crops a year and they seldom exceed 10 or 20 % of the double cropping areas in which they are located. The farms where this practice exists all have permanent access to water, even if some secondary source may be used during short specific periods of the dry season.

[8] areas with land preparation in April may not have been considered.

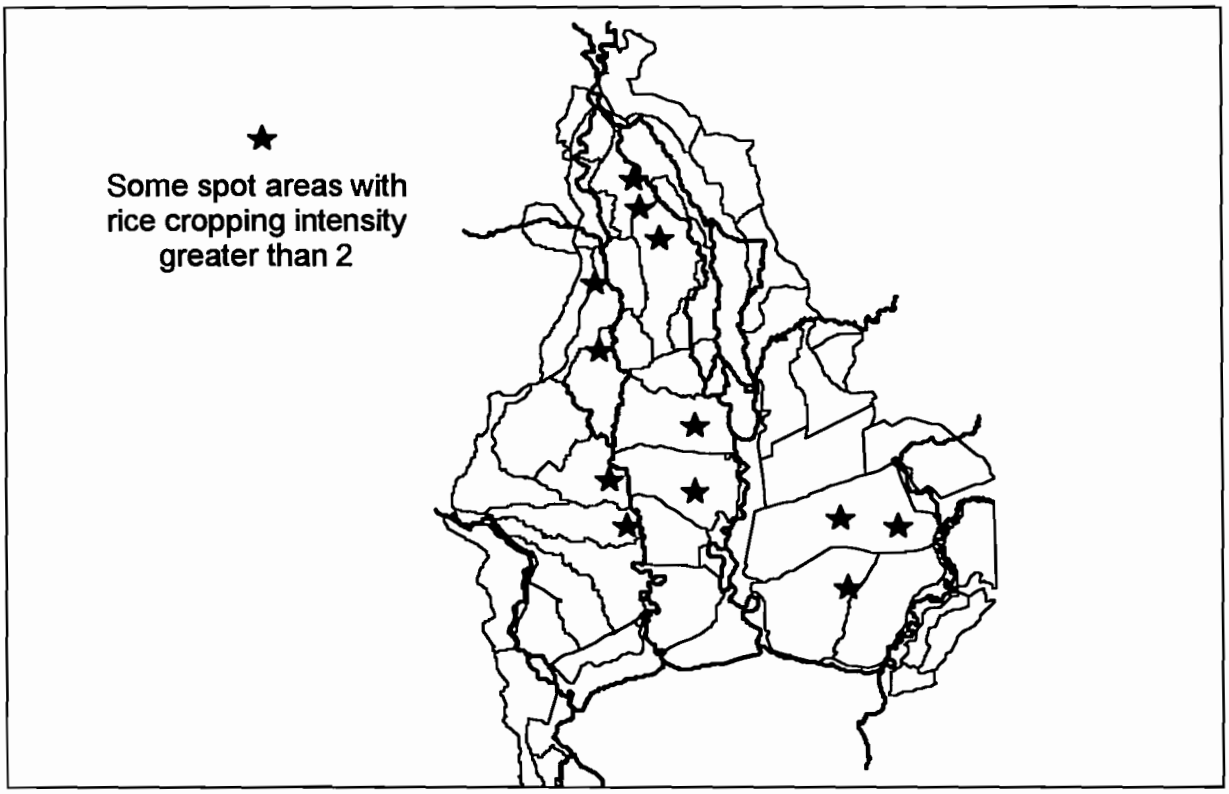
MAP 3.7

Dry season rice cropping area 1994-1995



Areas with cropping intensity greater than two are often referred to as having in "two years, five crops". It is worth noting, however, that this common expression may cause some confusion : it can suggest that there is a calendar problem, which may occur, for example, in the case of labour constraints : agronomically, however, three cycles can be performed in one year (considering land preparation and harvest time requirements), given that farmers will also partly resort to some very short cycle varieties (90 days). It can also suggest that there is a water constraint (saline water, flooding period,... see below § 4) which imposes to avoid a period of a few weeks. In that case, nevertheless, it is logically impossible to perform 5 crops in 2 years.

Map 3.8 : Some areas with cropping intensity greater than 2



This expression most probably also mirrors the fact that this cropping pattern is not necessarily permanent. Many farmers are encouraged to plant three crops when the price of rice is high and give up when it turns low. In many cases, the farmers engaged in triple cropping are farmers owning or cultivating small farms, both because they need to increase their income and because they can more easily overcome the labour shortage constraint. Most of the double-cropping farmers, when asked why they did not choose to switch to three crops, would state that "the soil, and man also, must rest"...

3.2.3 Intensification and change in cropping techniques

Traditionally known as an extensive rice area, the Chao Phraya delta has nevertheless undergone some rapid and significant change in the last 40 years. This progressive intensification of rice cropping has been driven by three main factors.

- ***Water control*** : In the last three decades, water control (flood protection, drainage, regulation) has been continuously improved by the Royal Irrigation Department, allowing an increase in the area cropped with HYV (see § 2.5 and Chapter 4).

- ***Varieties and use of inputs*** : the introduction of HYV had, like in all other Asian countries, a significant role in raising yields. Their introduction also meant a shift towards higher input utilization (pesticide, chemical fertilizers) and increased labour requirements. Their rate of adoption has been quite progressive, yet sometimes slow, in part because of inadequate water conditions.

  In fact HYV are only one category of rice varieties which have been improved by research stations. Improved deep water and floating rice varieties are also used, in as much as 74 % of the farms which grow a single crop of rice, according to NRC2D database. Map 3.9 shows the distribution of farms using improved varieties, with no apparent specific sub-regions within the single rice cultivation area.

  The use of fertilizers and pesticide, although only a rough indicator of productivity, is also an aspect of intensification. Fertilization practices, as shown in map 3.10, show little differences in the double-cropping area but three peculiar sub-areas can be distinguished in the *Rice1* area:

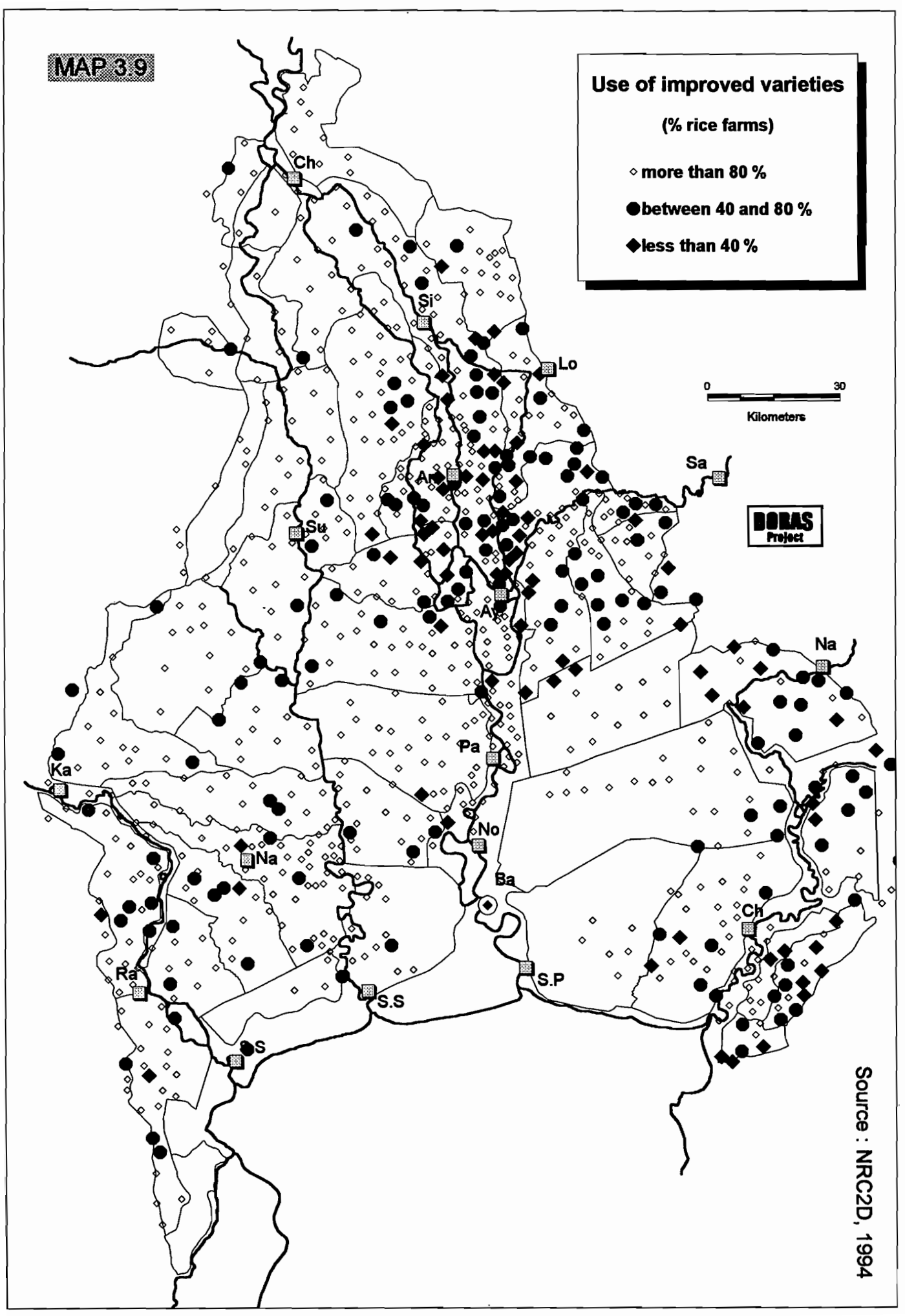
  - no fertilization, between Ayutthaya and AngThong
  - moderate fertilization (between Ang Thong and Lop Buri (in part because of the presence of some HYV in this area)
  - average fertilization south of Ayutthaya (Bangbal Project) and near the Pasak river (south of Roeng Rang Project)

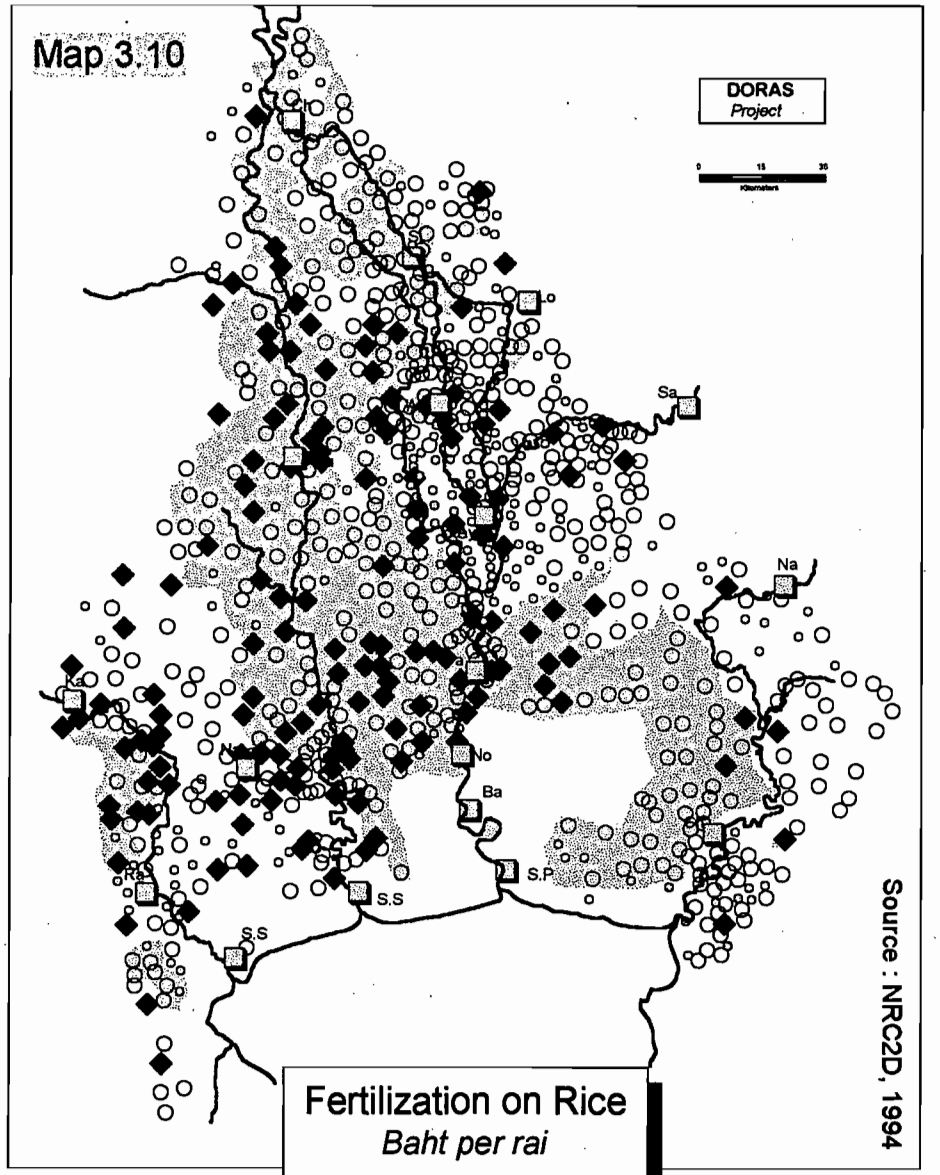
  Fertilization is not common in extensive rice with prevailing flooded conditions, partly because of uncontrolled water washing away nutrients. Manure is also used in rice cultivation, especially between Ang Thong and Ayutthaya (map 3.11) and in Nakhom Pathom Province (where animal production is common).

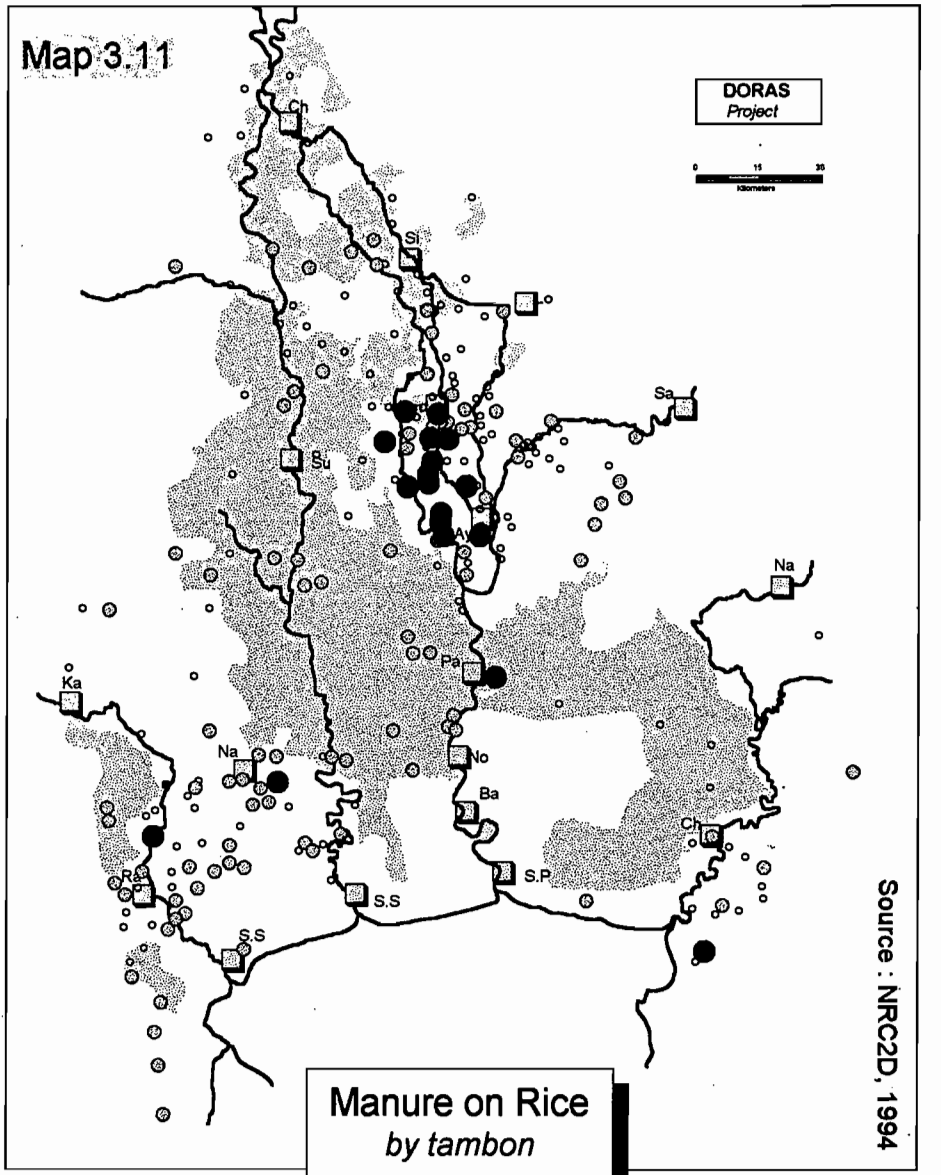
  Pesticide is also widespread in the delta but its use varies a lot from one season to another. In areas cropped with HYV, farmers spray their field from 0 up to four times. In this area, the use of herbicide is general at sowing time or just after. A second spray can occur if required but this is not widespread.

- ***Labour shortage and mechanization*** : the third factor is the constraint on labour, which has turned out to be of paramount importance. Lack of rural labour has been experienced as a result of migration to urban centres and of industrialisation which offered new job opportunities, and has doubtlessly been the main driving force of mechanization (see § 2.4). Pluriactivity also accounts for labour scarcity (see chapter 5).

In the late sixties and seventies, animal traction was replaced by two and four wheel tractors (see map 5.13). Two wheel tractors are used for land preparation, but also for transport and power sources for pumping. Apart from the factor of labour availability, mechanization has also been fuelled by the lower cost of machines, compared with the cost of cattle maintenance (Bot, 1983).


MAP 3.9
Use of improved varieties
(% rice farms)
more than 80 %
between 40 and 80 %
less than 40 %
0
30
Kilometers
BORAS Project
Ch
Si
Lo
Sa
Ar
Su
Ar
Na
Pa
Ka
No
Na
Ba
Ch
Ra
S.P
S.S
S
Source : NRC2D, 1994


Map 3.10
DORAS
Project
Sa
Na
No
Ba
S.P
S.S
S.S
Source : NRC2D, 1994
Fertilization on Rice
Baht per rai
0 to 200
200 to 400
400 to 1000


Map 3.11
DORAS
Project
Sa
Su
Na
Ka
Na
No
Ba
S.P
S.S
S.S
Source : NRC2D, 1994
Manure on Rice
by tambon
Few farms using manure
Mixed
Many farms using manure

In the eighties rice transplanting, which demanded a huge quantity of labour[9], swiftly vanished to the benefit of wet broadcasting (*nam tom*). This change represented a shift in the factors of production, labour being substituted by an increased use of herbicide required for weed control.

In the nineties, at last, harvesting turned out to be the major bottleneck of rice production and mechanized harvesters have spread throughout the delta (see map 5.16 and commentaries). Nowadays, a majority of farmers use such machines[10], but hand harvesting is still necessary for long straw varieties. A similar trend can be observed for sugarcane, where harvesting is also increasingly mechanized.

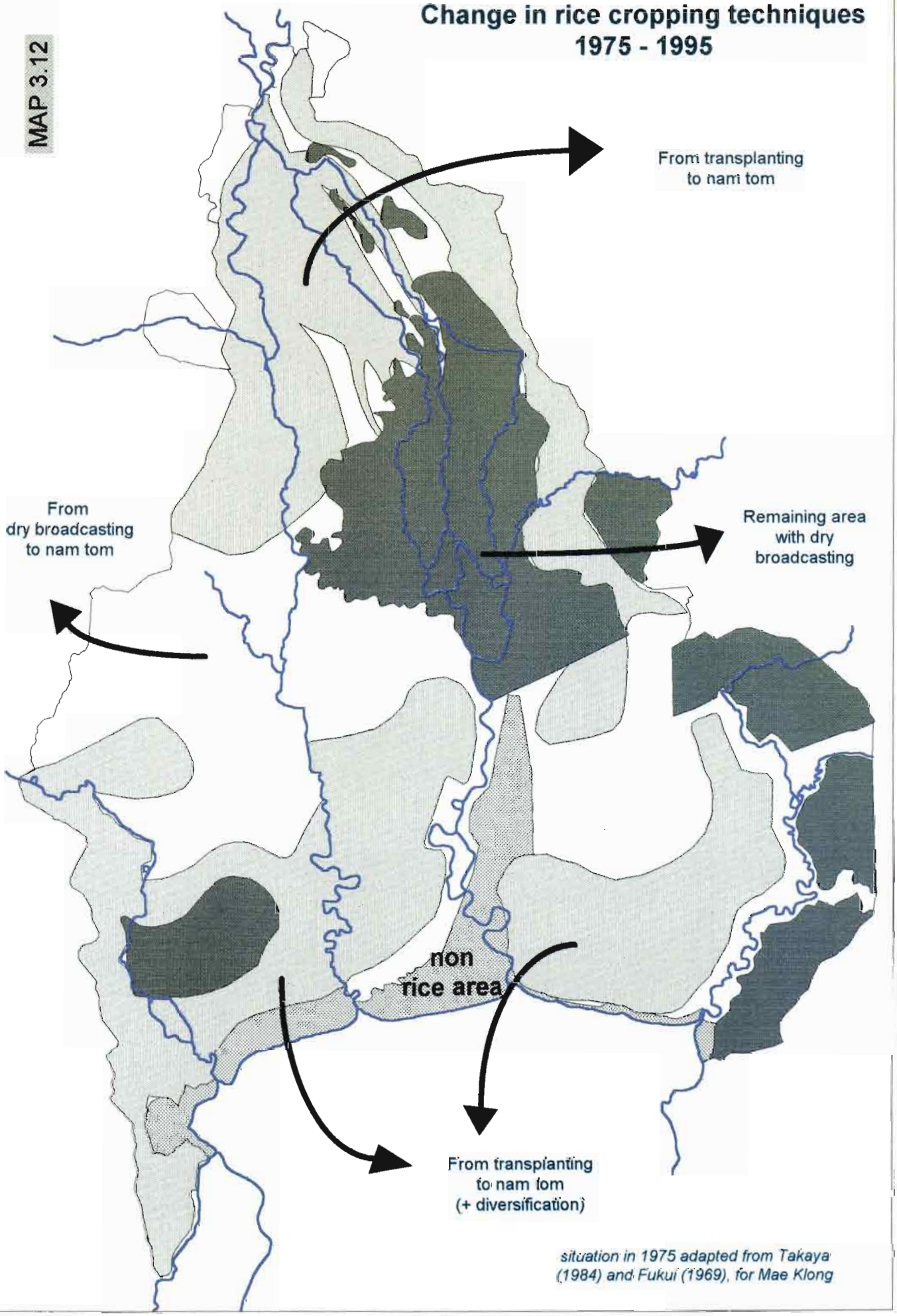
Most of the areas now relying on wet broadcasting were, before its adoption, either areas where transplanting was dominant, or areas using dry broadcasting techniques (which benefited from improvements in water control). This can be observed in map 3.12, which shows the approximate division between transplanting and dry broadcasting techniques 25 years ago (after Takaya, 1979), together with the actual extension of the flooded area. The shrinking of the latter is markedly apparent, together with the substitution of transplanting by wet broadcasting. In rough terms, dry broadcasting dwindled down from 55 % to 20 % of the area (the Mae Klong Project is not considered), while transplanting (from 45 %) almost disappeared, to the benefit of wet broadcasting, which now corresponds to 80 % of the area.

In the Mae Klong Project, the evolution has been similar but took place in accordance with the progressive establishment of the irrigation and drainage system (from 1970 to the present time). For this area, map 3.12 has been completed with data from the agricultural census of 1963 (Fukui and Takahashi, 1968), which is therefore older than the situation displayed for the Chao Phraya. Nevertheless, the bias can be considered limited because no land development took place in the Mae Klong area prior to the 70's. At that time, rice cultivation was also performed with dry broadcasting (deep water and floating rice in almost half of the area), together with transplanting. With the improvement of the water control, transplanting increased and was soon substituted by *nam tom* technique.

[9] one rai needs two persons during one day for transplanting.
[10] harvesters are generally rented for an average price of 320 bahts/rai.

MAP 3.12

Change in rice cropping techniques 1975 - 1995



situation in 1975 adapted from Takaya (1984) and Fukui (1969), for Mae Klong

3.3 The Diversification Process

Agricultural diversification is a recent trend which refers to production diversity in a *'traditional'* rice-based production system. The Central Plain of Thailand is often cited as an exemplary case of agricultural diversity in this region. Diversification appears to be an emerging topic of the current decades, when in fact historical accounts reveal that crop diversity existed in the Central Plain long before rice monoculture became well established in the area. Takaya, in his analysis of past agricultural development in the Central Plain (1987) noted that today's *'well-round'* agriculture can be regarded as a return to the diversified land use of the 19th century.

Diversification as it is today, however, features different purposes and contexts and appears to be much more complex in all aspects than it was in the earlier days. This section reviews some historical change related to crop diversification and specify recent evolutions.

3.3.1 Evolution of Crop Diversification in the Central Plain

Prior to the mid 19th century, crop culture in the Central Plain was not significant for the government income. Rice and mixed garden crops were grown primarily for local consumption. Land tax from farm use contributed partially to the government revenue. The single source of a substantial amount of revenue in this period was coming from forest products which were transported mainly from the mountains up north (Takaya, 1987). (Table 3.2)

Agriculture gained an important economic role in the period just before the reign of King Rama IV (approaching the mid 19th century). For the purpose of understanding the nature of agricultural diversification as it exists today, three periods of agricultural trends can be distinguished, beginning from the period around 1840. Namely, 1) E*mergence of Plantation-type Agriculture (1840s - 1880s), 2) A Century of Rice Intensification (1880s - 1980s), and 3) Toward Diversification (1980s-)*

1) Emergence of Plantation-type Agriculture (1840s - 1880s)

As an important local crop, sugarcane has a long history in Thai agriculture which could be traced back to the Ayutthaya period when sugar was produced as a home industry. It was not until the 1820s (during the reign of King Rama III) that sugar production shifted from a home industry to small sugar factories, and sugarcane plantations emerged (Jessadachatr, 1977). Beginning initially around the margin of the Chao Phraya Delta (Nakhon Chaisi and Chachengsao) by the overseas Chinese immigrants as early as 1810, sugarcane plantations later expanded with the development of transverse canals and local sugar mills (see § 2.5). Such a change from *home garden cultivation* to *commercial farm production* marked the first turning point of agriculture in the Central Plain (Ishi, 1978).

By the year 1840, garden crops and sugarcane production became the major source of government revenue coming from agriculture land tax and export monopoly. Even

though rice was emerging as an export earning item, the government revenue from garden crops and sugarcane production far exceeded the income obtained from rice (Table 3.3).

A variety of garden crops (vegetables and fruits), sugarcane plantations, and rice farms formed an early picture of *crop diversity* in the Central Plain. Rice was grown mainly in the lowlands of the flood plain, whereas fruits were planted on the natural levees. Mixed vegetables, grown along ditches and on raised beds, were concentrated around the Bangkok area, and later spread to other provincial centres along the lower reach of the main rivers.

Table 3.2 : Government revenue (around 1820)

Source	Baht	%
agricultural land	298,000	13.4
forest products	775,000	34.8
natural products	64,000	2.9
others	1,089,000	48.9
total	2,226,000	100.0

Source: *Adapted from an estimate by Crawfurd, Journal of an Embassy (cited in Takaya, 1987, p. 199)*

Table 3.3 : Government revenue (1840)

Source	Baht	%
Agriculture (total) (land tax & export monopoly)	9,305,000	62.2
rice	2,100,000	
gardens & plantations	6,045,000	
pepper	400,000	
others	760,000	
forest products	800,000	5.3
others	4,859,000	32.5
Total	*14,964,100*	*100.0*

Source: *Adapted from an estimate by Bowring, Kingdom and People of Siam (cited in Takaya,1987)*

2) A century of rice intensification (1880s-1980s)

In section 2.2, we have seen how rice production and exports developed since the middle of last century. Rice became the top ranking export item, totalling up more than two thirds of the export values since 1887 (Table 3.4). The reign of King Rama V was the period of drastic change for rice production, and probably for agricultural evolution in the Central Plain as a whole.

Table 3.4 : Export values from Bangkok (1887)

Items	Value (Pounds)	%
rice	1,918,783	73.8
pepper	95,731	3.7
others	584,387	22.5
Total	2,598,901	100

Source: *Great Britain, Foreign Office, 1887 (cited in Takaya, 1987, p. 204)*

As commented earlier, the rapid expansion of rice cultivation from small-scale subsistence farming to plantation-type and export-oriented monoculture was closely linked to several key determinants : the free trade policy following the Bowring Treaty (1855), the drop in the world price of sugarcane together with a greater demand for rice, the opening up of rice lands especially in the young delta resulting from the King's canal excavation policy, and the emergence of independent farmers following the abolishment of corvée peasants (Ishi, 1978).

From then on, rice became the single most important crop in Thai agriculture. The export of rice boomed after the first World War. During the years 1910-1930, rice lands were greatly expanded, many rice mills developed, and the price of rice increased sharply (Takaya, 1987). The big boom period ceased in 1930 with the world depression. However, after the Second World War, the development of the Greater Chao Phraya Delta Project, the new varieties introduced by the green revolution and the sustained demand of the world market contributed to increase the overwhelming preponderance of the rice production. Little remained for the development of agricultural diversification and, on the contrary, the priority given to rice was demonstrated by the support given to double-cropping.

Production of rice during the age of innovation diffusion in the 1970s was thus boosted towards a more intensive farming. Nevertheless, the fact remained that, up to this point, increased production of rice was mostly the result of extensive farming, that is to say, the expansion of rice land.

Land per agricultural worker was at its peak in the late 1970s, and agricultural exports were booming (Siamwalla, 1992). During the Fourth National Development Plan (1977-1981), rice exports increased at an average rate of 6 % per year. Rice continued to take a leading role as the number one crop with the highest farm value as well as export value throughout the 1980s. The Fifth National Development (1982-1986) focused on 'production efficiency', and the planted area of dry-season rice expanded at an average of 6.56 % per year with a production increase of 11.16 % per year. In 1984, up to 36 % of total rice exports in the world market came from Thailand, the number one exporter (DOAE, 1984). In spite of price fluctuations and several water crisis, rice exports reached their peak in 1989 with a total export value of 45,462 million baht, contributing to about 20 % of the total agricultural exports (Office of Agricultural Economics, 1991). The Central Plain, with its higher productivity per rai, thus significantly contributed to the country's export boom.

3) Toward Diversification (1980s -)

Following the period of the green revolution, the world's demand for cereal crops was well satisfied, and cereal supplies had gradually been saturated. Concern about a growing surplus led to international interest in agricultural diversification. In parallel, the growth of urban markets, notably Bangkok, has generated, like almost everywhere else in the world, a demand for a more diversified agricultural production.

Areas of good potential for diversified crops in Thailand are in the north and in some portions of the Central Plain. Data on farm cash income in the Central Plain from 1980-1991 (Table 3.5) are indicative of the increasing trend toward diversification. Income from rice, with some fluctuations, continued to constitute the largest share of the total farm income. Above all, the figures clearly reveal that fruit, vegetables, and livestock were the three fastest growing subsectors of agricultural production in the later years of the past decade.

Table 3.5 : Average farm cash income in the Central Plain (1980-1991)

	1980/81	**1982/83**	**1986/87**	**1987/88**	**1988/89**	**1991/92**
Total crop income	36479	33722	28640	8939	35537	56318
rice	14904	14076	13134	20338	9790	21862
field crops	14902	11553	8529	13731	9946	19063
vegetables	783	1188	1187	3732	3451	4333
fruits/trees	2757	2657	3073	7366	7630	9295
flowers-	*no data* -		601	704	270	774
Livestock income	3884	4310	5605	4657	7424	11720
Aquaculture	306	234	1472	592	1433	3425

Source: Office of Agricultural Economics, 1992

Data of 1991 on utilization of farm holding land reveals that paddy fields constituted nearly half (43.8%) of the total farm holding land in the Central Plain, followed by field crops (33%) and fruits/trees (15.3%). (OAE, 1994)

On the basis of farm cash income, farms in Thailand have been classified into 4 categories, as follows:

1. single-crop farm
2. diversified farm
   - 2.1 two-crop farm
   - 2.2 three-crop farm
   - 2.3 integrated farm (more than three crops)

Approximately one thirds of the farms (by number of households) in the central region[11] are of the diversified type with three productions. ***Rice-field crops-livestock*** is the most common type of diversified farms in this region. As for single-crop farms, rice farms rank first, followed by field crops, fruit/trees, and livestock

[11] here considered under its administrative definition.

farms. When compared with other regions, the central region ranks second with regard to the proportion of diversified farms (Wiratpong & Poomlek, 1992).

3.3.2 Diversification and the Government Policy

In Thailand, agricultural policies have considered diversification since the implementation of the ***First National Development Plan*** (1961-1966). New crops other than rice were produced and new cross-bred livestock and chicken were promoted. The foundation of the infrastructure in the ***Second Plan*** (1967-1971) set the stage for agricultural development in the following decade. However, it was not until 1972, during the implementation of the ***Third Plan*** (1972-1976), that diversification policy was officially initiated by the government, with emphasis on the promotion of agricultural exports. The expansion of irrigation systems in the Central Plain allowed the introduction of dry-season crops, rice together with other field and vegetable crops, in the irrigated area. In 1972, the Office of Agricultural Economics (OAE) attempted to classify the farm land of the country into 19 agro-economic zones. The purpose was to encourage agricultural diversification to match suitable areas. In this zoning, the Central Plain was labelled as the most appropriate area for *rice, diversified crops in paddy field,* and *sugarcane.*

Crop diversification, as well as production efficiency, was focused on in the ***Fourth Plan*** (1977-1981). Crop diversification, from the six main crops at the time to other promising crops, were targeted according to the suitable geographical locations. Higher land use intensity was expected in the irrigated area of the Central Plain.

Crop distribution - a former name of crop diversification - was further extended in the ***Fifth Plan*** (1982-1986). An area of 16 million rai was irrigated in an attempt to increase production efficiency. Even though this period was considered as the prosperous years of rice production and export, diverse cash crops were also encouraged in order to reduce the risk of price instability, and at the same time to intensify the land use. ***Production efficiency*** was targeted to increase at an overall rate of 4 % per year for 11 economic crops: *rice, rubber, maize, sugarcane, tobacco, mung bean, sorghum, caster bean, soybean, peanut, and cotton.*

At the beginning of the ***Sixth Plan*** (1987-1991), the weakened production structure became an important concern for agricultural development (Thai Military Bank, 1993). The production of agricultural products was not flexible enough to meet the demand for Thai exports. Hence, in the sixth Plan, the ***restructuring*** of the agricultural production system was targeted in order to boost crop diversification. Having reached the limits of cultivation expansion, emphasis was laid on production increase per rai. Expansion of production towards other promising crop productions was emphasized. Lists were prepared for crop distribution planning, using criteria of geographical location and the type of production appropriate to small farmers. In addition, the policy measures targeted for the development of agro-industry in the sixth plan also helped set the stage for the promotion of contract farming systems as an approach to enhance agricultural diversification (Manarungsun, 1991).

The economic structure of Thailand within the past 30 years, from the First Plan (1961-1966) to the end of the Sixth Plan (1987-1991), has gradually shifted from

agriculture dominance to the growing industrial sector. The agricultural sector contributed to 13.2 % of the economic structure after the Sixth Plan (1991), compared to 37.4 % at the beginning of the first Plan (1961)(Thai Military Bank, 1993). The sharp drop of the price of rice in the late 1980s has reduced the marginal return of rice production. Price fluctuations versus higher production costs of rice have adversely affected the farmers, especially those in the Central Plain where production costs of rice are higher.

The focus of the ***Seventh Plan*** (1992-1996) was on income distribution and the environment. For the agricultural sector, a policy was set to reinforce the ***restructuring*** of the agricultural production system in order to maintain the growth of the agricultural sector and to raise farmers' income. The Department of Agricultural Extension (DOAE) stated as its strategy to *"promote farmers to* ***restructure*** *their agricultural production system so that what they produce be in line with the demand of local and foreign markets in terms of type, quantity and quality as well as area potential."* (DOAE, 1993, p. 5). Farm commodities were grouped in 4 categories. Rice, cassava, coffee, and pepper were on the list of crops which production should be decreased. The government provided a budget of 65,874 million baht for the initial 2-year (1994-1995) restructuring project. The budget covered low interest loans for farmers, and production inputs to be supplied by the DOAE.

The objective was to reduce planting areas for rice (dry season and unsuitable area), cassava, coffee, and pepper by initiating more profitable and sustainable production such as fruits, trees, vegetables, flowers, and orchids, integrated crops, and livestock (cattle). It was estimated that this substitution would cover 4.912 million *rai* within the 2 years, and that farm income would increase by 2.8 times. Twenty-two provinces in the Central Region were on the list of the target areas for which dry season rice was to be reduced. The implementation of this strategy may be regarded as the first major attempt of the government to foster agricultural diversification in Thailand. The restructuring project is currently undergoing an evaluation. It will be interesting to observe the extent to which this plan has induced change in the pattern of agriculture in the Central Plain.

The policy to reduce dry-season rice is carried further in the upcoming ***Eighth Plan.*** Emphasis will be placed more on the production of high-quality rice for export and the strengthening of diversified agriculture. In view of the government policies, agricultural diversification will inevitably be the most probable direction for Thai agriculture in the decades to come, and the Central Plain will definitely be a major target for such a change.

3.3.3 Problems and Issues in Promoting Crop Diversification

Efforts by the Thai government in implementing crop diversification in a rice-based production system, especially in irrigated areas, have nevertheless faced several constraints, the major ones are cited below (Ouraikul, Rewtarkulpaiboon, & Somwatanasak, 1993) :

1) Rice farmers usually expanded their cultivated areas during the dry season without due regard to the availability of water, resulting in water shortages and low crop yields.

2) Because of the farmers' lack of collateral (land title) as required by banks, institutional credit is often a problem. This makes it difficult for farmers to buy the inputs needed to increase their yields.

3) There is a high risk involved in investing in crop diversification, as experienced by several agro-businesses during the last decades.

4) Substitute crops to replace rice during the dry season are still not well-known. Farmers often do not trust the market stability of other crops than the ones already known. The price of existing crops still attracts farmers more than other considerations. Skills and experience, as well as additional investment required in other crop productions, are also the major aspects considered by rice farmers to shift from rice cultivation to other crops.

5) Often, there are conflicts among users who grow different crops. Different maturing rice varieties and field crops have different demands for water in terms of quantity and timing.

6) Non-agricultural employment which provides more income than on-farm activities during the dry season causes labour shortages in the rural area. This, in turn, has two effects: a) farmers cannot expand dry-season cultivation, especially for intensive crops such as vegetables, and b) delay in planting and harvesting which affects the quality of some crops.

7) In some irrigated areas, farmers do not plan their irrigation due to the lack of know-how on appropriate watering technique.

3.3.4 Recent trends in crop diversification: illustrative cases

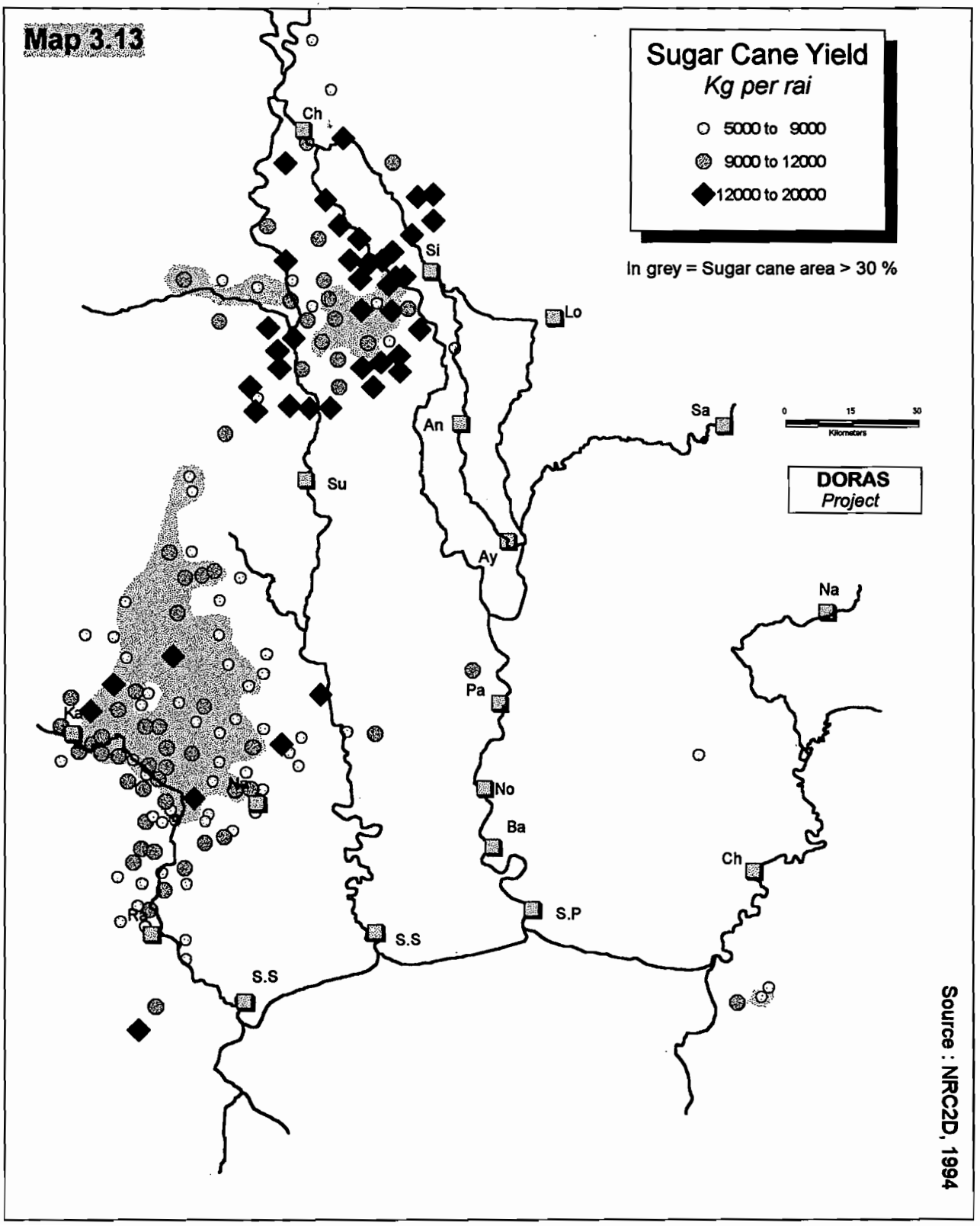
During the past three decades, Thailand has greatly diversified its agriculture from 2 or 3 main crops to several new economic crops. Above all, diversification toward commercialized vegetables, fruit cultivation and aquaculture has constituted the most evident trend in recent years, especially in the Central Plain, as noted earlier.

The following cases with high dynamics in diversification are illustrative of the changes in agriculture which have occurred in the region.

1) Sugarcane : a field crop with development in irrigated areas

Established in the Central Plain near Chachoengsao and Nakhon Chaisi, sugarcane, by the middle of last century, was considered a promising crop and was already being exported. Several negative factors accounted for a sharp decrease of the production in the 70's and 80's, as commented earlier (see details in § 2.2).

A new impulse was given to sugarcane production, with the installation of sugar mills in the 50's and 60's. Opportunity was given to this crop because of the clearing of the residual forests and bamboo groves, both in the upper Mae Klong area and in the old delta. Sugarcane gradually occupied most of these highlands and new sugar mills were opened in the 70's and 80's. In the Mae Klong area, cultivation was first rainfed, with secondary use of tube wells, whereas in the northern delta it could also benefit from some water delivered by the canals constructed in the 50's.

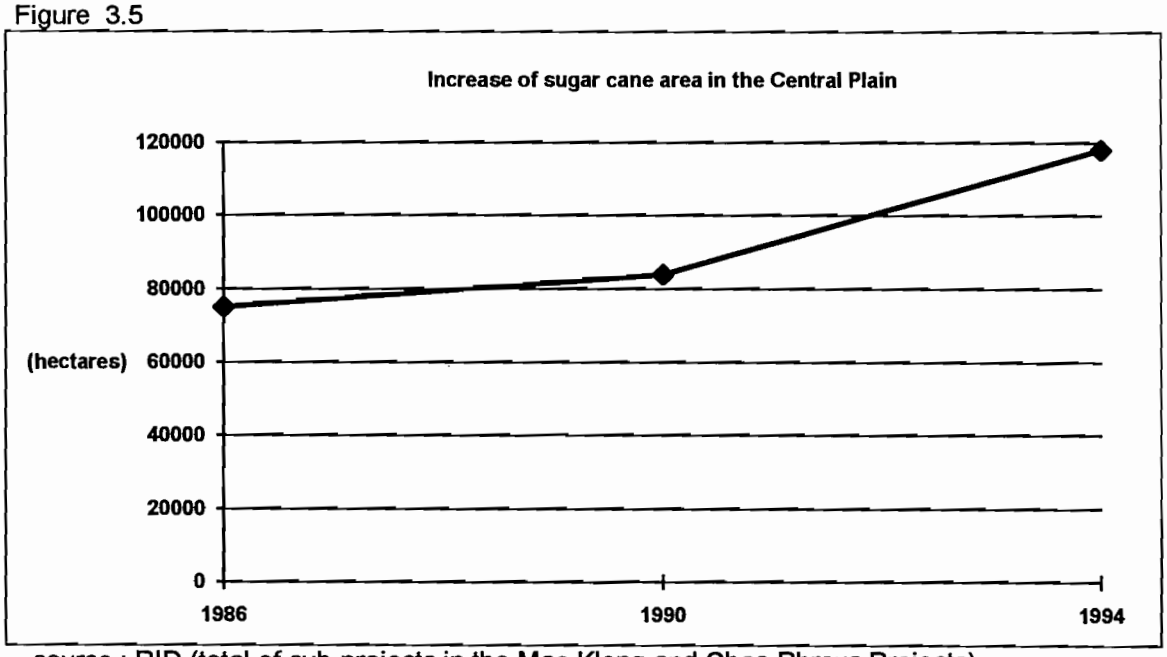

Map 3.13
Sugar Cane Yield
Kg per rai
5000 to 9000
9000 to 12000
12000 to 20000
In grey = Sugar cane area > 30 %
0
15
30
Kilometers
DORAS
Project
Ch
Si
Lo
An
Sa
Su
Ay
Na
Pa
No
Ba
Ch
S.P
S.S
S.S
Source : NRC2D, 1994

Although provided with recent infrastructures, the upper Mae Klong area still heavily relies on pumping, either from well or from ditch, because of the lack of on-farm development and the high topographic position of many plots. In the northern delta, the average situation is slightly better, with even some plots located on consolidated land.

These differences may explain the discrepancy observed in average yields, which are above 72 t/ha (11.5 t/rai) in the old delta and 57 t/ha (9.2 t/rai) at best in the Mae Klong area (map 3.13, NRC2D). Fertilization seems to vary accordingly, with higher use in the northern delta (map 3.14 and 3.15).

Sugarcane production significantly increased in the last decade. This increase occurred especially in the northern delta and in the upper Mae Klong area, further to the introduction of irrigation. On the other hand, the acreage decreased in the Nakhon Pathom and Thamaka Projects area. Nevertheless, the overall increase observed in irrigated areas (51 % between 1986 and 1994, see fig. 3.5) has been offset by a sharp decrease in the surrounding rain-fed areas.

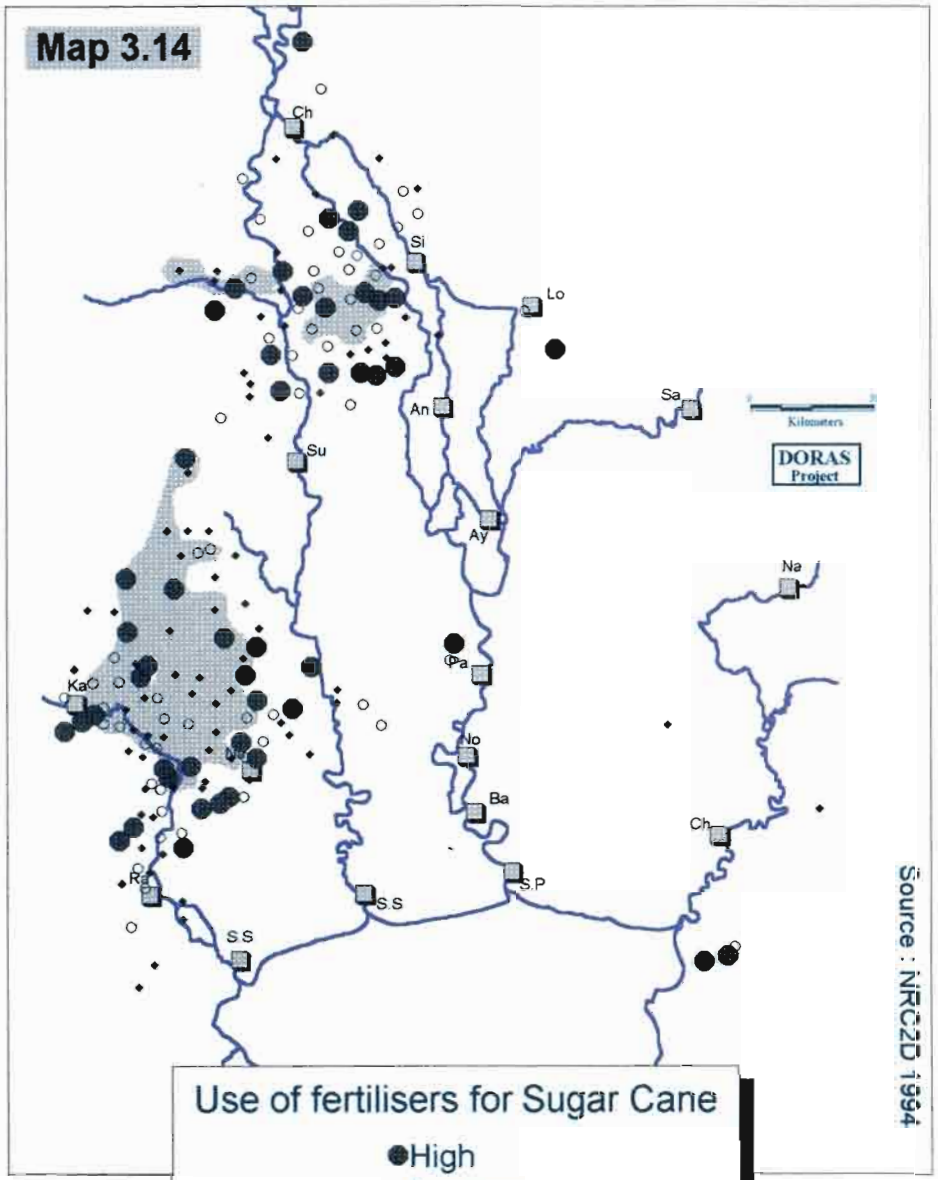
Figure 3.5

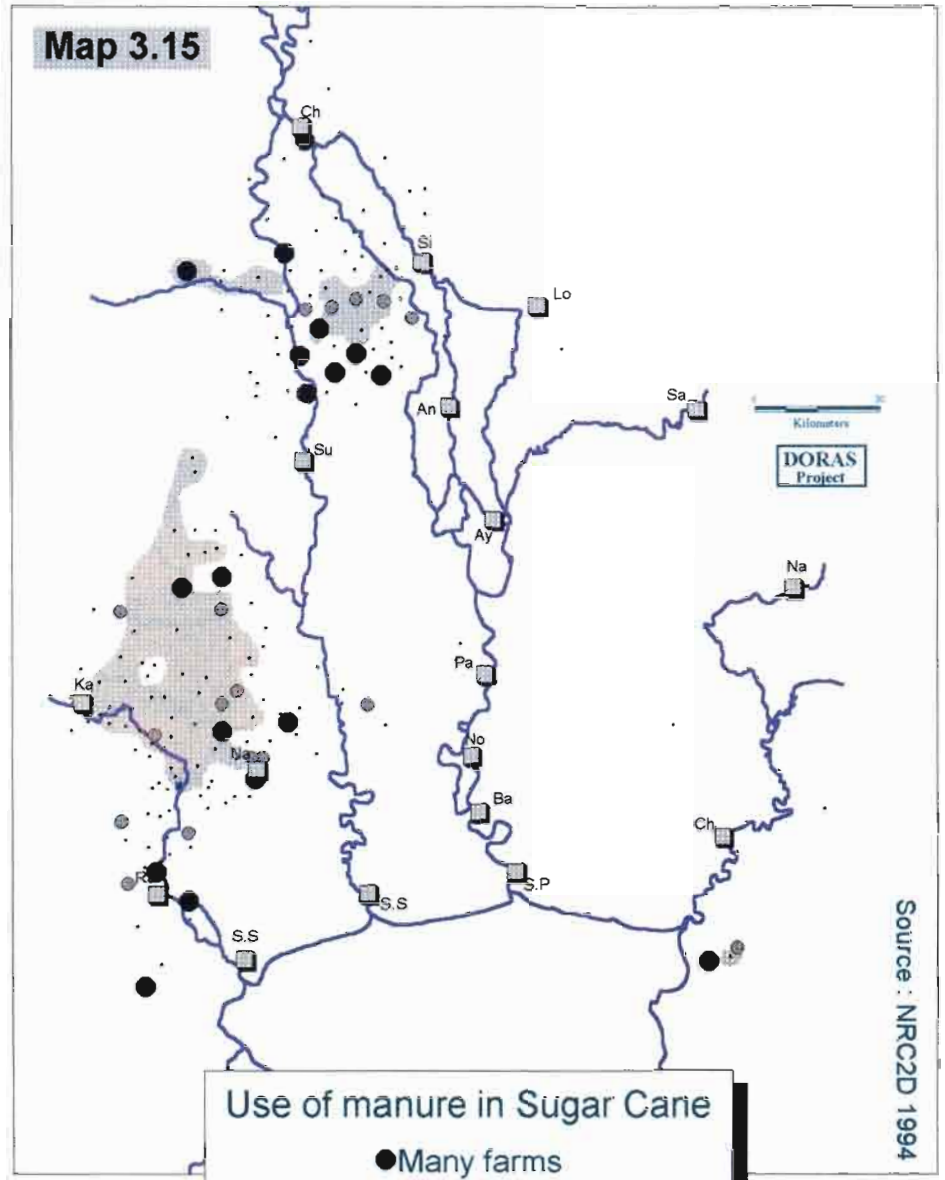


source : RID (total of sub-projects in the Mae Klong and Chao Phraya Projects)

In 1958, Samchuk Project had only 3,600 *rai*, against 20,000 by the year 1964. It further expanded to 30,000 *rai* in the eighties and reached 50,000 in 1995. In Krasiew Project, sugarcane leapt from 15,000 to 35,000 *rai* in the last ten years and it also shows recent development in Projects where it was almost absent, such as Tha Bote, where it increased from 300 to 6,000 *rai* between 1990 and 1995, and Borommathad, with around 17,000 *rai* against 700 ten years ago.

In The Mae Klong Project, the planted area expanded because of an increase of 25,000 ha in the upper part (Song Phi Nong and Phanomtuan Projects) during the last ten years, due to irrigation facilities.


Map 3.14
Ch
Si
Lo
An
Sa
Su
Ay
Na
Pa
Ka
No
Ba
Ch
Ra
S.S
S.P
S.S
Kilometers
DORAS Project
Source : NRC2D 1994
Use of fertilisers for Sugar Cane
High
Average
Low


Map 3.15
Ch
Si
Lo
An
Sa
Su
Ay
Na
Pa
Ka
No
Ba
Ch
Ra
S.S
S.P
S.S
Kilometers
DORAS Project
Source : NRC2D 1994
Use of manure in Sugar Cane
Many farms
Few farms
Never

Good water supply allows average yields of 9.3 t/ha (15 t/rai) which, together with rather high prices in the last years, have turned sugarcane into a good option for farmers with little labour availability. In some areas, the planted area increases or decreases mainly according to its comparative selling price with rice. This shift, of course, only occurs in soils where a medium location in the toposequence allows both types of cultivation (acceptable access to water and drainage conditions, with no prolonged flooding)[12].

The expansion of sugarcane is constrained by the actual location of sugar mills, because of transportation costs governed by the distance between the plot and the factory. At a macro-economic level, sugarcane is highly dependant of governmental policies, as influenced by lobbies (the production is subsidized by the government), and prices in the world market.

The difficulty of finding labour at harvesting time led farmers to delegate the whole operation to middlemen, with a subsequent decrease of the price they receive for their production (- 40 %). Mechanization of harvesting is also on the way and will probably be extended to most of the area in the following ten years.

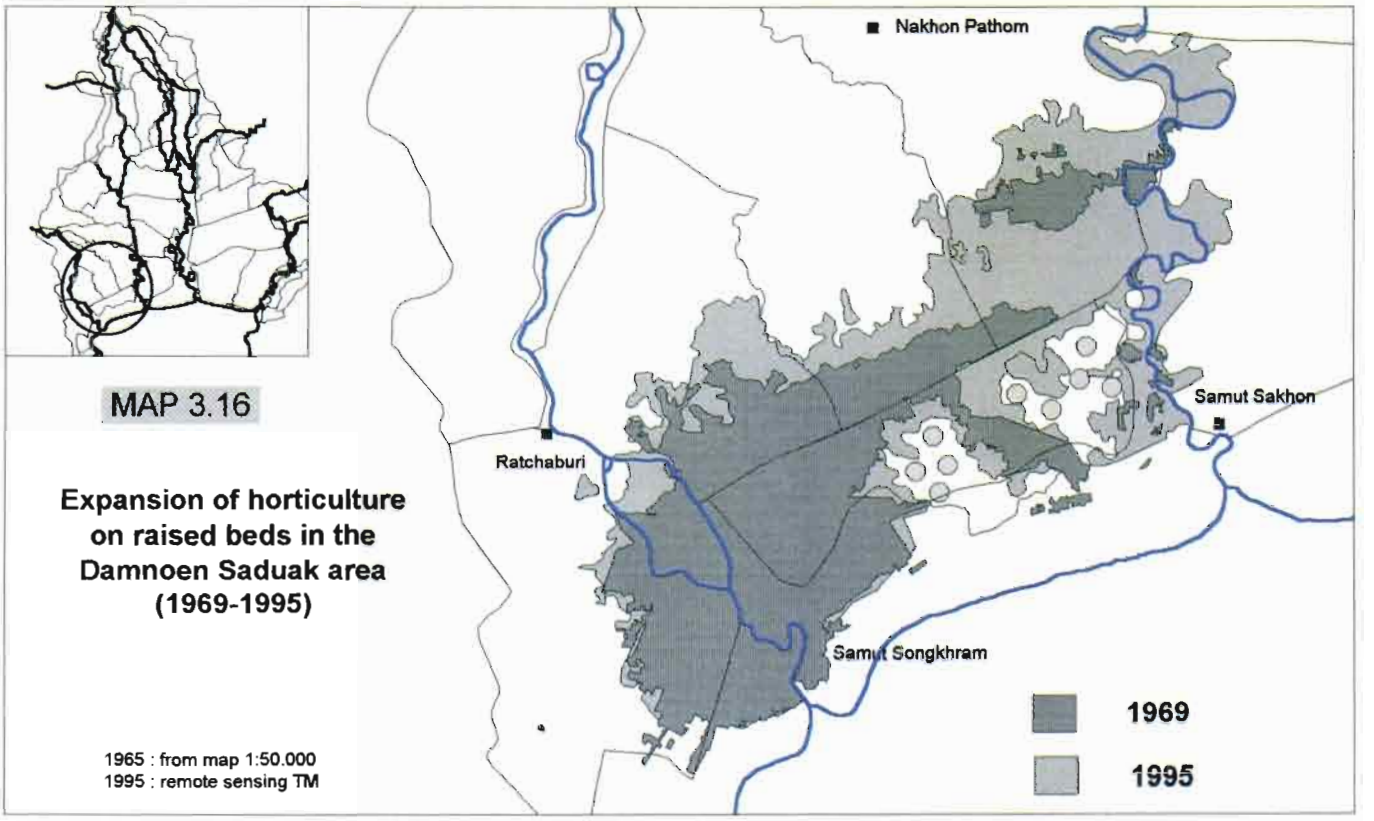
2) Expansion of Vegetables Crops and Orchards in the Damnoen Saduak area

Vegetable cultivation has long been a major farming enterprise, spreading in locations with good access to water and transportation. The total planting area for vegetables in Thailand increased until 1983, when it reached its peak with a total of 2.62 million *rai*. After that, it dwindled down to 1.70 million *rai* in 1990. The decrease in home gardening (< 6 *rai*) has been offset by the expansion of commercial farms, partly with the implementation of the contract marketing system (see Chapter V).

Fruit and vegetable gardens in ***Damnoen Saduak*** district of Ratchaburi have been renowned for being intensively cropped, mostly by the descendants of the Chinese migrants which helped dig the Damnoen Saduak canal in the last century. Fruit and vegetable cultivation in this area and its surroundings is characterized by a diversified and changing cropping pattern, high production inputs, and the use of the **raised beds** technique. A large diversity of fruit and vegetables can be found in this area : coconut, which corresponds to the oldest implantation, grapes, guayava and sapodilla are the most common.

Tracing the past 25 years of horticulture cultivation in the Dammoen Saduak area, some significant points may be noted. First, the production area has extended from the original site to further north and east; it now includes more of Samut Sakhon and Nakhon Pathom provinces (Map 3.16). This has been mostly allowed by steady profitability and improved water conditions created by the Greater Mae Klong Project. Secondly, also noteworthy is a rapid turnover in cropping patterns due to critical pest problems linked with an overuse of pesticides. In some periods of the year, for example, grape orchards must be sprayed every two or three days, with impact on production costs, quality and health.

[12] although prolonged saturated conditions of the rootzone have a clear impact on yields, sugarcane can stand some flooded conditions without incurring in a total loss of the crop.



MAP 3.16

Expansion of horticulture on raised beds in the Damnoen Saduak area (1969-1995)

Diversified activities other than fruit and vegetable cropping are also developing. For instance orchid farms and fresh water aquaculture in the recently reclaimed areas of the southern part of Damnoen Saduak area. Table 3.6 gives the estimated distribution of the agricultural distribution in the Damnoen Saduak Project (in *rai*).

Tab. 3.6 : Agricultural production in Damnoen Saduak Project (*rai*)

Field crops	940		
Vegetables	7.000		
Rice	15.000		
Fish and shrimps ponds	27.365		
Fruit trees	108.136		
Coconut	83.209	Orange	3.373
Mango	2.701	Jujube	2.865
Sapodilla	2.523	Grapes	2.357
Banana	2.263	Citrus	1.877
Sweet orange	1.705	Pomelo	1.403
Guava	1.285	Papaya	925
Litchi	984	Rose apple	317
Makhem theta	315		
less than 100 *rai* each : cocoa, sweet tamarind, betel nut, jack fruit			

Source : RID - Damnoen saduak Project

3) Growth of fruit/tree plantations : the case of Pathumtani

Diversification towards fruit production actually began as early as the 1950s, but on a limited scale and in specific sites. Like in the case of vegetables, commercial production of fruit originated in the suburban area, but most particularly in the area with good drainage and rather fertile soils. The former sites were Nonthaburi, Nakhon Pathom, and Ratchaburi (Damnoen Saduak district). Raised bed is the traditional characteristic of these fruit orchards.

Following the development of supporting infrastructures and the government campaigns in the 1960's, fruit production expanded gradually. It was not until the mid 1980s, however, that diversification toward fruit production became a dominant trend. The major motivating force for the expansion of fruit orchards was the much higher marginal returns as compared to rice or field crops. This in particular turned the investment for raised-beds systems profitable. For instance, the average net return from oranges is approximately 12 times higher than the one obtained from rice double cropping. Other contributing factors include : new production technology, improved breeding varieties, increase in the buying power of consumers, and the rise of export-oriented agro-industry.

With the urban expansion, the fruit growing area extended to more remote areas such as Nakhon Nayok and Prachin Buri. Rice fields have been converted into raised beds. Unlike the case of vegetables, fruit areas expanded continuously with an average annual rate of 1.66%. The periods of 1980-1985 and 1986-1990 saw a remarkable increase of fruit production by 69.5 % in the Central Plain. The most rapid expansion occurred from the year 1984, as can be observed in the cases of Chonburi and Pathum Thani provinces (figure 3.6)[13]

A closer look at selected districts of Pathum Thani province reveals that a sharp increase in fruit tree plantations occurred during the years 1980-1985, along with a rapid drop in the paddy area. Although a considerable part of the loss of rice fields has been due to the growth of built-up areas, about 11 % of the paddy area was converted to fruit tree plantations between the years 1979-1993. In addition, an estimated 19 % of land use change from horticulture gardens to fruit tree plantations has been observed (Table 3.7).

Through field observations in the north Rangsit area, a recent trend can be noticed of orange orchard expansion from the original area in the east toward the western rice area. Again, comparative marginal return was cited by the growers as an incentive for converting rice fields into fruit orchards.

However, this trend is likely to be more and more counterbalanced by cases of farmers selling their land to urban buyers (because of their extremely high value) and moving up north to carry on their activity with an increased capital. Such cases are already observed but in the future this will be limited by the fact that the land tenure status of this area is already - and historically - strongly dominated by absentee urban owners.

[13] The yearly data of land use by Jangwat sometimes shows some contradictions for specific years but the overall trend can be observed over almost 20 years.

Tab. 3.7 : Transitional matrix of landuse change in *changwat* Pathum Thani

Major land use	Year 1979 Area (ha) *Percen-tage*	Year 1993					
		Paddy	Plantation (trees)	Horticul-ture	Fallow	Waterbody	Built-up
Paddy	122752 *80.84 %*	75312 *61.35 %*	13541 *11 %*	20100 *16 %*	133 *.11 %*	0	1355 *11 %*
Plantation (trees)	3224 *2.12 %*	0	1616 *50 %*	0	1397 *40 %*	0	303 *9.4 %*
Horticulture	2184 *1.44 %*	0	417 *19 %*	456 *21 %*	495 *22.6 %*	0	816 *374 %*
Fallow land	4043 *2.66 %*	0			2031 *50 %*	0	2013 *50 %*
Water-body	1194 *.79 %*	0	0	0	0	1194 *100 %*	0
Built up	18455 *12 %*						18455 *100 %*
Total	151853 *100 %*	75313 *50 %*	15575 *11 %*	20557 *15 %*	3955 *.84 %*	1193 *.60 %*	35141 *20 %*

source : Andrianasolo (1995)

4) Dispersion of mixed cropping: the case of Nakhon Pathom

Nakhon Pathom Province and its surroundings may be representative of the western region of the Central Plain where dominant crops were rice (on the lowlands) and sugarcane (on the better-drained lands). With its proximity to Bangkok, supportive marketing channels and good water availability, the area between Bang Len and Ratchaburi has seen a rapid development of field and vegetable cropping in the past fifteen years.

The following table gives the estimated areas of various crops grown in the Nakhon Pathom Project, which total 42,000 hectares (262,785 *rai*). It is highly illustrative of the diversity of crops which are grown in the area, in response to urban and international markets.

A record of increasing planting area during the 1984-1994 period in the Kamphaengsaen Irrigation Project (figure 3.7) is another good example of the upward trend of diversification in the region. Some farmers completely shifted from rice cropping to field and vegetable cropping, while others adopted a mixed cropping pattern of rice farming and field crops or vegetable gardens. An example of the latter case is commonly found in *Amphoe* Bang Len, where two or more rice crops per year still exist together with other crops or animal productions.

Baby corn cultivation is also an example of recent diversification which is generally conducted in association with cattle breeding. This association is common along the lower left bank of the Mae Klong river (where the irregular topography is still responsible for extensive waste land) but has recently spread towards Kamphaengsaen and Phanomtuan Projects.

Tab 3.8 : Estimated area of diversification crops in Nakhon Pathom project (1994)

Field crops (27,600 *rai*)			
sugarcane	48,685	chinese cabbage	2,500
chinese keys	2,900	swatow mustard	3,500
cha-om (acacia sp,)	12,000	celery	500
Siamese ginger	200	chinese flat cabbage	1,550
lemon grass	300	water mimosa	2,000
groundnut	1,700	chinese kale	2,500
sweet corn	2,500	water spinach	700
baby corn	4,250	cauliflower	300
sweet potato	2,100	asparagus	3,300
yam bean	1,200		
mung bean	450	**Fruits (77,500 *rai*)**	
soybean		mango	29,000
	1,100	grape	7,000
Vegetables (36,000 *rai*)		coconut	10,000
shallot	1,800	banana	1,000
onion	2,000	banana *namwaa*	1,000
coriander	1,500	pomelo	10,000
cucumber	3,500	tangerine	500
yard-long bean	3,000	papaya	1,000
chilli	4,200	rose apple	10,000
egg plant	2,800	sapodilla	300
white gourd	350	Siamese olive	700
pumpkin	400	guava	5,000
	1,300	jujube	2,000

source : RID (Nakhon Pathom Project)

The vegetables grown are more diversified; the common types are leafy vegetables, asparagus, cucumber, and specially Cha-om (*Acacia pennata*) which is specialized in a large area north of Nakhon Pathom city. A distinction can be made between the vegetable gardens in this area and those in the Damnoen Saduak area : the latter are characterized by the use of raised beds, whereas the former are not, since most of the time there are cultivated in higher land provided with sufficient drainage.

In addition to field and vegetable productions, Nakhon Pathom is also known for swine, and secondly for chicken and duck productions. This adds to the diversity of agricultural productions in this area.

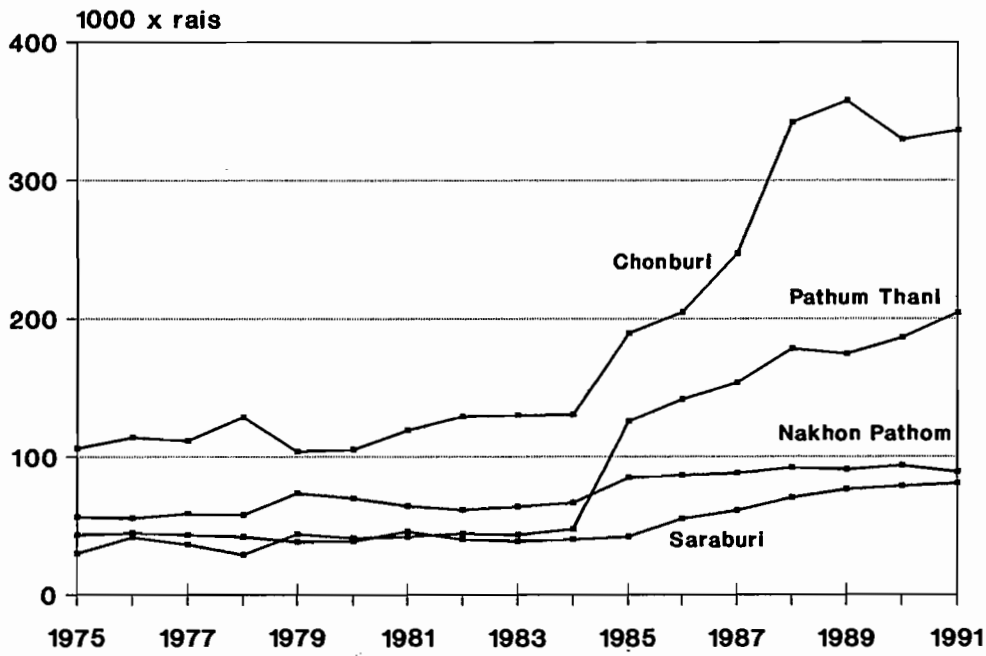
5) Aquaculture

Fresh water and brackish water aquaculture has undergone an impressive boom in the last 20 years. In 1965, there was 767 private ponds for aquaculture in the Central Plain, according to the Agricultural Statistics of Thailand. Nowadays it constitutes the main activity of the coastal area, especially the eastern side .

Fish and shrimp farming is sensitive to industrial water pollution and to disease. The former is responsible for a transfer of aquaculture from the industrialized south towards the centre and north of the delta.

Fig. 3.6

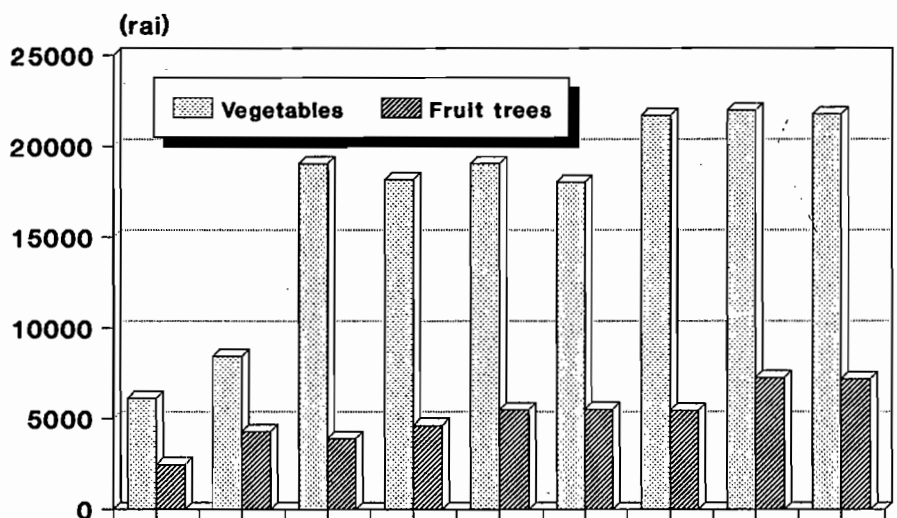
Evolution of tree plantations
in selected Jangwat of the Central Plain



Source: Office of Agricultural Economics

Fig. 3.7

Increase in diversification area
Kamphaengsaen Project - Wet Season



	1986	1987	1988	1989	1990	1991	1992	1993	1994
Vegetables	6121	8426	19051	18162	19039	18012	21683	21974	21747
Fruit trees	2492	4310	3905	4638	5488	5520	5463	7251	7201

Source: RID - Kamphaengsaen Project

Around 1,600 and 800 ha of aquaculture could be found in Chao Chet and Phraya Banlue Projects in 1984. These areas doubled to 3,000 and 1,500 ha in 1991. Projects in which such activities were unknown a short time ago are now developing aquaculture : Phophya (670 ha), Samchuk (260 ha), Chanasutr (222 ha).

In 1983-1984, serious diseases threatened catfish and serpent head fish farms. Prawns also have to cope with similar problems giving way to a change in species or migration to the north: giant tiger prawns have almost disappeared but some nurseries - using brackish water brought from the sea - have been observed in the Bang Len and Suphan Buri areas, where they have been transferred in order to avoid such problems.

Chapter 4

Main patterns of water use and water control

4.1 General conditions of water use

4.1.1 Water and agriculture

Water regimes in the Central Plain are very varied. They range from areas undergoing more than six months of flooding to full control irrigation, either by pumping or by gravity, with all intermediate situations.

These regimes are never definitive : water availability - think of flooding in the rainy season and water shortage in the dry season - changes throughout time. The first cause of change is the natural variability of rainfall and runoff which is responsible for periodic sharp year to year contrasts. The second is a middle or long term change in hydrology and in human use of water resources. Hydrologic conditions can be slowly modified by change in rainfall patterns, by deforestation or land use affecting run-off and by the action of man (construction of storage dams or dikes, diversion of flows, improvement of drainage, etc). On the other hand, increases in population, urban and industrial growth and the development of water consuming activities such as golf courses or resorts, concentrated in some specific areas of the water basin, take an increasing toll on available resources. Bangkok, for example, needs for its different activities a daily amount of more than 2 million m^3.

Agriculture is still the highest consuming sector in the Chao Phraya delta with an average of 80 % of the global amount of diverted water. Nevertheless, water availability, especially in the dry season, is far from matching a demand which is pulled upward by the predominance of rice farming.

In the past fifteen years, but especially in the last 5 years, water shortages during the dry season have been experienced as a result of low storage in the main regulation dams in the upper basin. Uncertainty concerning the main factor of production have doubtlessly affected the behaviour of farmers who tried to give an adequate response in terms of cropping patterns and development of secondary water resources in order to lower their risk.

Although an expression of a much deeper transformation of the agrarian system, diversification has therefore sometimes been considered - as long as water can be ensured - as an answer to water shortage, because of the smaller amount of water required, when compared with rice farming. This trend has been strongly encouraged by the Government which, among other reasons, considers it as a way to reduce water use in agriculture (see § 3.5).

On the other hand, farmers keep on trying to adapt their rice cropping calendar to the periods in which the risk of water shortage is minimal, giving way to some "shifting" calendars.

Lastly, farmers have sought to develop additional water resources, among which individual well drilling has been favoured as the simplest way. In that, they have been helped by government programs which have also implemented wells for collective use and subsidized drilling for diversification cropping.

4.1.2 Water management

Water management in the Chao Phraya and Mae Klong Projects is conducted at several levels. At the upper one, the level of the whole basins, water resource is managed by several administrations but mostly by the Royal Irrigation Department (RID) and the Electricity generation Authority of Thailand (EGAT), the latter being responsible for water delivery in the storage dams.

Deliveries in the dry season are calculated according to basic requirements (transportation, electricity generation, urban requirements and salt water control) and the share for agriculture depends on the available amount of water stored in the dam. In the rainy season, at least during the August-November period, management mostly aims at dividing excess flows in the different waterways in order to control the flood and avoid damages.

In both cases, this is achieved mostly through experience and manual regulation when the situation borders excessive imbalance. The situation is monitored by the three regional Offices located in Lop Buri, Chai Nat and Kanchanaburi (see Chapter 1), and by the Central Office in Bangkok. Water is then delivered into the main canal(s) of each of the 45 sub-projects.

At the Project level, monitoring and regulation mostly concern the trunk or primary canals, whereas at the secondary level, water management is under the control of zonemen who take care of an average of 2,000 ha. At ditch level, at last, farmers manage water by themselves. This division works until some breakdown appears in the network : water shortage or excess of water observed at a given level will be reported to the level above, who will endeavour to balance the situation. If the problem has its origin at an upper level, then the information will proceed upward.

Observations of water levels and discharge at the main regulation structures are recorded five times a day by the zonemen who transmit them to the Project's Office. Specific data related to water control in the main waterways is further forwarded to the regional office and Bangkok main office. At the project level, however, this large amount of data is seldom analysed and regulation is mostly based on experience, with responsiveness limited to the abnormal situations observed and reported by the lower levels.

In general terms, water management appears to be hindered by deficiencies in design or regulation (especially for deliveries smaller than full supply), by the complexity of the network itself (numerous side and return flows, interdependence of waterways, etc), and by the lack of targets, means and motivation to improve the situation. Nevertheless, the overall conditions for agriculture regarding water availability can be considered advantageous when compared with other regions of Thailand.

4.2 Overall zoning of water control patterns

4.2.1 Definitions and scale considerations

The conditions of access to the water resource are extremely varied in the delta.

They include, on one hand, the characteristics of *water acquisition* at both the main scheme level and the on-farm level. Here are defined the main types of water delivery : gravity area, conservation area, flooded area. At the farm level, water may also be acquired by gravity, pumping or flood, without necessarily matching the pattern of the upper level : a lot of individual (and sometimes collective) pumping is often required at the farm level in gravity areas, whereas some gravity inflow in plots can occur in the conservation area, where pumping prevails. In the flooded area, all kinds of farm acquisition can be found in the same plot, according to the period considered and to micro-topography (gravity, pumping, flooding).

On the other hand, access to water is defined by the more qualitative aspect of *water control.* This control can also be considered at two different levels : **the scheme level**, in which *deliveries* can be appreciated in terms of quantity, regularity and timeliness, together with *drainage conditions,* expressed in terms of risk of flood (short-term or prolonged, shallow or deep); **the farm level**, where in addition micro topography, on-farm development patterns, location within the network, etc. must be taken into account.

Water control therefore mostly relates to physical conditions (natural and artificial (network)) and to management and organizational capabilities. It may also imply some kind of underlying economic meaning : for example, in the gravity area we can find almost neighbouring plots with contrasting situations : one plot, too far from canals and ditches, may rely on pumping from a main drain, whereas another one will get water by gravity from the canal. In the strict term, the first plot can be said to have a better water control (by pumping at will from a perennial resource) than the other one (which may sometimes suffer from irregular canal deliveries). But if we consider the benefit drawn by both plots from their belonging to the same irrigation scheme, the second plot enjoys a better situation[1] because of a no-cost water supply. The first one has only been led to compensate a poor access to water by an investment and a more costly water acquisition.

Thus, as in the case of the land use map, attention has to be drawn to the scale factor. If some areas can be considered as relatively homogenous concerning the conditions of water control at the farm level, some others, most specially the gravity areas with poor on-farm development, do present a high variability of situations within small areas.

Similar remarks apply to differences in cropping calendars. The main zones described further do not account for variations at plot level, which are generally higher in situations where water control is good all year long (such as in some areas of the West Bank).

[1] as far as the irregularities in delivery have no repercussion on the productivity.

With these limitations, the *water control zoning at the Central Plain level* will therefore consider the main types of water acquisition, together with main constraints regarding flood occurrence and water quality, and considerations at farm level whenever possible. Later commentaries will try to supply additional information on the internal variability[2] of some classes.

4.2.2 Description of the zoning

Map 4.1 attempts to set a zoning of the main water regimes in the Central Plain, defining, at an upper level, four main classes, namely A, B, C and D, in which sub-classes are further distinguished, as detailed below. It has, of course, several similarities with the land-use map, in particular with its different rice-growing areas, which logic is related to the level of water control.

It also roughly matches the main hydrologic zones, as sketched by Takaya (1978) :

- **water releasing zones** : the old delta (which has its apex in Chai Nat) and the fan-terrace complexes, on the borders of the delta.
- **water accumulating zones** : some inner valleys within the old delta, the main Noi-Lop Buri flood plain.
- **water spreading zones** : the young delta, with its flat part (delta flat) and its slightly elevated hills (delta hights).
- **the tidal flat** : the unprotected coastal area

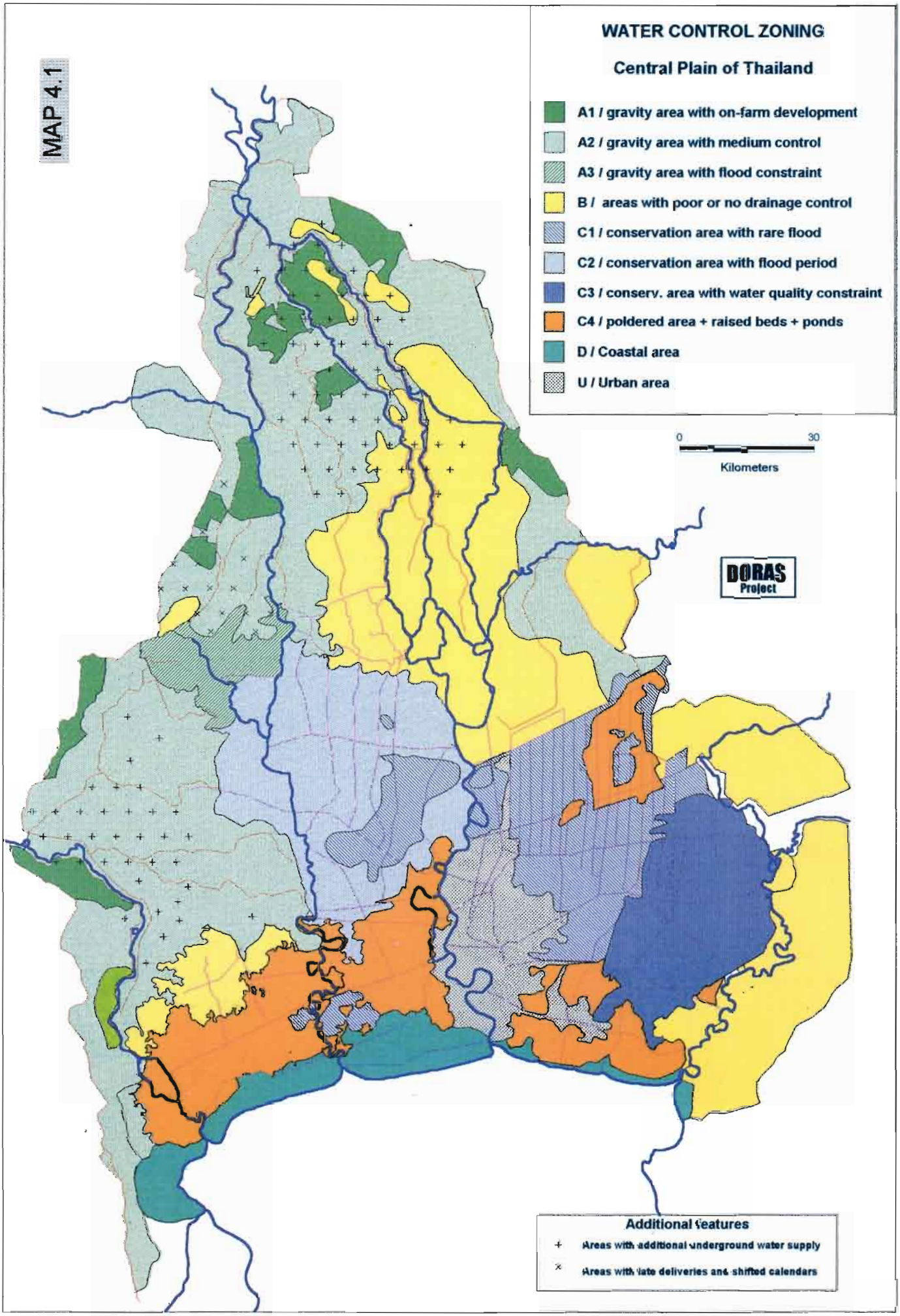
➲ *Class A : Gravity irrigation area*

Class A corresponds to common gravity irrigation (and appears in green in the map). It covers most of the Mae Klong Project, the non-flooded part of the old delta and most of the Projects bordering the neighbouring rainfed area.

The level of water control at plot level is very varied. Several reasons account for such differences:

- differences in technical options concerning hydraulic regulation and design;
- contrasted patterns of on-farm development;
- the irregular state of maintenance, some projects having more than 50 years and some being just constructed;
- the geometry of the network, which presents some very long canals along which water control tends to decrease, from head to tail.

[2] The variability and assessment of the real water control together with the risk factor at farm level will be addressed in the second phase of the project, where in depth studies will be carried out in the main zones identified here.


MAP 4.1
WATER CONTROL ZONING
Central Plain of Thailand
A1 / gravity area with on-farm development
A2 / gravity area with medium control
A3 / gravity area with flood constraint
B / areas with poor or no drainage control
C1 / conservation area with rare flood
C2 / conservation area with flood period
C3 / conserv. area with water quality constraint
C4 / poldered area + raised beds + ponds
D / Coastal area
U / Urban area
0
30
Kilometers
DORAS
Project
Additional features
Areas with additional underground water supply
Areas with late deliveries and shifted calendars

In addition, it should be necessary to consider water control for the dry-season rice-cropping, which mostly depends on the policy of water distribution at the level of the Central Plain. This aspect has been dealt with in the former chapter which differentiated levels of land use intensity : the corresponding zones are not shown in this section.

To take into consideration some of these differences, we distinguished,

- Class A1 : areas with a better location and/or a land consolidation development which allow all the farmers to have a fairly good control of irrigation and drainage.

  It has to be noted that some areas - not kept in this class - with land consolidation but bad drainage conditions can be found, like in the upper Borommathad Project and the southern part of the Manorom Project.

- Class A2 : areas with average gravity irrigation and basic ditch system for distribution at farm level. In these areas, a sometimes relevant proportion of farmers do not have access to the water distributed by the irrigation canals and generally pump from other sources (drain, pond, well).

  Many of the plots do not have direct access to a ditch or a drain and rice cropping is partly achieved through a plot-to-plot system of water distribution. In the case of sugarcane, generally located in higher plots, and even for some rice fields, additional pumping is necessary to lift the water from the ditch to the plot, especially during the dry season. In addition, insufficient levelling sometimes makes furrow irrigation (for sugarcane) difficult and hoses must also be used.

  Amid such areas, specific plots with excellent water control (but increased investment and production costs) can nevertheless been found, for example near main canals, or near main drains, with water supply and drainage ensured by pumping.

- Class A3 : some areas located along the Song Phi Nong river are subject to flooding until the end of the year. They start their dry season in the January-February period, after the receding of the flood, and their rainy main rice-cropping also earlier.

Differences in rice-cropping calendars, as described in Chapter 3, may also reflect untimely water supply specially in the dry-season. In the southwestern part of the upper delta (Phophya and Don Chedi Projects), but also in scattered plots in the whole upper delta, farmers who often have experienced lack of water in the dry season have therefore sought to shift their calendars in order to avoid such problems. In the northern part of the delta, water control has been improved both by well digging and calendar shifting.

To take into account these differences, we considered two over-impressed sub-classes :

- sub Class A(+) : water availability has been increased by individual and public well digging. The wells are used in case of insufficient or untimely deliveries and during the dry season when water is delivered to the other half of the Project (rotation). The dry season rice-cropping calendar is also often shifted forward.

- sub Class A(x): water control is poor, especially in the dry season; the constraint is dealt with by shifting calendars, the dry season rice-cropping being started just after the rainy season.

➲ *Class B : the flooded area*

This second category is composed of areas prone to submersion, the flooding depths and durations being quite variable from one area to another and from one year to another. In any case, water control is only partial; the speed of flood spreading and receding being for most of the time partly regulated by dike systems and check structures in the main drains.

We can distinguish :

- Class B1 : areas where flooding is severe and where floating rice is more likely to be found; this means that the flood depth generally exceeds 1 m and can reach three to four meters. Some of thes areas are indicated with dotted lines.

- Class B2 : areas where the flooding pattern allows the cultivation of deep water rice, generally traditional varieties, together with some possible floating rice in the lowest parts.

The separation of these two classes is rather uneasy for several reasons. Most of the time, this distinction is not taken into consideration by the RID Projects. In some cases, this is due to the fact that the two kinds of rice are found together, according to micro topographic conditions. In addition, the frontier between the two classes is not fixed and the farmers, at least in intermediate situations, will ponder about the risk and choose their variety accordingly.

The Maharat Project, which follows the eastern bank of the Chao Phraya, contains some of the areas where deep water rice, floating rice (in the lower parts and back swamps) and High Yield Varieties (on the natural levees), are deeply mixed. This last situation does not appear on this map.

Low lying areas are to be found principally along the Chao Phraya, Lop Buri and lower Noi rivers flood plains. Nevertheless, some remaining areas in the lower Mae Klong basin are typical of the situation which was prevailing everywhere before the expansion of the raised beds poldered system in the area. Similarly, some lower spots still remain in different projects (Don Chedi, Borommathad,..), but the extension of floating rice tends to decrease, or even almost disappear, like in the Phophya Project.

Note that most of the area corresponding to the class B is also situated in Projects which often come under the class of gravity irrigation. Nevertheless, these areas are different because of their flood water regime. In addition, they are sometimes deprived of ditches and the main canals are mostly useful to sustain the rice before the flood comes (July-August) and throughout the year for domestic use.

➲ *Class C : the conservation area*

Class C mainly corresponds to the flat land of the lower part of the delta (young delta), but also encroaches on some Projects from the gravity area : the eastern part of Bang Len and Kamphaengsaen Projects (which belong to the Mae Klong Greater Project); the southern tip of the Phophya Project, all located along the right bank of the Tha Chin river; an eastern tract of land along the Song Phi Nong river in the Song Phi Nong project.

In the Bang Len Project, natural and/or excavated channels are supplied by water diverted from the Tha Chin river (mainly through Klong Bang Len) and from Tha San Baan Plaa main drain[3], together with some release from Song Phi Nong main canal. In the Phophya Project, most of the water comes from waterways branching off the left bank of the Song Phi Nong river, with some deliveries from the irrigation canals. For the Kamphaengsaen and Song Phi Nong Projects, the canals from which farmers pump are mainly supplied by the irrigation canal network[4].

Class C zones are criss-crossed with channels, some natural (but dredged), some dug by man throughout the last 200 years. As such, they are equally prone to flooding but continuous dike construction and better water management at the basin level have enabled part of the area to be protected in normal years. The channels are used for both supplying water and drainage, and most of the water transfers between plots and channels are done by pumping. This area is often called a [water] conservation area (see § 2.5).

We can distinguish four sub classes in Class C:

- Class C1 : areas where the plots are almost fully protected from the flood and sea water intrusion, where water supply is rather regular during the year and which have therefore a good control of both irrigation and drainage. Flooding may occur but with low frequency, these areas benefiting of slightly higher location and/or higher dikes system.

  This include most of the east bank and part of the west bank, in which triple rice-cropping can also be found.

- Class C2 : poldered area with average to good availability of water during the year but with frequent flooding in the late rainy season.

  Most of the upper part of the West Bank area (between Tha Chin river and Chao Phraya river) has little control over frequent flooding occurring in the late rainy season. In addition, it is considered to be a necessary buffer to

[3] which constitutes the northern border of the Kamphaengsaen Project
[4] These areas can therefore be considered as an intermediate situation between the gravity irrigation area and the conservation area (lower delta), although closer to the later.

late rainy season. In addition, it is considered to be a necessary buffer to spread water more evenly in case of heavy flooding, thus lowering the risk of damage in the Bangkok metropolitan area. Farmers therefore avoid the flood period and take advantage of the good water availability during the year (specially at the end of the rainy season) to shift their cropping calendar. Starting the dry season between late November and January allows them to harvest the rainy season crop in August, before the flooding period of September-November.

This area includes parts where flooding is more prolonged and where dry-season cannot start before January or the first half of February. This is the case in the north of the Phraya Banlue Project and along the Song Phi Nong river (mainly the southern tip of the Phophya Project), where water will only recede in January.

These differences in rice-cropping calendars should not be regarded as rigid differences and are subject to evolution and yearly change. In 1995, for example, the magnitude of the flood over the West Bank impeded, in most of the areas, the second rice-cropping to be started before December.

- Class C3 : poldered area with rare flood occurrence but water quality constraint in the dry season.

  A large tract of land located in the eastern side of the young delta experiences high salinity levels in water during the dry season. This is due to the influence of the sea through the Bang Pakong river when its runoff is low. Consequently, the driest period of the year (March-May) is not suitable for rice growing and the second rice crop must be grown very early in order to avoid this problem. This area has therefore a water quality constraint which forces to shift the dry season rice-cropping calendar to the November-February period, which means that the second rice will start as soon as possible, continuing on from major rice (wet) season.

- Class C4 : poldered area with high level of protection against flood, good or excellent water availability along the year and transformation of the land into raised bed systems or ponds.

  Good water conditions and the development of diversification activities with high income allow increased investment in land development with higher security against the floods. This zone firstly comprises the fruit and vegetables orchards of Damnoen Saduak area, together with part of North Rangsit, where farmers have reclaimed former low land rice fields with the raised bed technique.

  It also extends to the lower West Bank (Phrapimol and Phasi Charoen Projects), where water availability is good but water quality often precarious.

  On the eastern side, mainly aquaculture has developed. Water levels in the canal have been insufficient during the dry season of the 1991-1993 period

and salty water draining from the soil into the canals has in some places hindered or stopped this activity for a few months.

➲ *Class D : the tidal area*

The tidal flats located along the sea shore are characterized by a marked influence of saline water intrusion and are therefore devoted to brackish water aquaculture or salt pans. Other swampy brackish areas, referred to as mangroves, still can be found, especially in the north of Petchaburi. Some coconut trees are grown amid the natural vegetation such as atap palm trees.

4.2.3 Types of water distribution, efficiency

To refine and describe the different kinds of irrigation found in the delta, table 4.1 gives additional information on the methods used to convey water to the fields and distribute it within the plots. These methods have been grouped in three sets named "gravity", "pumping" and "flooding" which, yet, do not exactly match the above classes : in the conservation area (Class C), most of the water acquisition and drainage is done by pumping from canals or farm ditches but gravity irrigation also occurs in areas where the water level is under tidal influence. In the gravity area (Class A), all situations between full gravity and full pumping can be found : farmers of course prefer gravity situations which do not include pumping costs, if they are reliable, but some of them have poor access to water (untimely deliveries or no on-farm development to convey water to the furthest plots) and are forced to rely on other sources (pumping in main drains or wells).

In some gravity areas, like in the Kamphaengsaen Project, the absence of tertiary canals means that the benefit of a good hydraulic head in the secondary is lost after the farm turn out (FTO)[5]. Because the level of the water poured into excavated ditches is lower than the plot surface, pumping from ditch to plot necessary. This is common in sugarcane areas where, in addition, insufficient levelling hinders the use of furrow irrigation. Irrigation with powerful sprinklers (canons) can also be found in the sugarcane area.

Furrow irrigation is often unsuited because of too heavy soils and improper levelling, but it is used for crops such as taro and baby corn. Retentive soils, bad drainage, and water stagnation in micro-depressions sometimes make it hard to avoid local water saturation. This often has a negative impact on this last type of production, especially when it occurs before flowering.

Some farmers now resort to sprinkler irrigation, which allows them to grow new categories of vegetables. Such techniques are mainly developed in the Nakhon Pathom Province.

Table 4.2 shows the main kinds of water distribution which can be found in each sub-project. It appears that very few projects are homogeneous in terms of water control and that diversity is the rule in the whole delta.

[5] Gated inlet regulating the discharge between the main canal (primary or secondary) and the ditch (or tertiary)

Table 4.1 : Main kind of water distribution

Main group	Class	Main water source and acquisition at farm level	Distribution within the plot	Code
1 (pumping)	C	➲ Pumping from canal to rice polders or ponds (aquaculture)	- basin	P1
	C	➲ Pumping from canal to raised bed polders	- boat (pump+sprinkler) - bucket (manual) - pump + hose	P2
	A, (B)	➲ Pumping from secondary resource: - drain - well - river, natural *khlong*	- any kind (basin, furrow, raised beds, etc)	P3
	A	➲ Pumping from main canal	- any kind	P3
	A, (B)	➲ Pumping from any source	- sprinkler or canon irrigation	P4
	D	➲ Pumping from ditch (wind mills for salt pans)	- basin (salt pans, ponds)	P5
2 (gravity)	A	➲ gravity from ditch (or canal)	- basin - furrow (sugarcane,baby corn, etc)	G1
	A,C4	➲ gravity from canal + pumping from the ditch	- basin or furrow - boat+sprinkler (raised beds)	G2
	A	➲ gravity from canal (or ditch) + plot-to-plot system	- basin (rice)	G3
3 (flooding)	B	➲ natural flood	(water level regulated by	F1
	B, (A)	➲ irrig. canal* + natural flood	structures in the drains)	F2

*** Canal refers here to a primary or secondary water distribution canal**

Irrigation efficiency[6] also varies greatly in the delta. Before all, it must be stressed that the notion of efficiency is sometimes meaningless or hard to evaluate. The overall efficiency at Project level, for example, must consider the reuse of return flows in downstream projects, which is not easy to compute given the complexity of water flows in the delta. According to Acres (Acres, 1979), between 66 and 86 % of the theoretically available return flow actually appears in the drainage system (given some storage in tributary drains or low lying fields).

Higher values of efficiency are often the result of insufficient water deliveries and may in fact indicate water shortages rather than good management. Low values may

[6] The overall efficiency is defined as the ratio between water requirements and deliveries

indicate over supply at the tertiary level but often overlook the fact that if some farm turnouts are over supplied, some other - especially those at the tail ends or in higher locations - may experience shortage.

Irrigation efficiencies differ, on one hand, between the wet and the dry seasons, and, on the other hand between gravity and conservation areas (little can be said about the flooded areas for obvious reasons).

In the rainy season, gravity areas often have efficiencies under 50 % which, during some rainy months, can be as low as 17 %, as encountered in the Samchuk project (RID-Acres, 1980). In the dry season, it can reach 80 % in the conservation area where water use by pumping makes farmers endeavour to save water in order to reduce costs. In gravity irrigation areas, even in rather good conditions provided by land consolidation facilities, efficiency has been found not higher than 38 %, in three tertiaries of the Tha Maka Project, Mae Klong (Suchatpong, 1988).

Table 4.2 also displays efficiency values for each sub-Project as estimated by Acres (in Jha, 1993).

4.3 Water delivery in the dry season

The evolution of the dry season rice-cropping area has been commented earlier (section 3.2.2). It developed due to the regulation allowed by the Sirikit dam (1972) and plateaued in the last decade around 500,000 ha before collapsing in the 1990-1993 period.

The still limited water resource and the insufficient design of some canals to meet dry season water requirements have led to the establishment of a yearly rotation system, water being delivered alternately between two halves of each Project. This is effective only in the Greater Chao Phraya Project (in the Mae Klong Project, and to a lesser extend in the young delta, good water availability allows double cropping in all the area).

Over the last four years, insufficient water in the dry season limited the extension of dry season rice cropping : in rough and average terms, only two thirds of the supplied area would have access to water and this area is concentrated along the main waterways. In the other half of the Project, farmers are not supposed to grow rice and are encouraged to grow vegetables or field crops. But as RID still delivers between 10 and 30 % of the maximum discharge (for domestic use and field crops), some farmers - an average of 5 to 10 % - are sometimes found to pump water to grow rice.

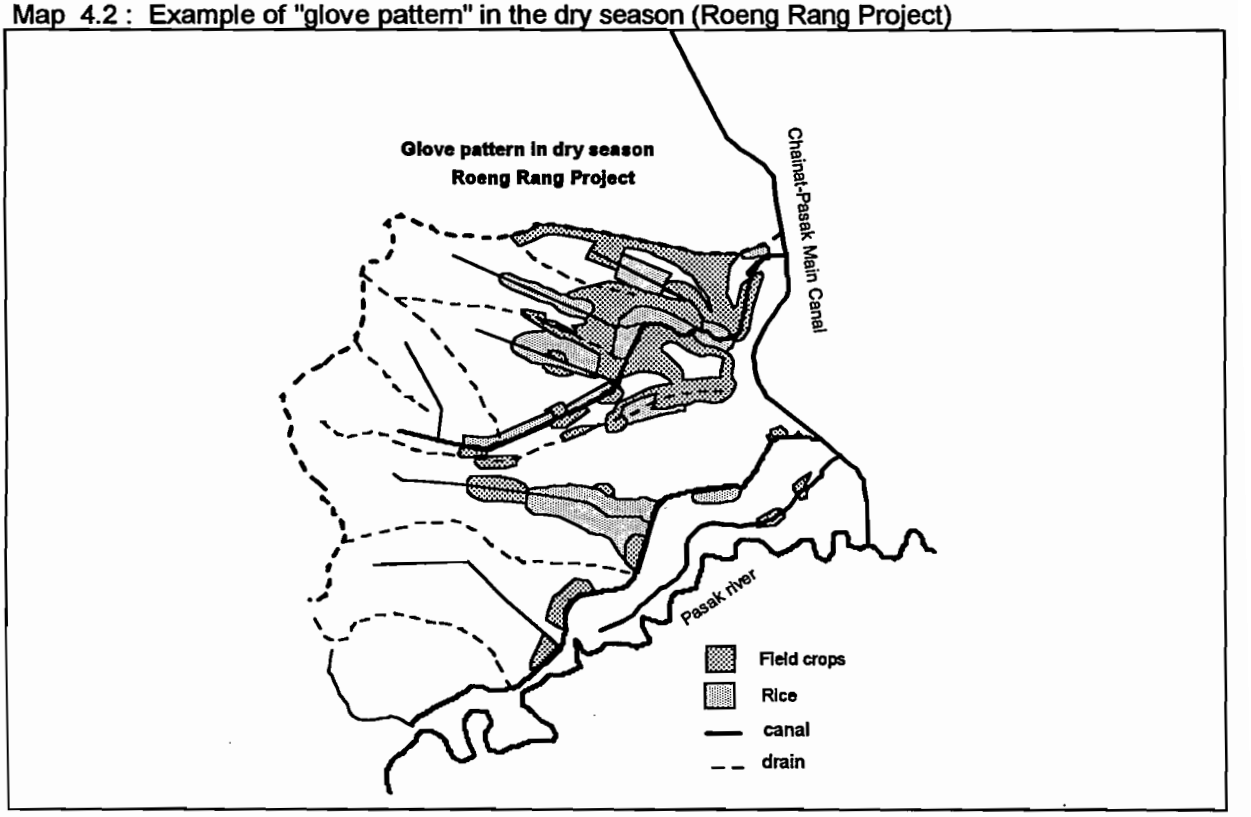
The rotational system appears to be somewhat theoretical in parts of the upper delta and no really contrasted pattern (between the supplied and non supplied halves) can be observed. Relying also on pumping from waterways and tube wells, using water supplied for consumption or intercepting water destinated to areas located downstream, some farmers manage to overlook the rotational water allocation. This is particularly the case in areas with a high density of wells and along the main canals, which very often convey water to other Projects situated further south

(conservation area), or to areas where priority delivery is required (land consolidation, fruit trees - and sometimes sugarcane areas).

Map 4.2 gives an example, for the Khok Katiem Project, of a typical distribution pattern of dry season cropping in a normal year (where half of the project will be supplied with water) : rice is mainly grown along the head reaches of the main canals (primary and secondary) in what can be called a "glove pattern". Plots situated too far from these canals or at their tail end reach are likely to have bad access to water and farmers therefore prefer not to grow rice. Field crops are scattered all over the area but always near a secure water source.

In some cases (Nakhon Nayok Project, Roeng Rang Project, etc), farmers grouped together and ask for pumping assistance from RID who, given the exceptionally dry conditions, tried to satisfy these demands by operating some mobile pumping stations. In the 90-94 period, RID thus operated for each dry season an average of 300 mobile pumps in the Central Plain.

Map 4.2 : Example of "glove pattern" in the dry season (Roeng Rang Project)



The flooded area (class B) generally grows only the rainy season rice. A double cropping is for most of the time impossible (too long duration of "heavy" rice cycle) and is also hampered by other factors (bad water distribution facilities, inadequate equipment, bad levelling and bunding, limited labour force,..) which excludes these areas from the consideration of water planners. In a 1994 survey, the reasons given to explain the absence of a second crop after major rice were : bad water conditions

(88 %), lack of labour (29 %), bad soils or lack of skill (14 %) (Charoendham et al. 1994).

On the contrary, in normal years, most of the rice-growing part of the conservation area (class C) allows the planting of two crops, albeit with a shifted cropping calendar. It is mainly in this area that triple rice-cropping can be found, under the constraint of good water availability all year long. These cases have been commented in a former section (§ 3.2.3).

In the Mae Klong area, water storage and regulation are sufficient to ensure dry-season rice-cropping over most of the area, without resorting to a rotational system. Nevertheless, the cropped area for the year 1995 was almost 100,000 ha, slightly less than a potential of 150,000 ha[7].

Available data on rice acreage at the Project level allows the importance of double cropping in each sub-Project together with its global evolution to be specified. Table 4.2 shows the respective importance of wet and dry season rice cropping in the different Projects and for the 1986-1994 period. The ratio between average wet and dry season cropped areas is higher than 100%[8] in some projects like Chao Chet Bang Yeehon and, in general, is high in the young delta (Rangsit and West Bank) and in the Mae Klong. Samchuk, Phophya and Pollathep are the only Projects of the upper delta where the ratio is greater than 50 %.

4.4 Relationship between water control, risk and rice cropping patterns

4.4.1 Water shortage in the dry season

In the last four years, as commented above, drastic water shortages have been experienced during the dry season, leading the Royal Irrigation Department to restrict water delivery in the Chao Phraya Project's area to domestic use only.

This shortage compelled the farmers to look for additional sources of water and contributed much to the quick expansion of private wells observed over the last few years. This expansion has also been boosted by government policies to develop diversification and subsidize well digging (one well is dug free if the farmer plants four *rai* of diversification crops). In addition, many collective wells have also been dug by the Provincial administration to smooth the impact of water shortages.

These wells are 20 to 40 meters deep and have a pump which can be powered by a two-wheel tractor motor when the water level is less than 7-10 meters. In 1994, many of these wells have been reported dry in the month of April and have been further deepened. Due to the cost of pumping, they are in fact used only in case of water shortage, although some farmers, who grow rice only with their support, can also be found, such as in Borommathad and Manorom.

[7] considering an estimated area for the Banglen Project

[8] because the cropped area in the dry season is higher than in the rainy season (some low parts being left uncultivated)

Table 4.2 : other characteristics of irrigation sub-projects

PROJECT	PROJECT	(t/ha)	Efficiency %		Average rice area (86-94)		%	Main kinds of water distribution
		Av. Yield	wet season	dry season	wet	dry	dry/wet	
Bangbal	บางบาล	2.72	39	55	20091	186	1	F, (G)
Bang Len	บางเลน							P1, (P2)
Bang Pakong LB	ฝั่งซ้ายแม่น้ำบางปะกง	3.10			13829	9	0	F, (G)
Borommathat	บรมธาตุ	3.73	31	37	56322	14276	25	G, (F2)
Chanasutr	ชัณสูตร	3.73	30	40	57229	20859	36	G, F
Chao Ched Bang Yeehon	เจ้าเจ็ด-บางยี่หน	2.93	39	55	30015	40175	134	P1,(P2)
Chong Kae	ช่องแค	3.96	20	20	37367	2628	7	G, F2
Damnoen Saduak	ดำเนินสะดวก	3.63			5226	850	16	P2
Don Jedee	ดอนเจดีย์	3.74	36	44	21660	10068	46	G, (F1)
Khamphaengsaen	กำแพงแสน	3.50			14740	15725	107	G, P4, P3, P1
Khlong Dan	คลองด่าน	2.92	20	37	34993	11810	34	P1
Khok Katiem	โคกกะเทียม	3.32	20	20	32271	3037	9	G, F2
Klong Priew	คลองเปรียว	3.07			21058	449	2	F, (P, G)
Kra Siew	กระเสียว	3.63			14076	5395	38	G, (P)
Maharat	มหาราช	2.93	18	33	71871	6241	9	F, G, P
Manorom	มโนรมย์	3.69	22	33	39061	9234	24	G, (P)
Nakhon Pathom	นครปฐม	3.48			20132	11917	59	F, G
Nakhonchum	นครชุม	3.07			26070	854	3	F, G
Nakhon Luang	นครหลวง	2.71	20	55	36861	190	1	F, (G)
Nakhon Nayok	นครนายก	3.03			47429	417	1	F, G, P
Pasak Tai	ป่าสักใต้ (ท่าหลวง)	3.24	50	50	33457	4177	12	F, G, P
Pasicharoen	ภาษีเจริญ	3.49	20	55	9853	6906	70	P1,(P2)
Petchaburi	เพชรบุรี	3.92			55262	2304	4	G, P
Phak Hai	ผักไห่	2.43	39	55	27887	1349	5	F
Phan Tong	พานทอง	3.39			3829	0	0	F, P
Phanom thuan	พนมทวน	3.20			13824	9285	67	G,(P)
Pho Phaya	โพธิ์พระยา	2.85	40	52	32190	26503	82	G,(P)
Phra Ong Chai Ya Nuc	พระองค์ไชยานุชิต	3.29			58781	42151	72	P1,(P2)
Phraplmol	พระพิมล	3.75	20	55	31480	31485	100	P1,(P2)
Phrayabanlue	พระยาบรรลือ	2.85	20	55	44748	50516	113	P1,(P2)
Pollethep	พลเทพ	3.58	20	39	15087	8280	55	G,(P)
Rangsit Nua	รังสิตเหนือ	2.90	50	50	36602	15127	41	P1, P2
Rangsit Tai	รังสิตใต้	2.81	50	50	70677	29440	42	P1
Ratchaburi LB	ราชบุรี (ฝั่งซ้าย)	3.30			20009	26	0	F, G
Ratchaburi RB	ราชบุรี (ฝั่งขวา)	3.38			26698	10813	41	G, F
Roeng Rang	เริงราง	2.92			27540	903	3	F, G, P
Samchuk	สามชุก	4.01	41	55	40691	22432	55	G, P
Sao Hai	เสาไห้							F, G, P
Song Pee Nong	สองพี่น้อง	3.91			11409	10940	96	G,(P)
Tha Lard	ท่าลาด	3.02			19469	60	0	F, P, (G)
Thabote	ท่าโบสถ์	4.29	32	44	27498	11498	42	G,(P)
Thamaka	ท่ามะกา	3.78			31243	18009	58	G,(P)
Yangmanee	ยางมณี	3.11	22	22	29089	3333	11	F, (G)
TOTAL					**1267622**	**459843**		

Map 4.3 shows the distribution of tube wells in the Central Plain. Areas with high density can be found in the Northern Delta and in the sugarcane area of the Mae Klong Project. This map distinguishes between public and private wells but does not specify the purpose of these wells. They include an unknown but probably low proportion of wells used for domestic purposes. Public wells are noted in Chai Nat and Sing Buri Provinces, where they represent an average of 10 % of the wells. They have been mostly excavated in the last five years as a governmental aid to counterbalance the water shortage of the dry season.

According to RID data, five thousand wells used for agriculture have been dug in the Borommathad Project, six thousands in the Chanasutr Project.

This map can be compared with map 4.4 which gives a qualitative idea of the accessibility of water for farmers. It displays an indice (water satisfaction), which is the average of the answers given (by each *mubaan*) to five questions of the NRC2D questionnaire related to water supply :

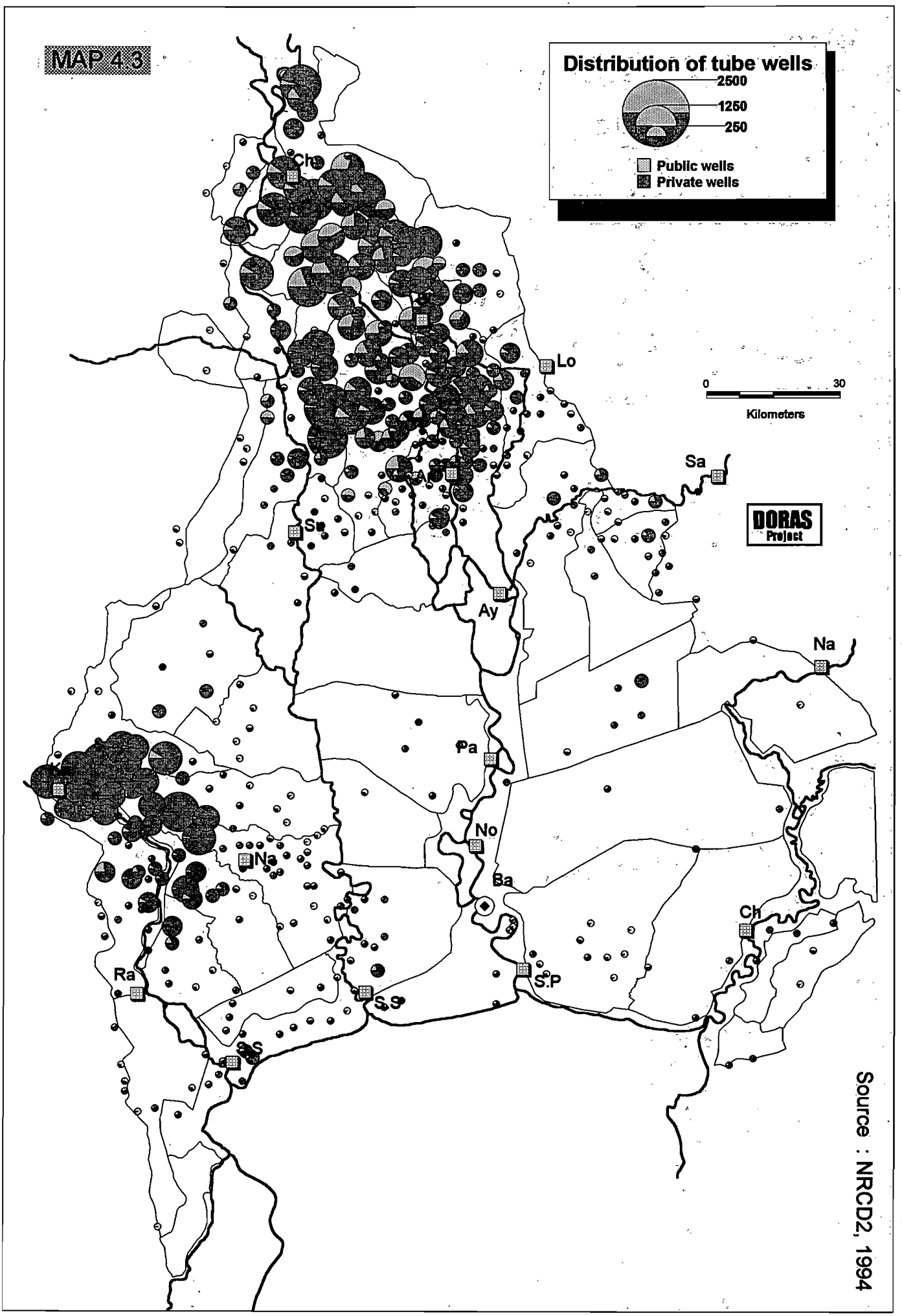
- Is there enough water supply for sugarcane (no = 0 ; yes = 1)
- Is there enough water supply for vegetables (no = 0 ; yes = 1)
- Is there enough water supply for tree plantation (no = 0 ; yes = 1)
- Is there enough water supply for second rice (no = 0 ; yes = 1)
- Is there enough water supply for annual field crops (no = 0 ; yes = 1)

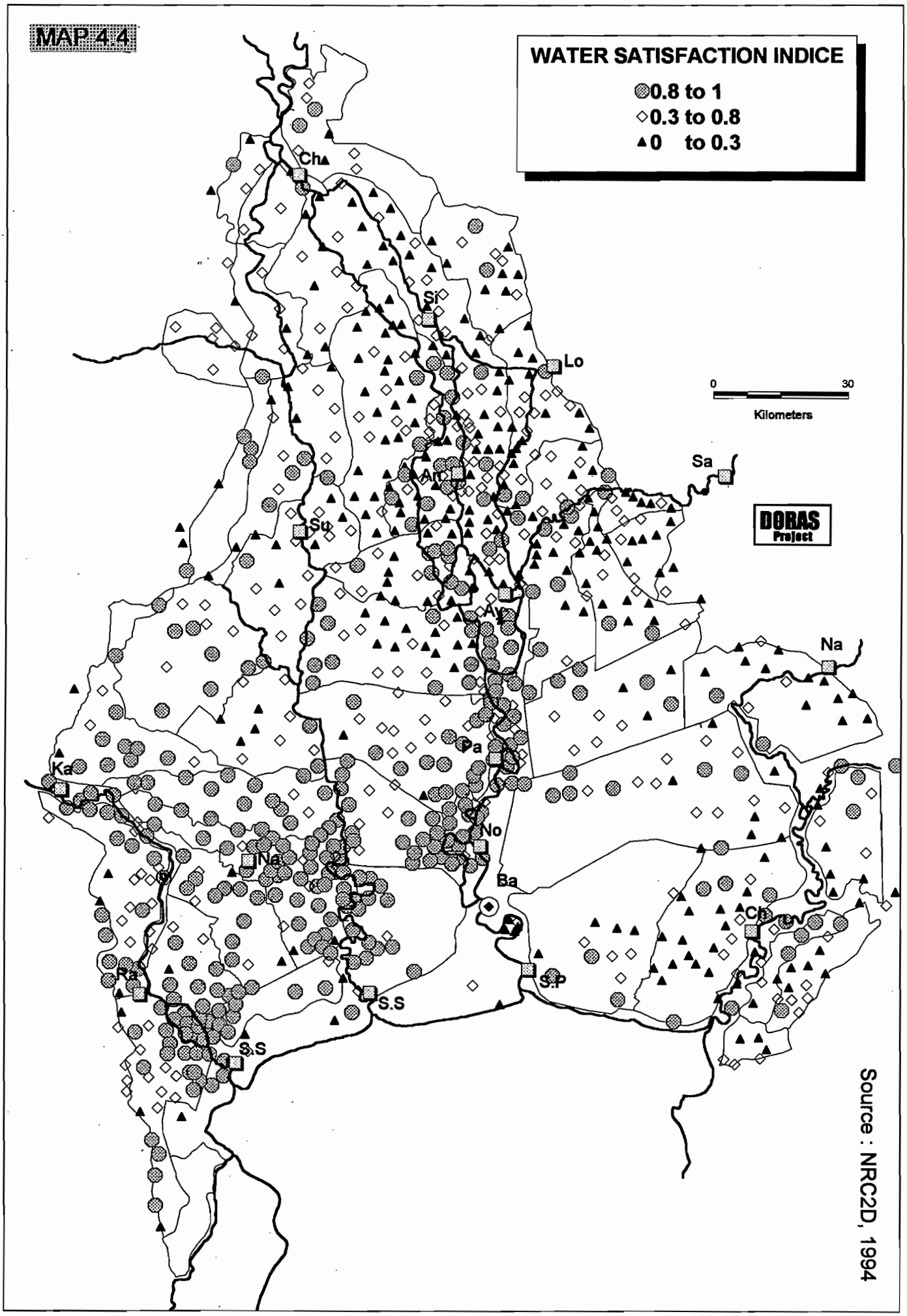
This map reflects the good average conditions of water supply in the Mae Klong area and along the main waterways of the upper delta. The worst conditions are to be found in the northern delta, especially in the flooded parts. They confirm the shortage experienced in the dry season and match the areas with higher development of ground water use.

Another consequence of the water shortage in the dry season is the trend to shift the dry season rice-cropping calendar, as described in section 3.2.3. This strategy is a farmer's alternative to having to face the water shortages of the dry season (March-April) which, in particular, may make land preparation impossible (peak of demand). In addition, such a calendar takes advantage of the residual field wetness and thus reduces the amount of water needed at the beginning of the cycle. Another benefit from such calendar shifting is the higher price of out-of season rice which can generally be obtained.

Among the drawbacks of such a strategy, is the necessity for farmers to find a secondary water resource (remaining water in canals and borrow pits, ponds, drains, natural depressions) during the month of January (during which supply is suspended), and the fact that the wet season crop harvesting will generally occur during rainy periods, with adverse impact upon the quality of the production.

The southern part of Don Chedi Project, which is badly affected by shortage due to it being at the tail end unit on the Chai Nat-U Thong Canal (dry season acreage being lower than 12 % in the 92-94 period), was recently subject to such a shift, with farmers trying to start second rice in late October.


MAP 4.3
Distribution of tube wells
2500
1250
250
Public wells
Private wells
0
30
Kilometers
DORAS
Project
Ch
Lo
Sa
Ay
Na
Pa
No
Ba
Ch
S.P
S.S
Ra
Na
Source : NRCD2, 1994


MAP 4.4
WATER SATISFACTION INDICE
0.8 to 1
0.3 to 0.8
0 to 0.3
Ch
Si
Lo
0
30
Kilometers
Sa
Ar
Su
DORAS
Project
Na
Ka
No
Ba
Ra
S.S
S.S
S.P
Source : NRC2D, 1994

It is worth noting that the other main area of the gravity zone which advanced its cropping calendar is the Phophya Project, also at the southern extremity of the upper delta; its conditions (main canal branching from Tha Chin river) are nevertheless better than those in Don Chedi.

Another aspect of the calendar shifting is worth noting : in the eastern part of Kamphaengsaen Project (class C2), for example, only a certain proportion of the land - the lowest parts - will have drainage problems in the late rainy season. Some farmers therefore choose to start their dry season in December, instead of February as is the rule in the Greater Mae Klong Project, and advance their wet season rice-cropping as well. By doing so, they impose flooded conditions in their areas and the other farmers, who might not have made the same choice, are forced to adopt the same calendar. In that particular case, water shortages at the end of the irrigation system may also have contributed to induce this strategy, like in the upper delta.

A reduced discharge in the canals also has an impact in the projects located near the sea shore. As already noted, in the eastern part (Khlong Dan Project), the *khlongs* function as drains and receive an inflow from the superficial and saline water table. This seriously affects the water quality and some of the many fish/shrimps ponds of the area have to interrupt their production.

As a palliative to bad water access during the dry seasons of the 91-93 period, some farmers have formed groups in order to request mobile pumps from RID to ensure irrigation of their diversification crops. This has been noted, for example, in the Nakhon Nayok, Roeng Rang and Khok Katiem Projects.

4.4.2 Decrease in risk and shift from traditional varieties to HYV

In the last ten years, the average overall diminution of water flows, in both rainy and dry seasons, have benefited some areas prone to prolonged mild flooding (see next section for details). In the Rangsit Tai, Pasak Tai and Chao Ched Projects, for example, change in flooding conditions has allowed some farmers to plant High Yield varieties for the first time. In Nakhon Nayok Project, the use of *namtom* together with HYV has also increased in the upper lands during the last two years

Nevertheless hydrologic conditions are **fluctuating** and the **risk** is constantly evaluated by the farmer. In Rangsit Tai Project, decreasing flooding depths allowed the cropping of HYV, even if the duration of the flood is such that harvesting must be done by hand with some ponding water. This shift is not, of course, deprived of risk, and some farmers who engaged in it damaged their crops. The severe flooding of 1995, for example, took many farmers who had given up floating rice by surprise, which resulted in the complete loss of their crops (e.g in Khok Katiem and Roeng Rang Projects).

Likewise, in some areas where formerly floating rice was grown, the change of the flooding pattern allowed farmers to shift to deep-water rice, like in the south of the Chanasutr Project for example. In many cases, this is combined with some intensification features (herbicide and fertilizer). Yields can amount up to 60 thang/rai (3.6 t/ha) and are commonly between 40 and 50 thang/rai.

Generally, considering only physical constraints, farmers will attune their cropping calendars and techniques, together with the choice of rice varieties, to the patterns of the water regime and to their perception of risk. This is especially the case in the Maharat, Roeng Rang, Khok Katiem, Yangmanee and Chanasutr Projects.

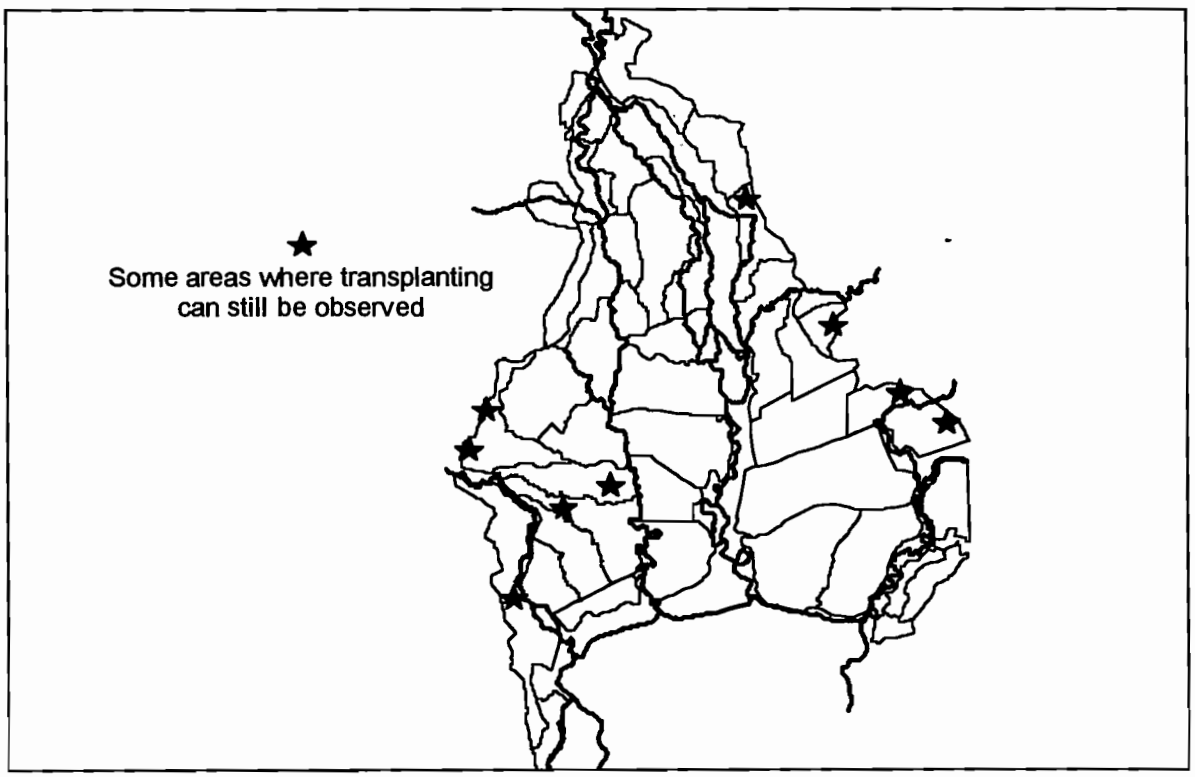
4.4.3 Some limited areas with transplanting

Nowadays, transplanting can still be found in the Central Plain, but is not likely to exceed 2 or 3 % of the rice area. We have seen earlier (§ 3.2) how and why its dominant position of 25 years ago shrank to almost nothing within 10 years.

Transplanted paddy fields generally correspond to three main situations :

- depressions where the first rains accumulate and where no drainage is possible.
- transplanting is used as a secondary technique to replant ill-drained areas of plots where *nam tom* has been used and germination has not been successful.
- in some - very rare - other cases, when farmers have sufficient labour force (often in small farms), they still may prefer and use the transplanting method to lower the costs of production, or to increase productivity, when they observed that, in the specific conditions of their plot, it gives a better yield.

Map 4.5 : Spot areas with transplanted rice in the rainy season



Map 4.5 shows some of the locations where transplanting can be found : some of the main areas are in the Nakhon Pathom Project, in the western border of Phanom

Tuan Project (40 % of the area), in the Chong Kae Project (around 5 %) and others like Nakhon Nayok or Ratchaburi Right Bank.

Transplanting, as stressed above, needs good water conditions for land preparation (or natural ponding water). This explains why some areas have reverted from transplanting to dry broadcasting, because of increasing uncertainty in water supply, such as in the Pasak Tai Project.

4.4.4 Adaptation of cropping techniques to the water regime

As for the case of transplanting described above, physical constraints of land (soil, topography, levelling) and water (irrigation and drainage control) strongly influence rice growing techniques and define an overall framework in which farmers will choose between possible options.

The most obvious relationship between cropping technique and water regime concerns class B where partially controlled flooded situations only allow the growth of deep water varieties or floating rice in the rainy season. If the flood period is limited (2 months), another solution consists in shifting the cropping calendar in order to avoid the flood (like in the West Bank, where water is available for two crops).

In the first case, the normal technique used for rice cropping is dry broadcasting, the land being prepared and ploughed by tractor before or at the beginning of the rainy season (*wan samruai*). Aside from this traditional technique, however, it is not uncommon to see cases of traditional varieties (of medium duration) established with a wet broadcasting method (*wan nam tom*). This is only possible when enough water is available for the land preparation and when the levelling and bounding of the plot are suitable. Farmers have thus improved their plot conditions to allow such a change, such as in the lower Chanasutr or Damnoen Saduak Projects. They have been encouraged to do so when water was available for dry-season cropping and the *nam tom* technique was to be used.

In fact, the cropping techniques also vary according to the possibility of growing a second crop of rice. In case of single cropping, traditional varieties are used with dry broadcasting; in case of double cropping, remaining water from the dry season allows the growth of traditional varieties with the *nam tom* technique. In Chanasutr and Khok Katiem, some areas alternate between these two situations, according to water delivery in the dry season.

In some places, like in parts of Nakhon Nayok and Bang Pluong Projects, farmers would use *nam tom* with local varieties because water control is good at the time of land preparation but uncertain afterwards (mild but possibly too long water accumulation for HYV).

In other projects, like in Chong Khae, the impossibility to grow dry season rice in the last four years drove the farmers to prefer dry broadcasting with an improved medium-cycle variety (in the rainy season). In that case, like in some others, it can be observed that the traditional *wan samruai* technique is not associated with flood

conditions but with water availability : in similar conditions, in the Roeng Rang Project for example, some farmers will grow HYV but a poor or delayed availability of water in the beginning of the rainy season may impede them to make a land preparation with the *nam tom* technique. In that case, when uncertainty on water delivery is too high, some farmers prefer to resort to dry broadcasting.

In summary, the most common cases of relationship between water control and cropping techniques are :

1➢ good access to water (canal, drain, well..) and good drainage : HYV varieties can be grown with the nam tom technique.

2➢ good access to water, especially in the period of land preparation, bunded and levelled plots, but risk of limited flood, in terms of duration or water depth : traditional varieties can be used with nam tom, in general with some fertilization.

3➢ bad or irregular access to water, especially in the period of land preparation; dry broadcasting of traditional varieties, with fertilization, is preferred, in particular if drainage conditions may be insufficient.

4➢ bad drainage conditions with ponding water in the plot before irrigation water is accessible; transplanting is adopted, in general with traditional varieties due to the risk related with poor drainage.

5➢ poor access to water, no on-farm facilities, unbunded plots and prolonged flood with limited water depth : deep water rice is grown with dry broadcasting and the water level is controlled by regulators located in the main drains.

6➢ poor access to water, unbunded plots, high probability of flood exceeding 1.00 m or very quick rise of the water level : floating rice is grown with dry broadcasting.

Some farmers may of course adapt their choice to the water regime : sufficient dry season water delivery allows a shift from 3) to 2); diminution of the flood risk, from 6) to 5); etc.

4.4.5 On going change of water regime and its consequence

Water conditions in the delta are slowly but continuously changing in many areas. The area of floating rice decreased and even disappeared in some Projects such as Phophya. Areas which were commonly using boats twenty years ago are not using them any longer. HYV can now be planted where 20 years ago deep water rice was to be found (see map 3.9). Several reasons account for such an evolution:

- ➢ the continuous improvement of drainage in the delta
- ➢ the construction of dikes and embankments (protection dikes and roads), which hinder runoff.
- ➢ the decrease of side flows coming from rainfed areas in the Central Plain, because of better storage and increased use in these areas;

- a decrease in the runoff due to better control (dams) and higher water consumption in the upstream part of the Chao Phraya basin.
- possible hydrological change regarding the decrease of average rainfall.

These changes can especially be noticed in the low lying areas where the flood regimes impose the use of deep water rice.

In order to :

a) sustain these medium or long cycle varieties at the end of the year (when water is likely to recede rapidly);

b) to raise the water level in order to reach higher lands;

c) to regulate the water level in the flooded areas, and

d) to help storing water in the waterways for the dry season,

regulators have been constructed in the main drains. Some of these regulators are very old, some are still being planned. Nevertheless, it appears that this "water retention management" can in some places be substituted by a "full drainage management". Such a substitution allows an increase in the acreage cropped with High Yield Varieties together with land use intensity, resulting in spectacular benefit for the farmers concerned.

Such an hypothesis is supported by a case study which has been carried out in the southern part of Borommathad Project where such a change occurred three years ago. Agriculture has been completely changed in an area of approximately 6,000 ha (38,000 *rai*) due to the non-use of a drain regulator. These changes include :

- switch from deep water rice to HYV
- large expansion of double and triple cropping
- marked increase of sugarcane which can now be planted in lower areas.

Such situations are common in the upper delta, with its undulating relief, and in the flood plains. Further research is required to better characterize these hydrologic changes and to analyse the possibility to modify water management together with agricultural patterns.

4.5 Water quality and environmental aspects

An extensive network of interlinked waterways allows a widespread and almost direct access to water. On the other hand, it constitutes a diffusion network for diverse kinds of pollution.

Pollution can be caused by agricultural wastes (pesticide, fertilizer, pork farms dejection), sewer outlets and industries. It has impact on domestic uses along waterways, on human health, aquatic fauna and flora and on several agricultural activities.

Organic load, with subsequent low levels of DO (dissolved oxygen) in the water, is mostly caused by domestic waste water and by waste water discharged from prawn, duck and pork raising farms. The situation is often worsened by high densities of

water hyacinth. Such problems are common but seem to be still marginal. However, even some rice cultivation or coconut plantations in the surroundings of Nakhon Pathom have been impeded or damaged because of pig farms waste water.

The problem of water quality in *khlongs* and rivers is not new and has been a source of public concern and action since the early 1970's. In 1979, pesticides residues were found in water, sediments and fish with a frequency of 50, 90 and 91 % respectively, even though in low concentrations. Dieldrin molecules have been found with a rate of 0.07 ppm in the Mae Klong river and concentrated in its aquatic fauna up to 0.358 ppm (Pimpan, 1979). In the Damnoen Saduak area, dieldrin was found in snake-head fish at the concentration of 3.59 ppm (Pethburanen et al., 1979).

High pollution in the Mae Klong triggered demonstrations by farmers and fishermen in 1973. In 1974, a project was launched to reduce the pollution originating from 20 sugar mills located along the river. Nowadays the level of DO in the Mae Klong is above national standard (Churai, 1995).

Pollution from chemicals products used in agriculture also reaches alarming values in areas devoted to intensive vegetable and fruit cropping. Overuse of pesticide is the rule in the Damnoen Saduak area where spraying, in some periods and for crops such as grapes, can take place every second or third day. Preliminary surveys carried out this year revealed that DO was as low as 1 mg/l in some areas, which turns water not suitable for agriculture. Pest pressure, possibly linked to chemical overuse, has led to shift or abandon diverse crops in the last years. In addition, farmers seem to be poorly aware of the impact on health of such frequent applications.

Industrial pollution is observed near urban areas, where agricultural and industrial activities have to cohabit. Along the Phasi Charoen canal, for example, as noted in the former chapter, water quality is often too low for some sensitive activities such as shrimp raising or orchid farming. Consequently, these activities are moving northward in search of more suitable conditions regarding water quality. Industrial waste in also a problem in the Tha Chin river, even at the level of Suphan Buri, were many food, textile and sugar manufacturing enterprises are located, and high levels of mercury are recorded (Churai, 1995).

Sea water intrusion can also be a problem in periods of low runoff in the rivers and can influence water quality along these waterways and in some canals of the lower delta which are not equipped with regulators.

4.6 Example of change in water management and water control : the West Bank

The West Bank area lies between the Chao Phya, the Suphan Buri river and is bordered by the Chao Chet canal on its northern part. Originally, this flat area was largely submerged in the rainy season and, similarly to the Rangsit area, lacked water in the dry season, which hindered settlement. Different historical phases of

land development and corresponding agricultural patterns can be briefly distinguished to exemplify change in water control in the Central Plain :

① Three canals were dug in the 40's to divert water from the Noi and Chao Phraya rivers to this zone, improving water deliveries throughout the year. At that time, rice cultivation was restricted to some deep water rice and floating rice, planted with the *wan samruai* traditional technique.

② In the 60's, the West Bank was converted into a reservoir to protect Bangkok from flooding and excess water led to the progressive abandonment of rainy-season cropping (traditional (dry)broadcasting), with a change to premonsoon cropping. This consists in shifting the agricultural calendar in order to avoid the deep flooding of September-October. In order to compensate the deterioration of the situation in the wet season, the Royal Irrigation Department tried to ensure better water supply in the dry season (see Takaya, 1987). The late sixties also correspond to the introduction of HYV, which allowed dry-season cropping (short cycle and photoperiod-insensitive varieties). The preparation of seedbeds was taking place during the month of April, transplanting in May and harvesting by the end of August.

③ During the 70's, a further shift to dry-season cropping was observed, further to dam regulation of dry season deliveries. Dry season cropping was preferred to premonsoon cropping because the yield (and often the price) was higher (better photosynthesis), and because harvesting did not take place in the middle of the rainy season (Takaya, 1987).

④ At the same time and subsequently, double cropping tended to spread throughout the whole area, like in many locations of the delta. The dry season rice, HYV, was transplanted in February (with seedbeds prepared in January) and harvested from April to May. At the same time nurseries of traditional varieties were prepared for the rainy season rice-cropping, which would be harvested in December.

⑤ In the 80's, transplanting was substituted by wet broadcasting. Improvements in embankments and water regulation allowed the use of HYV in both rainy and dry seasons.

⑥ In the late 80's and early 90's, shortage of water in the dry season led farmers to advance the calendar of the dry season in order to capitalize on the plentiful water available at the end of the rainy season. The second rice was planted between October and December, according to the receding of the flood.

Such an evolution is instructive of the relationship between rice cropping and overall water conditions. It also provides clues to alternative proposals and improvement of water deliveries, such as a possible policy to plan dry season rice-cropping as a continuation of the rainy season.

Chapter 5

Farming Systems :
Production structure and economic environment

Introduction

The farmer's decisions, about crop choice and cultural intensity, depend on many factors. Their combination and the resulting technical behaviour observed on the farms may be analyzed as a system. Such an approach stresses the interdependence not only between components, but also between levels of organization : field, farm, region... For instance, the investment required for a change can be sought in the assets of a big farm. When lending institutions offset the lack of resources of small farms, these also take part in the change.

For that reason, as an initial attempt to clarify the role of the main factors, two sets are presented here : firstly, the production structure, which includes the labour force, assets, surface area, and, secondly, the economic environment which includes the possibilities of contracting workers, renting land, engaging in off-farm occupations and obtaining credit. When required, it will be called on other types of factors involved in the crop combination : cultural, social, technical... In order to prepare a general frame of interpretation of the behaviour of the farmers, the concepts of family objectives and functioning limitations issued in the farming system analysis will be used.

5.1 Specialization of cropping patterns

5.1.1. Methodology

To simplify the analysis of production structures and the economic environment of farms, seven main cropping patterns have been defined. This simple typology is based on plant productions, which are supposed to mirror a set of ecological, structural and environmental conditions. Thus, the comparison of two cropping patterns or one of them with the average of the delta can clarify the role a factor plays on a particular choice in a particular situation.

The bulk of the information comes from the 1994 NRC2D dataset designed by the Ministry of Interior (Appendix 1). We grouped the villages in nearly 1000 *tambons*. Most of them are rather specialized, at least in respect of the seven cropping

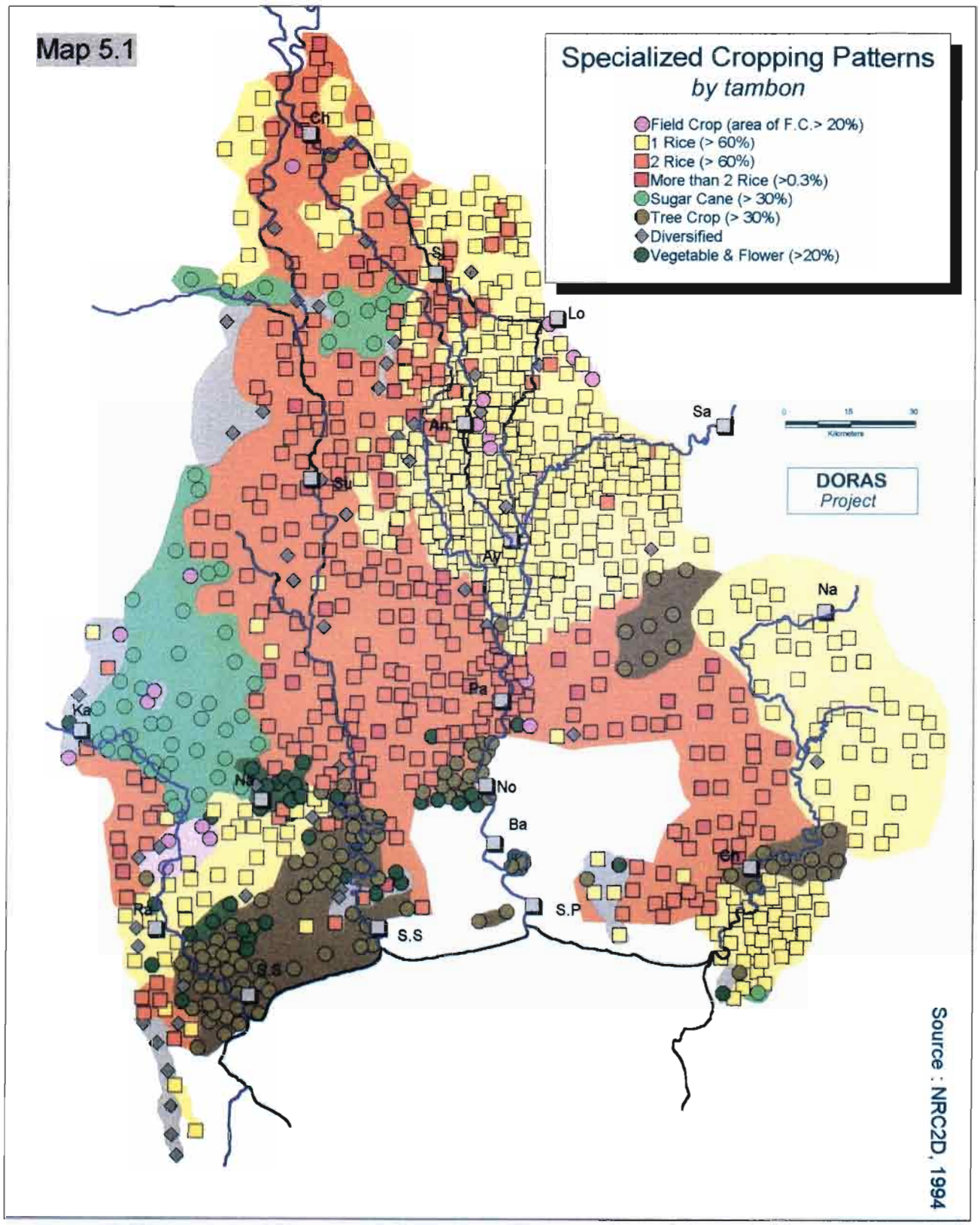
patterns. Of course, Tree crops, Field Crops and Vegetables & Flowers included a variety of plant produce. We separated the sugarcane cultivation from the Field Crops cropping pattern because it concerns a relatively larger area.

Table 5.1 : Definition of 7 specialized cropping patterns

Cropping pattern	Planting area threshold	number of *tambon*
Field Crops (except sugarcane)	≥ 20 %	23
Vegetables & Flowers	≥ 20 %	42
Sugarcane	≥ 30 %	62
Tree Crops	≥ 30 %	133
Single rice cropping (Rice 1)	≥ 60 %	435
Double rice cropping (Rice 2)	≥ 60 %	288
Triple rice cropping (Rice 3)	≥ 0.3 %	32
Diversified	Other	37
	Total :	1052
Chao Phraya delta	Total :	996

When more than 60 % of the planting area of one *tambon* is occupied by one rice crop a year, the *tambon* is classified as Rice 1 cropping pattern. It does not mean that there is no other crops in this domain. In general, the planting area threshold has been defined to get a meaningful number of *tambon* in each group, at least 20. *Tambons* that belong to no group at all are included in an additional Diversified cropping pattern. Such a way minimizes the problem raised by *tambons* which contribute to two groups. For example, *tambons* with more than 60 % of one rice crop and more than 20 % of field crops are included both in Rice 1 and Field Crops cropping patterns. For that reason, the sum of *tambons* classified by cropping pattern exceeds the number of *tambons* within the Chao Phraya delta.

The specialized cropping patterns localized in map 5.1 follow a simpler pattern than the main land use map. Slight differences between the two maps are the result of the information processing and the purpose of this classification. Thus, small areas of rice farming are classified as Sugarcane or Diversified cropping patterns because planting areas are close to the threshold. Rice 1 cropping pattern includes floating, deep-water and rain-fed rice area. Rice 2 cropping pattern is more homogeneous because more intensive rice growing requires better water control and mechanization. Tree Crops are mostly localized in the young delta with some exceptions such as the pomelo cultivation near Chai Nat. As a rule, Tree Crop cropping pattern shows little sugarcane, and vice-versa. Field Crops are scattered over Rice 1 domain, near Ayutthaya, and over the Mae Klong Sugarcane domain. Vegetables & Flowers are close to Tree Crops cropping pattern, but can be clearly distinguished. A few *tambons* classified as Diversified are scattered over the Chao Phraya delta.


Map 5.1
Specialized Cropping Patterns
by tambon
Field Crop (area of F.C.> 20%)
1 Rice (> 60%)
2 Rice (> 60%)
More than 2 Rice (>0.3%)
Sugar Cane (> 30%)
Tree Crop (> 30%)
Diversified
Vegetable & Flower (>20%)
DORAS
Project
Ch
Lo
Sa
An
Su
Av
Na
Pa
Ka
No
Ba
S.P
S.S
Source : NRC2D, 1994

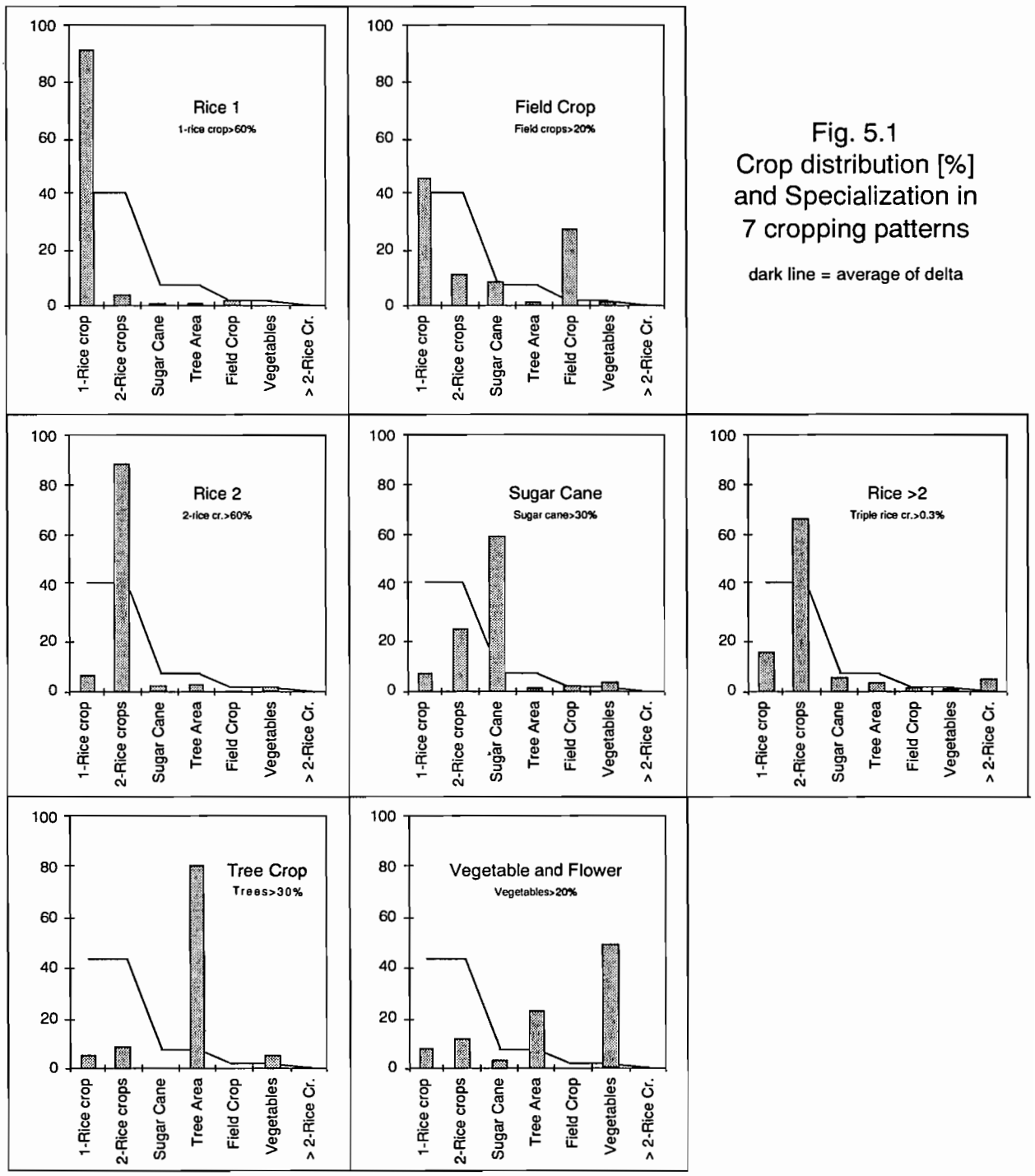


Fig. 5.1
Crop distribution [%] and Specialization in 7 cropping patterns

dark line = average of delta

5.1.2. Magnitude of specialization

As shown in figure 5.1, three cropping patterns present a high degree of specialization: Rice 1, Rice 2 and Tree Crops. For them, the *tambon* agricultural area comprises of hardly any other crops. Rice 3 cropping pattern is an intensive version of Rice 2 cropping pattern with 3 crops a year in general and is scattered in the Rice 2 area. Although a small area is concerned, it is meaningful both to understand the involved factors and for the future of the rice growing in the Chao Phraya delta.

Figure 5.1 can be read in this way : for *tambons* classified in Rice 1 (planting area of 1-rice crop a year > 60 %), the average area of 1-rice crop a year reaches 91 %. It is a very specialized domain. The remaining 9 % are shared by 2-rice crops a year (4 %), field crops (2 %), sugarcane and vegetables.

The three remaining cropping patterns are specialized, but less than the first three. The Field Crops cropping pattern is clearly linked with Rice 1 of which it is a less specialized version. It also appears in the Sugarcane domain. *Tambons* classified in Vegetables & Flowers show an average orchard share of 20 %. Sugarcane is grown in two areas that also receive an average of 20 % of 2-rice crops a year in scattered lowlands.

5.1.3. The demographic aspects of cropping patterns

The Chao Phraya delta agriculture has not yet reached its highest level of output, even though we note various trends in that direction, in particular with vegetables and triple rice cropping. On the other hand, a large stretch of land continues to be dedicated to low-input and low-productivity farming, in particular in the Rice 1 cropping pattern. Floating, deep-water and rain-fed rice cropping can only be improved through increased land development and water control. Here, farmers have developed strategies in conjunction with other economic sectors. These features are well expressed through the demographic structure. Thus, if few differences between rice production and other ones are observed, Rice 1 cropping pattern and all other forms of more intensive farming can clearly be distinguished.

Rice 1 and Field Crops cropping patterns show a particular demographic profile in the Chao Phraya delta. Rural families are small (4.7 persons) whereas the families in Sugarcane domain are larger (5.5 persons). If the working population is similar with the delta average, young people particularly men leave the villages. By contrast, elderly people return to the village to enjoy their pension after a working life spent outside. Such a demographic structure is a consequence indeed of a harsh agricultural situation. In return, peasant dynamism is low and farmers carry on a low-input, low-labour farming. Field crops are a way to improve the agricultural income and the population in the Field Crops cropping pattern seems to have preserved a better-balanced demography.

By contrast, Sugarcane and Vegetables & Flowers regions succeed in stabilizing the rural population, in part because the agricultural income is higher. However, working

populations are rather different : big families in the former and more men to cope with the labour demand of vegetable cropping. Both show few elderly people.

Table 5.2 : Demographic structure by cropping pattern

Cropping Pattern	Non Municipal Population per Household	Population under 14 years-old [%]	Sex ratio	Population 15-50 years-old [%]	Population above 50 years-old [%]
Rice 1	**4.7**	**23**	**0.92**	**55**	
Field Crops	**4.8**	24	0.94	56	20
Tree Crops	4.9	24	0.93	56	20
Chao Phraya delta	4.9	25	0.93	56	20
Rice 2	5.1	25	0.94	**55**	20
Rice 3	5.1	25	0.94	56	19
Vegetables & Flower	5.0	25			**18**
Sugarcane			0.94	56	**17**

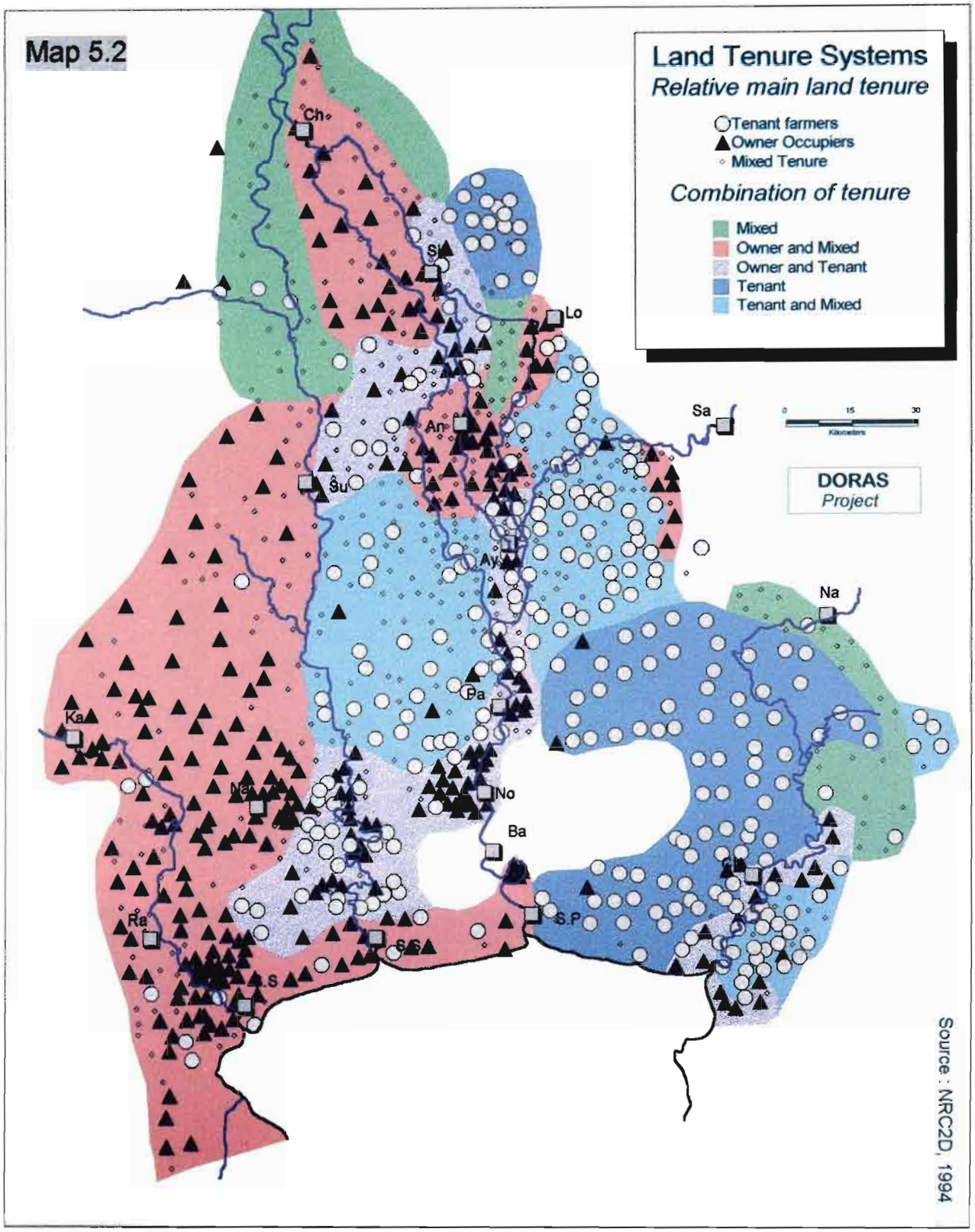
Here it is assumed that the range 15-50 year-old matches with the rural labour force, particularly in agriculture. To make the columns comparable, table data have been firstly standardized by a classical average and standard deviation process. Then, columns, as well as rows, have been swapped to highlight the table structure with a "diagonalization" of the data. Two nearby columns display a similar profile, as Rice 1 and Field Crops for instance. Conversely, the more remote the rows, the stronger the opposition between cropping patterns, as shown by Sugarcane and Vegetables & Flowers versus Rice 1 and Field Crops in table 5.2. Variables are also grouped together to stress opposition and vicinity.

5.2 Farm Production Structures

The distribution of production factors, as land, labour force and farm equipment, witnesses the development reached by the farms. It sheds light on the crop potential and on the functioning of farms as well.

5.2.1. The land

During the past few centuries, the delta has been an agricultural frontier and its steady reclamation gave way to various land tenure systems and property size distributions (see historical aspects in Chapter 2). Presently, the many land contracts are adapted, when possible, to the farming situations. Renting in particular can be found with groves or fields with raised beds. However, a sharp distinction remains in the delta between ownership and tenant farms as shown in map 5.2xx. In times past, large holdings have been created in the eastern delta because landlords of the Thai gentry participated to its reclamation and, nowadays, tenant farming is common in this part of the delta. Elsewhere, full ownership is dominant because the abolition of *corvée* and the development of personal freedom in the nineteenth century allowed many families to settle as farmers wherever land was available. The widespread ownership along the Chao Phraya, Bang Pakong and Lop Buri rivers, where it follows a lane pattern between mixed or rented tenures, mirrors old settlements.


Map 5.2
Land Tenure Systems
Relative main land tenure
Tenant farmers
Owner Occupiers
Mixed Tenure
Combination of tenure
Mixed
Owner and Mixed
Owner and Tenant
Tenant
Tenant and Mixed
DORAS
Project
Ch
Si
Lo
Sa
An
Su
Ay
Na
Pa
Ka
Ner
No
Ba
Ra
S.P
S.S
Source : NRC2D, 1994

Although freehold is predominant in the delta (table 5.4), each *tambon* is shown as a relative dominant land tenure. It has been computed as the maximum of the standardized data. As a result, map 5.2 displays a more or less equal number of *tambons* in each of the three classes : owner, tenant and mixed.

As no area shows complete ownership, the delta is shared between 4 types of combination : Rent, Mixed, Rent-Mixed and Owner-Mixed. Rent farming in the southeastern part sets off a true core which spreads eastward from the Tachin river in the young delta. By contrast, full ownership combined with mixed tenure occupies the remaining delta. Freehold is especially dominant in the Mae Klong area and south of Nakhon Pathom around Damnoen Saduak. The upper part of the old delta, as well as the eastern margin of the young delta, show a peculiar pattern of mere mixed tenure where ownership is systematically combined with renting.

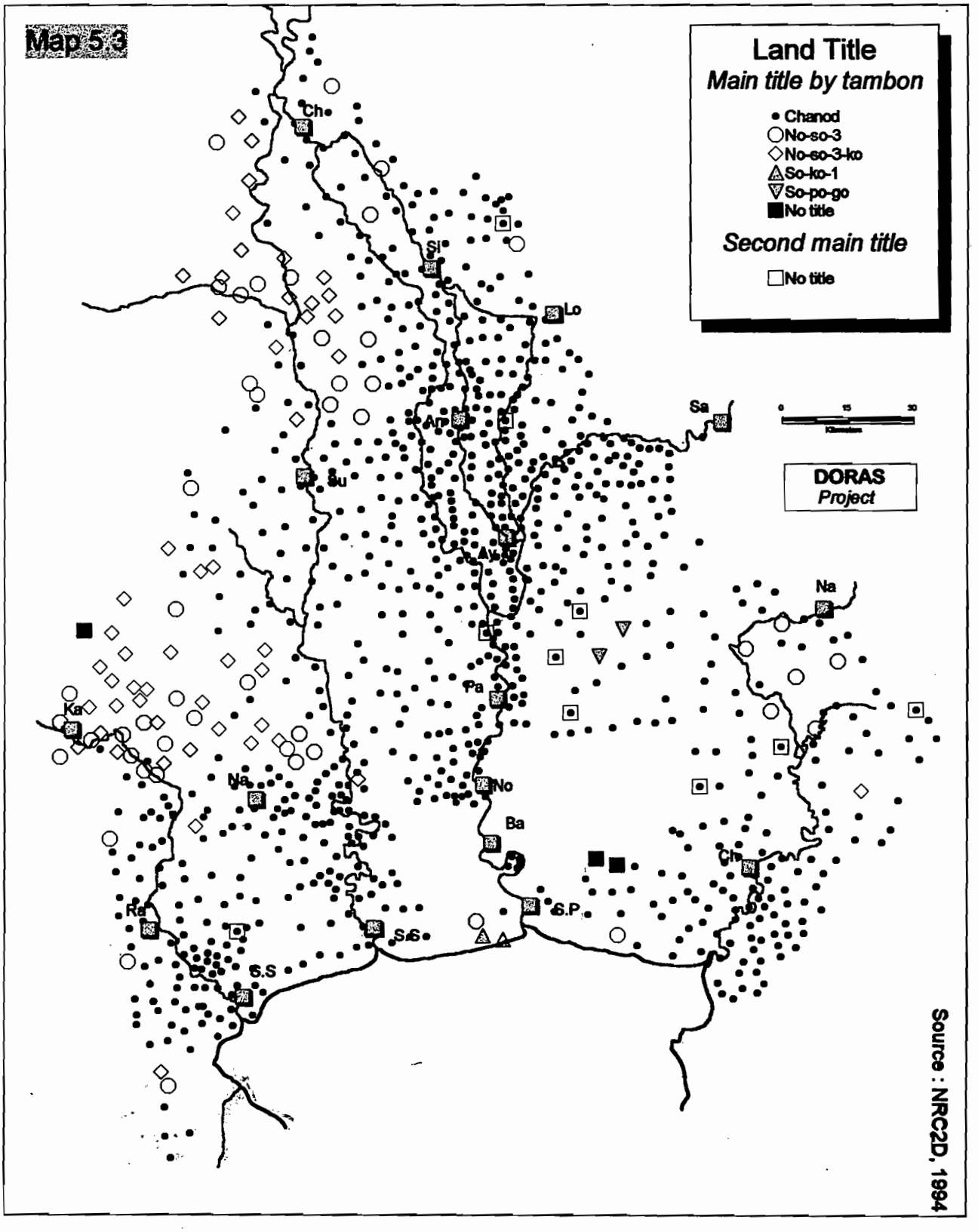
Table 5.3 : Land title issued by the Land Department

Name	Document	Kind of property	Collateral from	
			official bank	middlemen
Chanod	First class	Freehold	Yes	
Nor-sor-3	Third class	Right of usage	No	Yes
Nor-sor-3-kor	Second class	Right of usage	Yes	
Bai-song		Settling allowed		
Sor-kor-1 1955				
Sor-tor-gor				
Sor-por-gor				

In the delta, almost every owner has a land title from the Land Department (map 5.3). In 912 *tambons*, *Chanod* title, namely full ownership, is the most widespread document. Titles *Nor-sor-3* and *Nor-sor-3-kor* are common in 98 *tambons*, in particular in the sugarcane area. Among the second main titles, *Nor-sor-3* is widespread. No title can be found in a few places where it is probable recent encroachments onto public forests or mangroves have occurred.

Although on some occasions nearby *tambons* have contrasting farm sizes, map 5.4xx shows that the overall distribution of size specifies a few zones. The smallest farms are located south-west of the delta, roughly around the towns of Nakhon Pathom and Ratchaburi as far as the sea, and, in the old delta, specifically in the flood plain between the towns of Angtong and Sing Buri. By contrast, the largest farms are included in the eastern part and in the middle of the delta. It is approximately the pattern followed by tenure. Large farms are also located on the edge of the delta, which result from recent settlement. Conversely, the smallest farms situated in the flood plain are likely to be the result of long years of settlement and of the splitting up of land through generations of farmers.

In some cases, the average farm size by *tambon* hides an extensive range with landlord farms and land-less peasants. For rice holdings, the available information enables to be more specific (see further).


Map 5.3
Land Title
Main title by tambon
Chanod
No-so-3
No-so-3-ko
So-ko-1
So-po-go
No title
Second main title
No title
DORAS
Project
Ch
Si
Lo
Sa
Ar
Su
Ay
Na
Pa
Ka
Na
No
Ba
Ch
Ra
S.P
S.6
S.S
Source : NRC2D, 1994

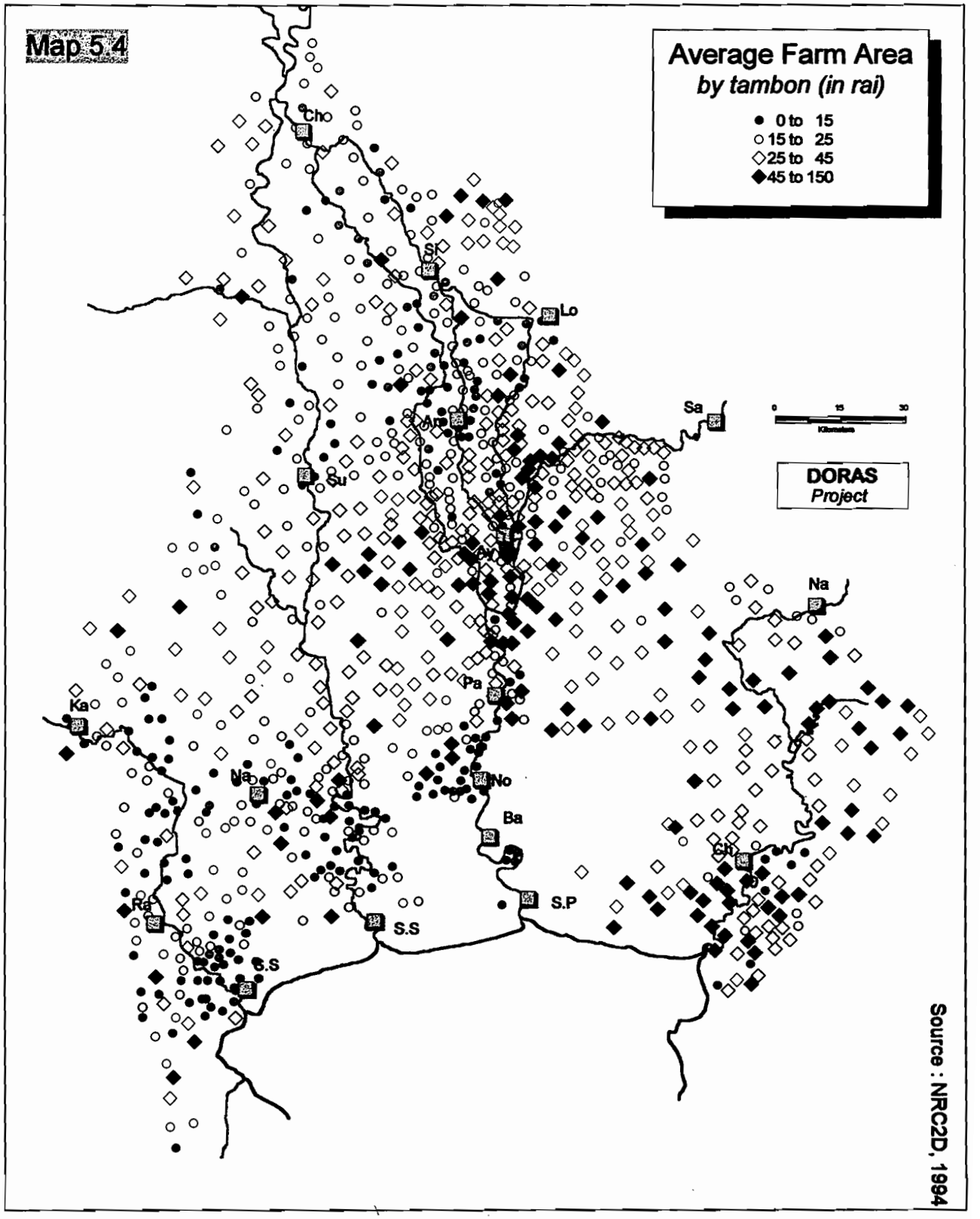

Map 5.4
Average Farm Area
by tambon (in rai)
0 to 15
15 to 25
25 to 45
45 to 150
Cho
Lo
Sa
Su
Na
Pa
Ka
No
Ba
S.P
S.S
DORAS
Project
Source : NRC2D, 1994

Table 5.4 : Land tenure system of cropping patterns

Cropping pattern	% Main Title *Nor-sor-3-kor*	% Main Title *Nor-sor-3*	% Full Owner Farms	% Mixed Tenure Farms	% Rent Tenure Farms	Origin of Rented Land
Sugarcane				23	**10**	**2.2**
Tree Crops	**0**	**1**		**15**	19	2.3
Vegetables & F.	**0**	5		**12**	24	2.3
Field Crops	17	4	57	29	14	**2.2**
Delta	5	2	51	28	21	2.4
Rice 3	6	2	44	30		2.4
Rice 1	2	3	44		24	2.4
Rice 2	4	5	**43**		24	

Farm size and land tenure have an impact in many ways on the choice of cropping pattern. Property is used as a collateral to obtain credit and to allow for investment in new cropping systems. Renting diminishes the income, above all it can prevent plot development or hinder the establishment of an orchard. Property may lead to the diminishing of farm population when "Sunday farmers" give opportunistic prices for the land. It is thought that big farms with enough capital use more fertilizers and chemicals. In fact, they have the choice either to intensify or to practice a low-input agriculture. On the other hand, small farmers have to intensify land-use unless they work off farm.

Sugarcane farms are mainly owner-operated. Tree Crops and Vegetables & Flowers cropping patterns rest also on ownership. For paddy farms, with either extensive or intensive technology, every tenure system can be found. The same occurs for Field Crops where there is little renting however.

In table 5.4, the variable "Origin of rented land" displays a higher figure when the renting is further from the village.

The relationship between renting places and renting suggests that where it is widespread, farmers must seek plots outside the village. This is the case of rice farmers, whether Rice 1 or Rice 2. By contrast, in the Sugarcane domain, tenants rent few fields mostly within the village.

Vegetables and fruit tree farming are an opportunity for small farms to earn more money per rai, such as in the south-eastern part of the delta. Where conditions are adverse, as in Ratchaburi region, small rice farmers with one crop a year began abandoning farming a few years ago and in some cases they sold their land to families of Damnoen Saduak region. In Rice 1 cropping pattern, with extensive farming, we find as many small owners as large tenants. However, field crops are found in small farms to supplement their income. Lastly, Rice 2 shares every type of tenure and farm size. Table 5.5 summarizes these features.

Lastly, Rice 1 and Field Crops cropping patterns are the domains of relatively large farms, which seems compulsory to ensure the economic viability of an extensive

package. As seen before, the smallest farms are located in Tree Crops and Vegetables & Flowers cropping patterns, with remarkable exceptions in Rangsit and Chachoengsao area. However, the farm size range varies widely in every cropping pattern.

Table 5.5 : Land system of cropping patterns (summary)

Cropping patterns	Main Tenures	Main Property Title	Average Farm Size [rai]
Field Crops	Owner and Mixed-operated	*Chanod*	27
Rice 1	Often	*Chanod*	29
Rice 2	Rent-		25
Rice 3	and Mixed-operated		26
Sugarcane	Owner-operated	*Nor-sor-3, Nor-sor-3-kor*	21 (uneven)
Tree Crops	Owner-operated	*Chanod*	18
Vegetables	Owner-operated	*Chanod*	14

5.2.2. The labour force

a. Man power in agricultural evolution

Following the saturation periods in the delta (see chapter 2), a preindustrial agriculture, without industrial inputs, should follow an evolution where more population means less land per family and more work per rai. Total production increases to feed more people, but labour productivity and surplus diminish at the same pace. In Thailand however, two events modified the preindustrial pattern. Firstly, in the 1960s, the purchase of two-wheel tractors and the rent of big tractors (Tanabe, 1994) avoided any division of properties. Furthermore, these enabled the farmers to farm all the land, alleviate strenuous work and offset the sons' departure to towns. At the same time, the improvement of both water control and irrigation allowed for yield increases in the now Rice 2 areas. However, the low to medium use of fertilizer, including in the double rice cultivation, might be less due to the labour shortage than to the risk of flood or irrigation water shortage. This transition period towards industrial agriculture saw the shift from the maximization of labour productivity to the increasing of the per land unit yield.

Secondly, in the early 1980s, a boom in industry mobilized rural manpower and forced agriculture dynamics to adapt to a low labour force. Mechanization and labor-saving practices continued to spread within the delta. At the same time, a new demand from the food industry and urban markets enabled high value farming such as vegetables and flowers. These labour intensive activities cannot be grown on a big scale without retaining workers with higher wages. In many cases, vegetables are grown on small farms with the family labour force. Today, a sharp contrast opposes low-input, low labour farming as single rice cultivation and high input, high labour market gardening. At the same time, fallow land can be observed nearly everywhere, which emphasizes the gap between the farming intensity levels and reveals the extremely different stimuli offered by the agricultural business.

For Rice 1 cropping pattern, an increase in output would require better water control without which technical changes - such as mechanization and herbicide use - only reduces labour. Large stretches of fallow land question the future of this agriculture which is mainly composed of part time or elderly farmers. In the Rice 2 situations, high-input farming is sought, but poor water control makes the agriculture risky and hinders a more intensive use of the land in some parts of the delta. Moreover, technical change -such as *nam tom* technique, efficient irrigation and drainage, or harvest mechanization- only occurs if labour is reduced. This trend towards labour-saving technology goes alongside the development of a labour intensive farming which can be found in many situations as stressed in the next table. In a few cases, the manufacturing sector secures a part of the agricultural manpower instead of removing it. Near Banglen, in Nakhom Pathom province, where there are some scattered industrial estates, a few farmers grow vegetables because they have the opportunity to hire women whose husbands work in nearby factories.

Table 5.6 : Requirement in production factors for some activities

	Capital	Labour force per rai	Income per rai	Water control	Farming system
Orchid farm Crocodile farm	Very high	Very high	Very high	Artificialization	Entrepreneur
Guava, Chicken	High	High	High	Artificialization	Wealthy, small farmers
Shrimp farming, Mango, Orange	High	Low	High	Artificialization	Large and small farmers
Low-i. Coconut, Eucalyptus	Medium	Low	Low	Medium	Absentee landlords
Asparagus, Baby corn	Low to Medium	High	Medium	High	Small farmers
Leaf vegetables	Low	Medium	Medium	High	Small farmers

With insufficient irrigation or drainage and poor farming practices, labor shortage is among the main reasons to explain the medium intensity of farming in the delta, especially for double rice and sugar cane cultivation. As shown in the historical process, manpower and water control are dependent upon each other. Nowadays, the agriculture of the delta is much more complex. Up until the 1950s, an absolute labor shortage impeded the rural population to cultivate every part of the delta. Today, fallow land expresses the relatively low incentive of the agricultural activities and the departure of the bulk of the working population towards the industrial sector. However, today's situation is different from that prevailing before. On the one hand, low input agriculture will be preserved owing to off-farm jobs. On the other hand, intensification is sought elsewhere, with triple rice cultivation or high value-added farming. In the short run, a relevant problem occurs in the areas without any possibility to intensify or to practice off-farm occupation, namely in some parts of Rice 1and Rice 2 cropping patterns.

With the gap being becoming increasingly wider between cropping systems, a general view of the agriculture in the delta is misleading because the average situation does not exist. It is the same within each cropping pattern. Thus, Rice 2

and Sugar Cane make use of various levels of technology while the preceding table shows the conditions required for new crops. Labor and water control issues have impacted differently according to the location and to the stage of development. A thorough study of each case is required to characterize the technical system and to provide an interpretation, given that a particular technique must be assessed within its own working environment. Unlike high levels of fertilizer use and high yield varieties, mechanization and herbicides do not always mirror higher output farming. In the delta, they constitute the first labour saving technologies. As for *nam tom*, water and capital are a substitute for labour. Regarding pesticides, their use mirrors the objective of securing a harvest. If excellent yield can be found in some parts of the delta, generally high yields are widespread. Adaptation to diminishing labour and water control improvements are two relevant issues to be addressed, but they also have to be treated separately. Adapting to labour shortages caused by migration or off-farm activities may lead to technical change without improving productivity. Conversely, improvements in water management allow more crops per year or higher input-output agriculture. Furthermore, there is a relationship between both factors as stressed by the substitution of labour by water management as with the *nam tom* practice.

b. Agricultural population

With a low level of mechanization, single rice harvesting and above all sugar cane cultivation still require the use of seasonal migrants. Except for the harvest period at the beginning of the year, the farmers engage a small labour force. To regulate cane delivery, sugar mills have been leasing some harvesting machines for several years now. The labour requirement for tree crops is also low and equally distributed throughout the year. Rice 2 and Vegetables & Flowers demand more labour all year round. In rice cultivation, farmers face peak work periods at the turning-point between harvest and tillage.

Table 5.7 : Agricultural Population in the delta

Cropping Pattern	Rural Population by Household	Agricultural population per rai	Area per farm (rai) -*[recalling]*
Sugarcane	5.5	0.26	21
Rice 2	5.1	0.20	25
Rice 3	5.1	0.19	26
Vegetable&F	5.0	0.35	**14**
Delta	4.9	0.19	25
Tree Crops	4.9	0.28	18
Field Crops	5.1	0.18	27
Rice 1	**4.7**	**0.16**	29

It is assumed that Rural Population per Household is equivalent to Agricultural Population per Farm. Consequently :

$$\frac{\text{Agricultural Population}}{\text{Agricultural area}} = \frac{\text{Agricultural Population/ Farm}}{\text{Agricultural Area / Farm}}$$

These three variables summarize the relationship between population and land. Essentially, the relationship between Agricultural Population per Farm and Agricultural Population per rai highlights three peculiarities.

Table 5.8 : Land and Population by cropping pattern (Summary)

	Family	Farm Area	Density
Sugarcane	Large	Medium	High
Vegetables & Flowers	Medium	Very small	Very high
Tree Crops	Medium	Small	High
Rice 2, Rice 3	Medium	Medium	Medium
Rice 1, Field Crops	Small	Large	Low

Where average families live in very small holdings, vegetable farming is a remunerative activity. There, the agricultural population density reaches 240 persons per km2. Population density is high in the cropping patterns Tree Crops and Sugar Cane as well. The average situation for Sugar Cane is characterized by large families per farm. However, this average situation does not describe the reality and map 2.xx has already stressed the disparities between land and population for Sugar Cane, specially between the northern and southern part of the Mae Klong fan terrace. Orchards are planted to supplement the income of intermediate families on small farms. With the exception of sugar cane farming, land and population features are consistent with the cropping pattern choice. Even though other factors play a role in the strategies for vegetables, single rice and fruit tree cropping, there is a close relationship between population and land.

As seen in the map 2.xx, the distribution of densities of the agricultural population highly contrasts. Some cropping patterns exhibit a broad internal diversity, which would tend to bring some reservations on the effect the land and population characteristics has on the cropping strategy. However, a modal density is characteristic of two cropping patterns : Vegetables & Flowers and Tree Crops.

The regions with highest population densities, located in the southern part of the delta, near Bangkok, Samut Sakhon and Nakhon Pathom, have many vegetables and plantations of fruit trees. Small farms with sugarcane and vegetables are found near the Mae Klong river.

To summarize the portrait of the agricultural population, the delta can be divided in three parts :

1. approximately the eastern half, except Bang Pakong river banks, accommodates relatively little agricultural population. Single and double rice cultivation are common here.

2. the western half is more populated.

3. some parts in the south of the western delta and near Chachoengsao are highly populated. Labour intensive crops or high value added shrimp farming developed there.

c. Off-farm activities

In the delta, multiple occupation concerns 57 % of rural households. As displayed in map 5.5, it can be seen everywhere, except in the low populated east and in the Damnoen Saduak area. The latter situation might suggest that tree and vegetable cropping is determined by low wages, both for contracting extra workers and for not diminishing the family labour force. By contrast, Field Crops pattern, north of Ayutthaya, shows the highest rate of multiple occupation (67 %). Floating rice is often managed by part-time farmers.

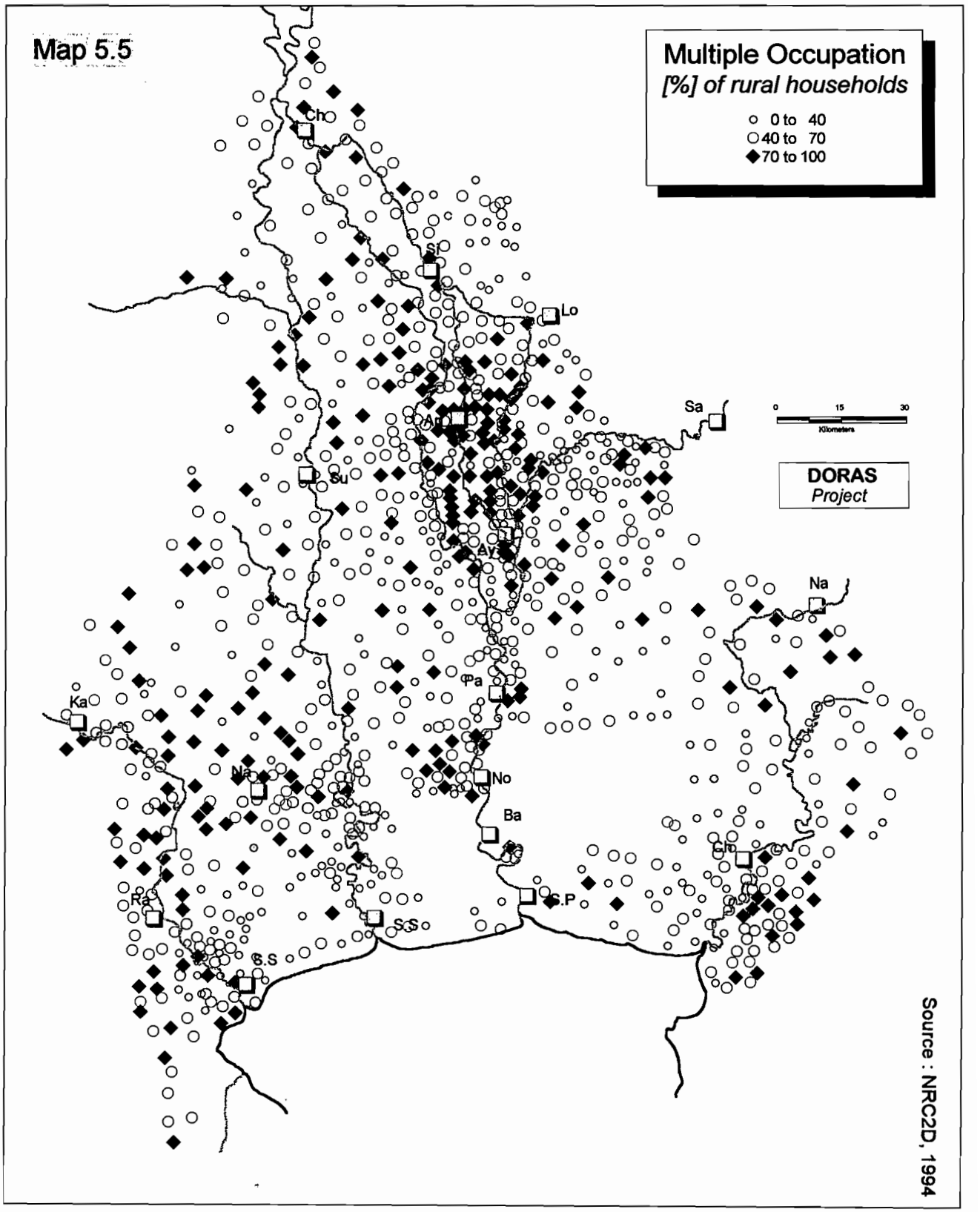
In the NRC2D dataset, non agricultural employment relates to rural population on the whole. However, home industry offers opportunities for farmers and their spouses during the off-season ; their children can find a job in nearby factories. Such a scope stabilizes income, agricultural population and farm size.

Strictly speaking, non-agricultural single occupations do not concern farming households. However home industry may be an opportunity taken by multiple occupation farmers or by a relative. As shown in map 5.6, home industry is well established north of Ayutthaya in the floating rice area. The main activity, there, is pottery (map 5.7). Damnoen Saduak region has a high concentration of canned food factories. Basketry and textile are widespread in the delta.

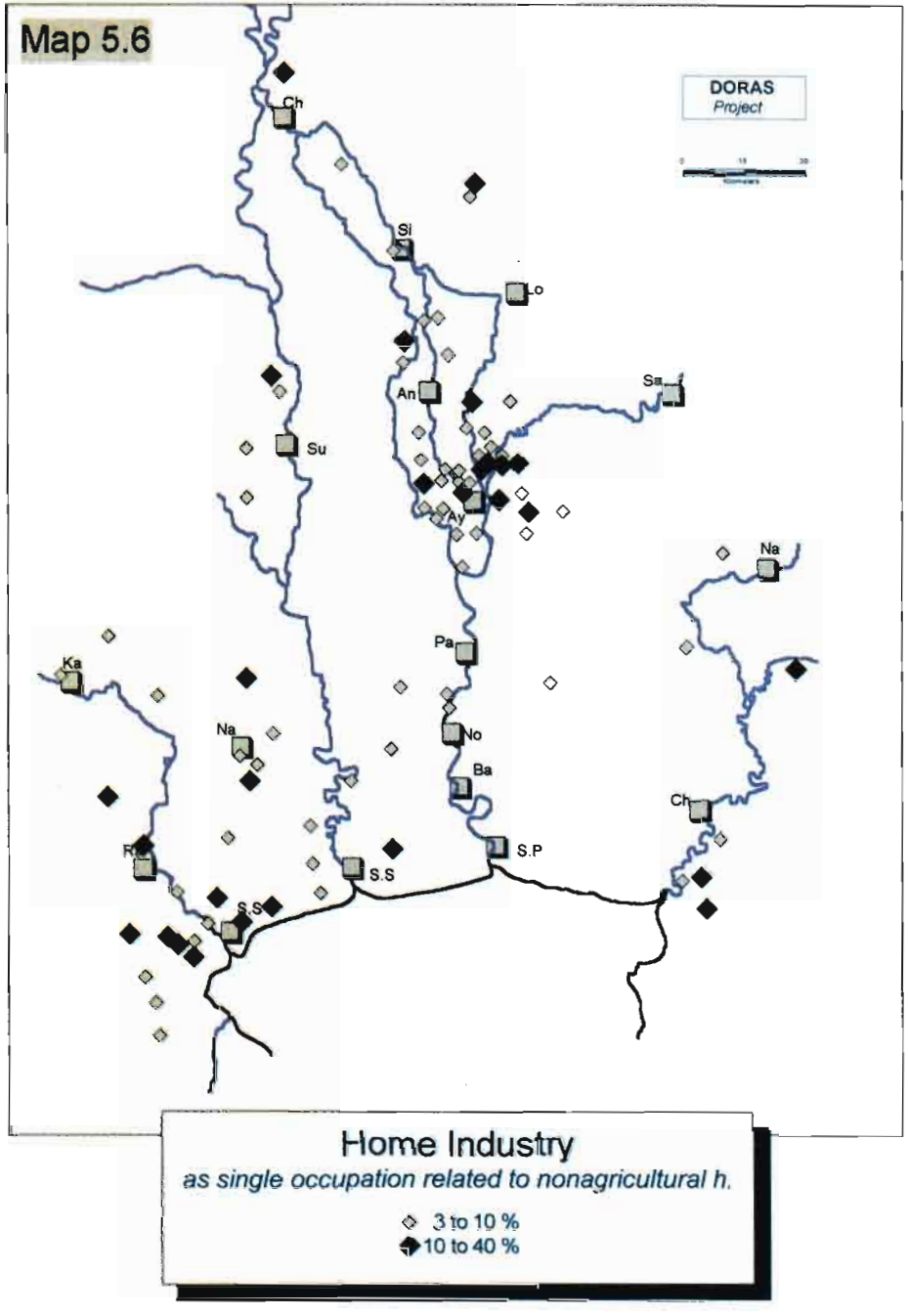
Table 5.9 : Home industry and off-farm activities in the delta

Cropping Pattern [%]	Multiple Occupation	Single home Industry	Single Employee	In Factory	In Agriculture	In Workshop
Field Crops	67	0.5	17	55	**18**	23
Sugarcane	63	**0.7**	**13**	**33**	53	12
Rice 1	60	1.3	18	54	25	**0**
Rice 2	58	**0.8**	18	46	37	14
Delta	57	1.4	21	51	31	13
Rice 3	55	1.4	20	42	39	19
Vegetable&F.	53	1.2	24	38	24	14
Tree Crops	**49**	3.0	24	56	37	**1**

Industry, agriculture and craft are sources of income for multiple occupation farmers. Whereas 1.4 % of non-farm households engage in home industry as a single occupation, 21 % of households are workers. Map 2.6 stresses the distinction between industrial wage-earners (51 % of households) and agricultural wage-earners (31 %), while service activities (13 %) are everywhere. The south, around Nakhon Pathom and from Bangkok to north Ayutthaya, offers higher salaries. Wage distribution in the area stresses the gap between industrial and agricultural jobs. In 1994 the daily wage of an agricultural worker was under 100 baht (without food), while the factory worker earned more than double this amount.


Map 5.5
Multiple Occupation
[%] of rural households
0 to 40
40 to 70
70 to 100
Ch
Si
Lo
Sa
Su
Ay
Na
Pa
Ka
Na
No
Ba
Ra
S.S
S.S
S.P
Cro
0
15
30
Kilometers
DORAS
Project
Source : NRC2D, 1994

Map 5.6

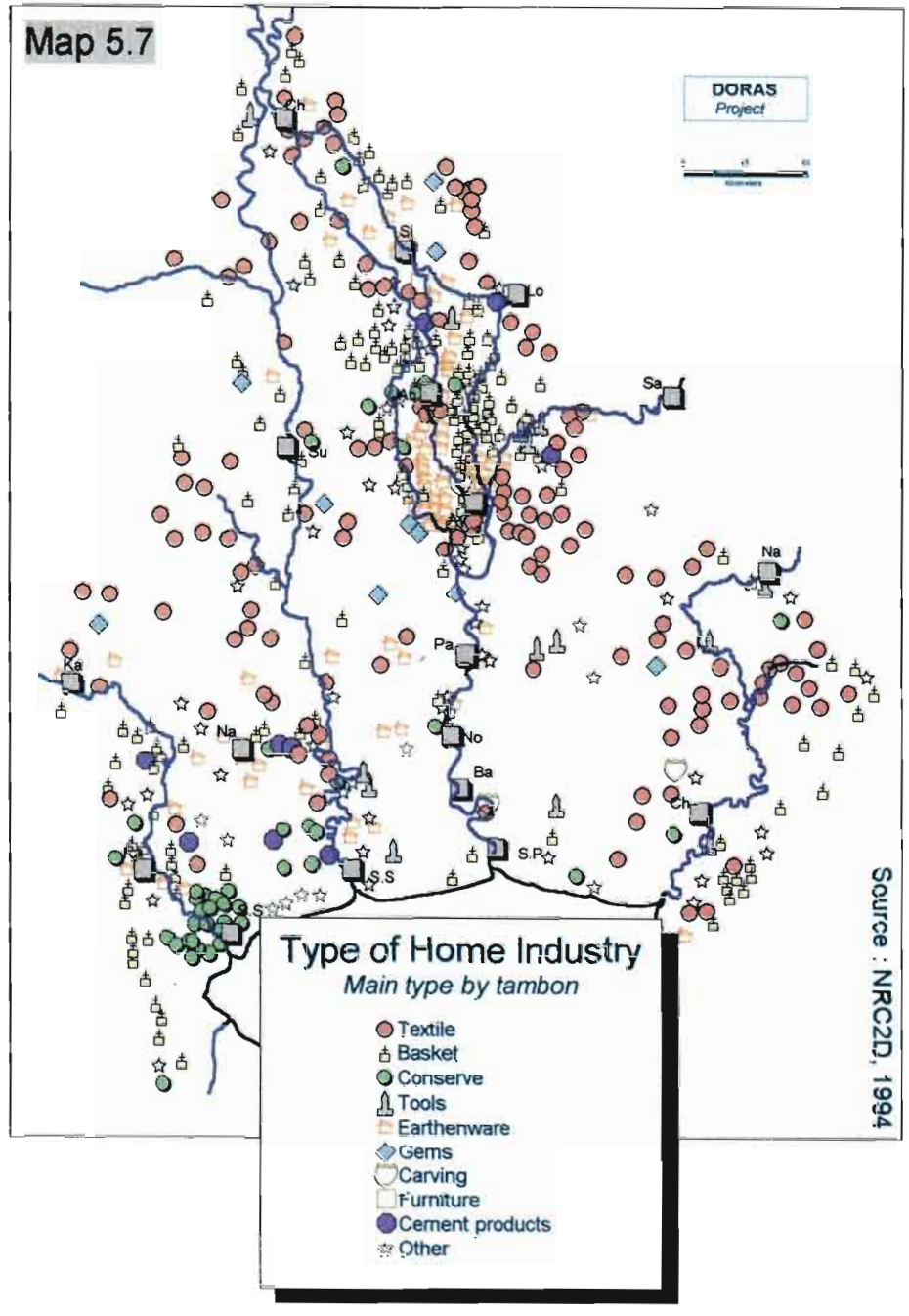


Home Industry

as single occupation related to nonagricultural h.

◇ 3 to 10 %
◆ 10 to 40 %

Map 5.7



Type of Home Industry

Main type by tambon

- Textile
- Basket
- Conserve
- Tools
- Earthenware
- Gems
- Carving
- Furniture
- Cement products
- Other

Source : NRC2D, 1994

Such a difference led people to abandon agriculture for the industrial sector or to seek employment in Bangkok. However, as the elderly farmers still continue to farm, the problem of an ageing working population will be revealed only when it is too late.

The north Ayutthaya region shows a peculiar pattern as shown in the home industry map 5.7. This extensive cultivation area, among the oldest settlement in the delta, presents the largest scope in home industry and factories jobs. This feature suggests the following process. Formerly, off season labour force and cheap land attracted firms ; later wages increased which prevented workers from staying in the agricultural sector (industrial tax policy could be an incentive to move from Bangkok). Today, rice management remains extensive because of not only poor water control, but also owing to part-time farming.

Obtaining off-farm jobs or leaving agriculture depends on two factors : the necessity for families and the attraction induced by the income gap. For smallholdings, survival is paramount whatever the level of wages. When, in addition little capital is available, the alternative is either intensification or departure to factories. Moreover, not only the farmer is involved in such a choice, but his sons as well. For wealthy farmers, the necessity of the son's departure is low, but as they obtain higher education, they prefer to leave for better incomes and less strenuous tasks. A provisory conclusion would assume that intensification of agriculture is conceivable with both good water control and income, and few other available jobs. In the Chao Phraya delta, not so many areas can achieve these conditions.

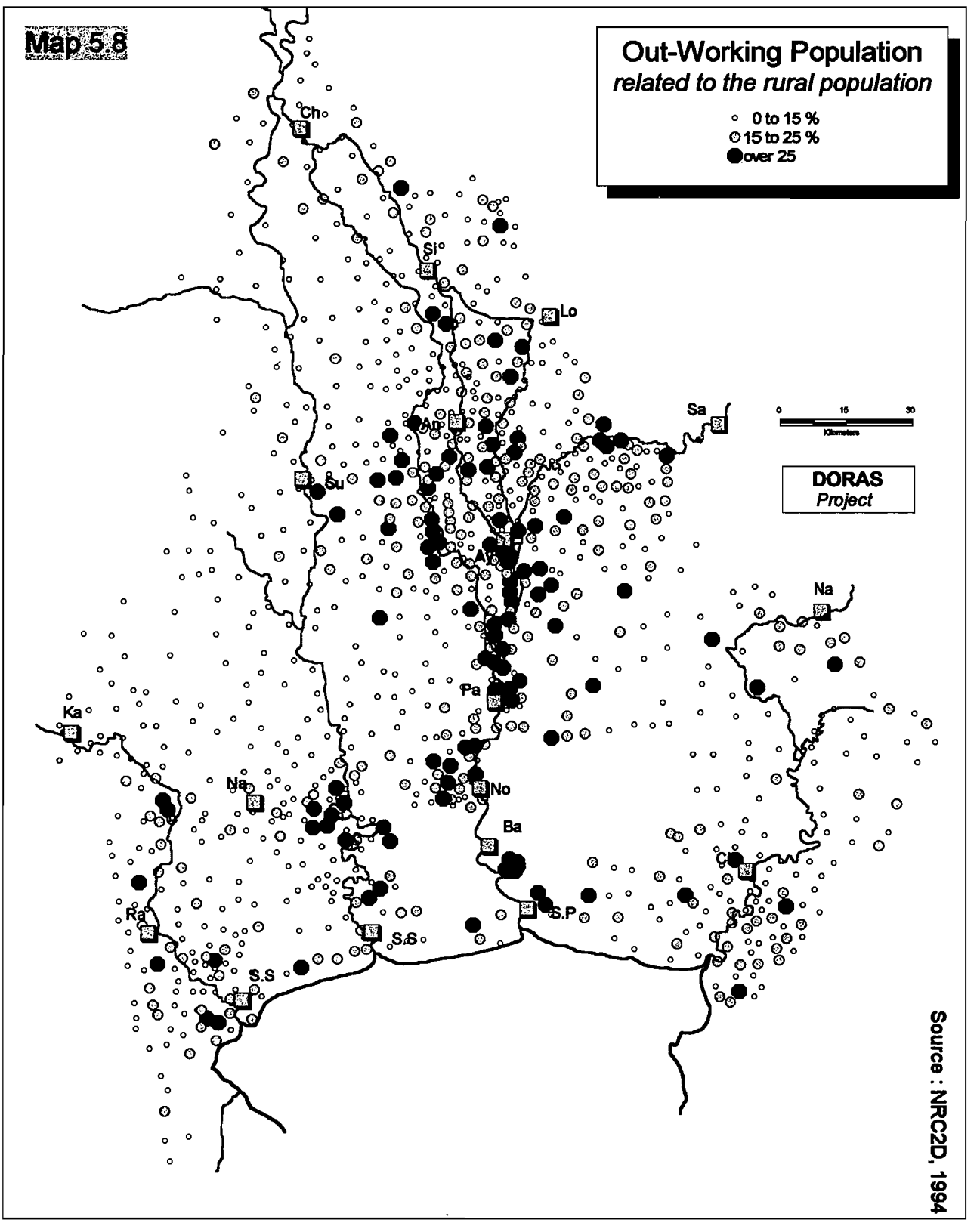
d. Working migration

Map 5.8 shows the weight of the rural population's migration in the Chao Phraya delta. The pattern is similar with multiple occupation and factory distribution. In other words, migration is an additional means for farmers to complement their income.

Table 5.10 : Rural migration by cropping pattern

[%] Cropping Pattern	Out work Population	In Agriculture	In Handicraft	Duration index	Distance index
Tree Crops	18	12	2	1.1	2.2
Rice 1	16	2	12	1.8	2.7
Field Crops	15	0	14	1.7	2.5
Delta	15	4	11	1.7	2.6
Rice 3	13	3	10	1.8	2.7
Rice 2	12	6	16	1.8	2.7
Vegetable&F.	12	13	9	1.1	2.3
Sugarcane	8	10	7	1.8	2.4

In the NRC2D questionnaire, the working migration is addressed with the following question : *Are the villagers go to work to other places ?* This pattern does not correspond to the change of residence seen in the chapter Population whose figures come from the Population and Housing Census.


Map 5.8
Out-Working Population
related to the rural population
0 to 15 %
15 to 25 %
over 25
Ch
Si
Lo
Sa
Ar
Su
Pa
Na
Ka
Na
No
Ba
Ra
S.S
S.S
S.P
0
15
30
Kilometers
DORAS
Project
Source : NRC2D, 1994

Fifteen percent of rural households have at least one migrant. This is a high figure. Destination and duration of migration (only map 5.10 is displayed) can be overlaid. Two main patterns of migration in the delta are observable :

- in industrial areas (Ayutthaya, Chachoengsao, Chonburi, Nakhon Pathom and Bangkok), migrants stay in the same *amphoe* and move daily. It is a commuter pattern.

- in agricultural and remote areas (old delta and Nakhon Nayok region), where less households are concerned, migration is planned for longer periods, in general towards Bangkok. It can be concluded by a change of residence (see chapter 2 on Population).

Lastly, map 5.9 complements the model of rural population's migration. Of course, the main out-works are jobs in industrial regions. In agricultural areas, service sector and agriculture offer more jobs, but migration to factories is significant.

The agricultural labour force is experiencing a shift with consequences for the future. The working population is decreasing and the ageing of farmers is increasing the sales of land. Land price is high because of industrial encroachment, housing development and speculation. "Sunday farmers" acquire a few rai at a high price. Such a level prevents farmers from expanding their land. The increase in off-farm occupations generates new sources of income that could be used to improve agricultural facilities. Generally speaking, multiple occupation farms are innovators, although they follow a particular trend, over-equipped (with labour saving technology) and under-represented in corporation unions.

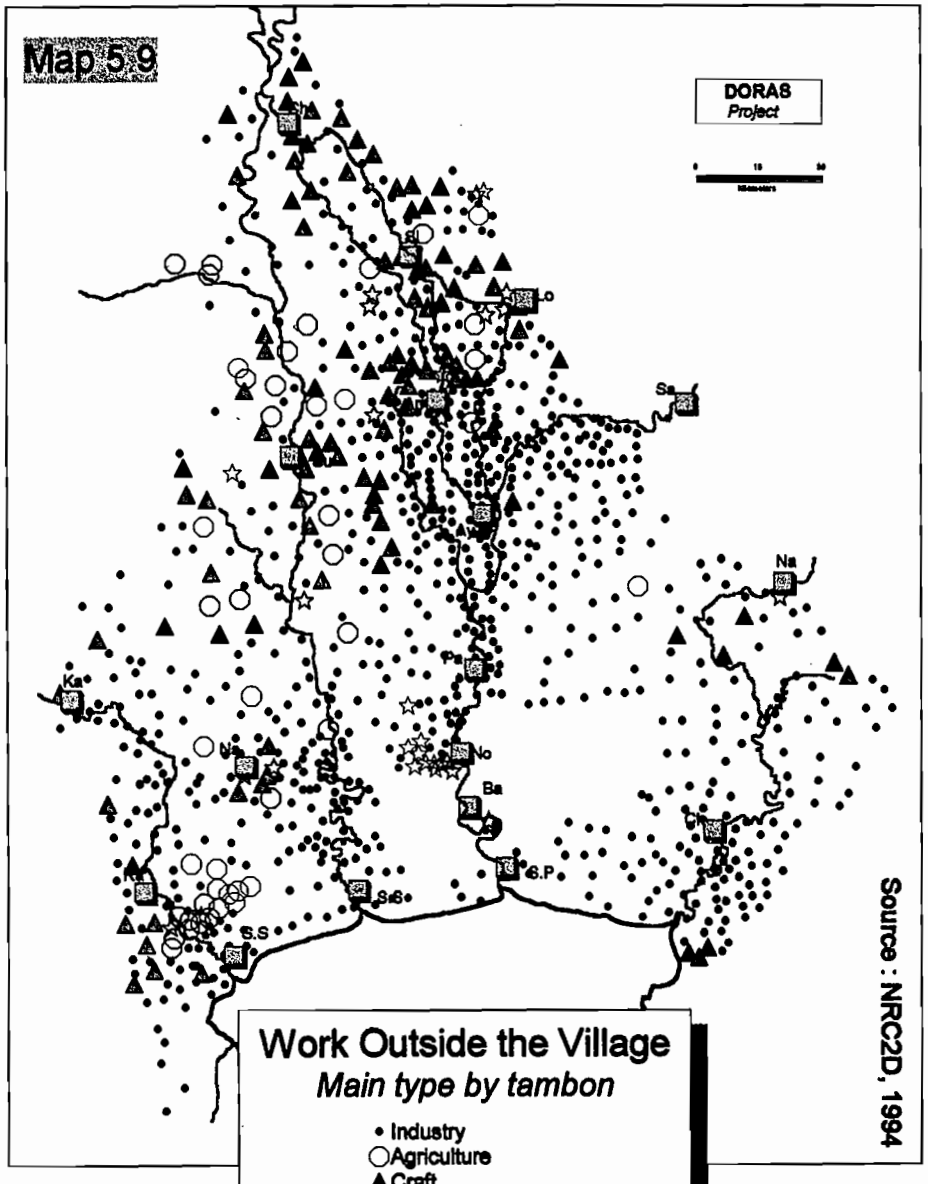
5.2.3. The farm equipment

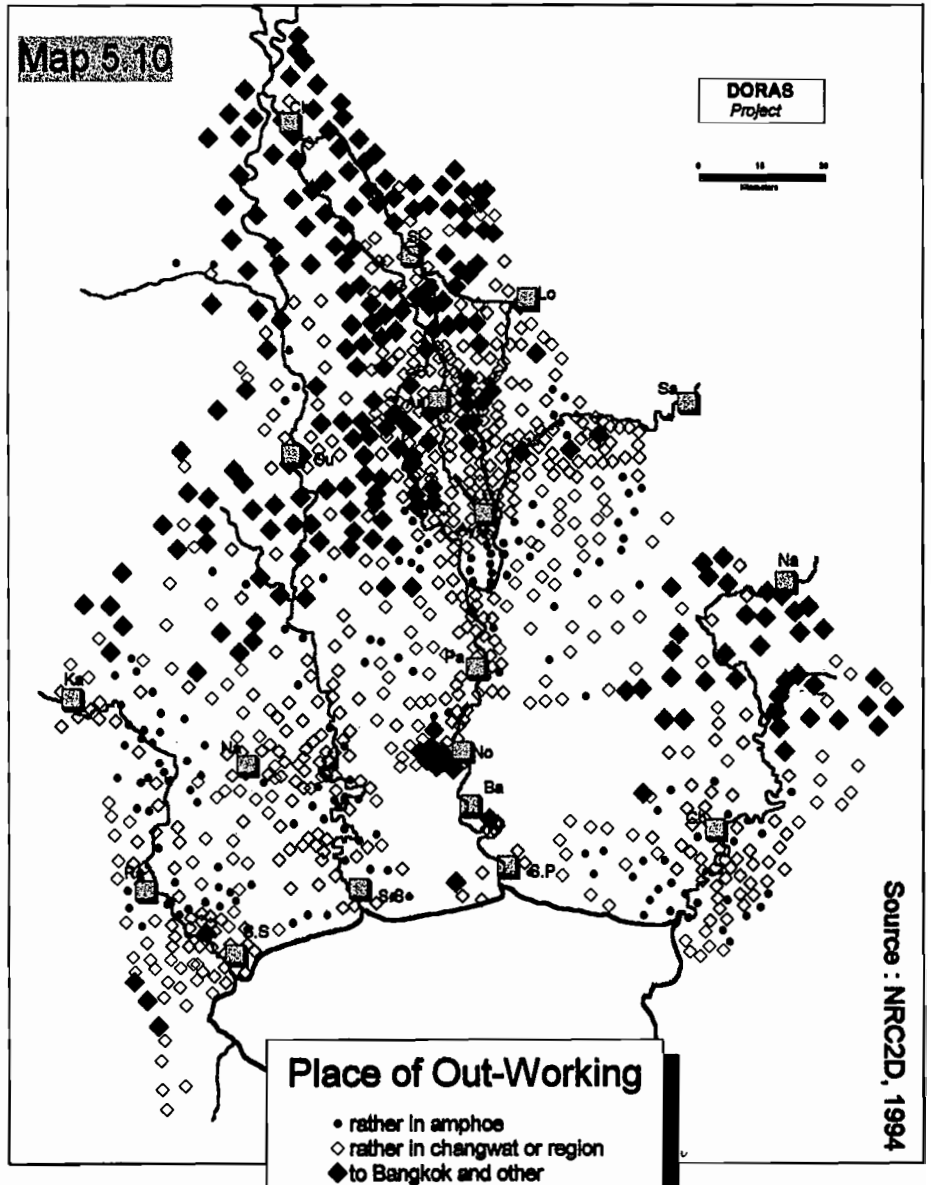
In this section, we review the main equipment at farm level for each cropping pattern : irrigation facilities, number and type of tractors and combine harvesters.

a. Water management equipment

Rivers, natural canals and irrigation canals can be used directly for irrigation, either in the rainy or dry seasons. The dense network of rivers favours riverside areas north of Ayutthaya where farms grow field crops in the dry season. Elsewhere, the farms do not benefit from the proximity of a river. The second kind of water sources are the "natural" canals, namely old canals, which are widespread in the young delta and the flood plain. They constitute a remarkable network that testifies to poor water control where the risk of flood, if low, exists. The third kind of main water source consists of planned and managed canals under the control of the Royal Irrigation Department. There are many of these in the old delta inland, or interfluves, as well in the Rangsit scheme and in the region of Mae Klong river.

As seen in chapter 4, deep wells, supposedly used mainly for agricultural purposes, are localized, firstly, in the old delta and upstream of the Angtong flood plain. Near Sing Buri, wells are excavated and equipped in order to grow a second rice crop. Secondly, they are in a part of the Mae Klong region as well as close to Nakhon Pathom.


Map 5.9
DORAS
Project
Lo
Sa
Na
Ka
Ph
No
Ba
S.P
S.S
Work Outside the Village
Main type by tambon
• Industry
○ Agriculture
▲ Craft
☆ Rubber plantations
Source : NRC2D, 1994


Map 5.10
DORAS
Project
Lo
Sa
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S.S
Place of Out-Working
• rather in amphoe
◇ rather in changwat or region
◆ to Bangkok and other
Source : NRC2D, 1994

Their location depends not only on the availability and the quality of underground water, but also on the difficulty of securing water from other sources. They mirror less the wealth of farmers than a powerful interest in intensifying agriculture, even though irrigation canals are present. As a matter of fact, wells are in the region of the canals managed by the Royal Irrigation Department.

Table 5.11 : Main water surfaces by cropping pattern

(%)	River	Natural Canal	Irrigation Canal	Other swamp, pond	Total	Total Area / Well (rai)
Sugarcane	15	21	52	12	100	34
Field Crops	17	43	35	5	100	40
Rice 1	30	44	18	8	100	63
Delta	26	48	20	6	100	61
Rice 2	23	50	24	3	100	66
Rice 3	22	50	22	6	100	57
Vegetables & Flow.	19	64	14	3	100	55
Tree Crops	29	65	5	1	100	94

The NRC2D questionnaire that addresses wider issues than agricultural ones did not distinguish between pumping water for agricultural and domestic uses. However, ground water use in the dry season for fields crops and vegetables is linked to the location of deep wells. Consequently, we discarded shallow wells and the lower reach of Bang Pakong river where there are many. Shallow wells often have not mechanical pumps, nor concrete structure. We assume that most of deep wells are used for agriculture.

Wells indicates the will of the farmers to intensify, either rice cultivation or with a shift to higher value added crops. As the Singburi area shows, wells allow the farmers to grow an extra crop. It is not the case with sugar cane cultivation and some other field crops where many wells do not seem to increase the production (see chapter 3), but rather to secure the water supply.

Water sources do not differ between intensive and less intensive cropping patterns. The history of the reclamation might explain the joint process of location of cropping patterns and water network. Vegetables & Flowers and Tree Crops cropping patterns are close to ditches because they are located in the lower delta. Rice 1 and Tree Crops are near rivers, the first one because it is in the river interlacing in the Ayutthaya region, the second because of the traditional location on the banks and natural levees in the old delta. Sugarcane and Field Crops are located near irrigation canals and there, farmers have drilled many wells. By contrast, Tree Crops are near rivers or on raised beds in flood prone area and do not require additional water.

Table 5.12 : Type of irrigation for field crops and vegetables in the dry season

[%] Cropping pattern	Irrigation from : Canal	Ground water	Remaining water	Farms with dry season irrigation
Tree Crops	88	10	2	6
Vegetables & Fl.	86	11	4	30
Rice 2	78	19	3	12
Rice 3	73	23	5	13
Delta	72	19	9	12
Rice 1	67	17	16	11
Sugarcane	62	36	2	18
Field Crops	55	15	30	29

Historically, irrigation waterworks were designed to secure the major rice crop. Indeed, the climatic risk from April to August is extremely high although rainfall is abundant (see chapter 2). Then, dry season irrigation was planned, first for rice, secondly, for water-saving crops. Indeed, a more or less acute water shortage in recent years has led authorities to take drastic measures and farmers to adapt. An effective network of canals allows for more intensive crops such as fruit trees, vegetables and rice. Ground water is a significant complement in Rice 3 cropping pattern. Sugarcane farming which has easy access to secondary canals developed the use of ground water. Lastly, the more noticeable feature pertains to Field Crops cropping pattern where few canals obliged farmers to use remaining water stored in ponds or in canals.

Table 5.13 : Satisfactory irrigation indicator assessed by farmers by cropping pattern

Cropping pattern	Satisfactory Irrigation Indicator (0 = No ; 1 = Yes) for : Sum/10	Vegetable	Field crops	Tree	Double rice
Vegetables & Fl.	8.6	0.9	0.9	0.9	0.7
Sugarcane	7.4	0.8	0.8	0.7	0.7
Tree Crops	6.8	0.8	0.6	0.8	0.6
Field Crops	6.4	0.8	0.7	0.8	0.3
Rice 2	6.0	0.7	0.6	0.7	0.5
Rice 3	5.6	0.6	0.7	0.7	0.4
Delta	5.2	0.7	0.6	0.6	0.4
Rice 1	4.0	0.6	0.5	0.5	0.2

In table 5.14, the Sum/10 column provides a global assessment of the farmers' perception about water deliveries. It is naturally bad where single rice is grown. More interesting is the opinion where farming is intensive. Thus, the cropping pattern Vegetables & Flowers rates the higher index, efficient and secured water being vital here. The sugarcane areas are well furnished with canals and wells and, if this crop does not take full advantage of abundant water, the latter gives the best opportunities here to grow field crops with an intensive package. The farmers' perception in the Field Crops cropping pattern is between Sugarcane and Rice 1,

showing that a low water supply in the single rice cultivation areas allows for the diversification to the field crops. Lastly, farmers in Rice 2 and Rice 3 do not express a so good opinion about irrigation. For Rice 3 in particular, water seems to be a constraint to intensification. Regarding Rice 2 and Sugarcane, the great range of opinions could point to a variety of water supplies. In particular, north and southeast of Rice 2 cropping pattern experience shortages that may harm yields and intensification.

b. Pickups, trucks and tractors

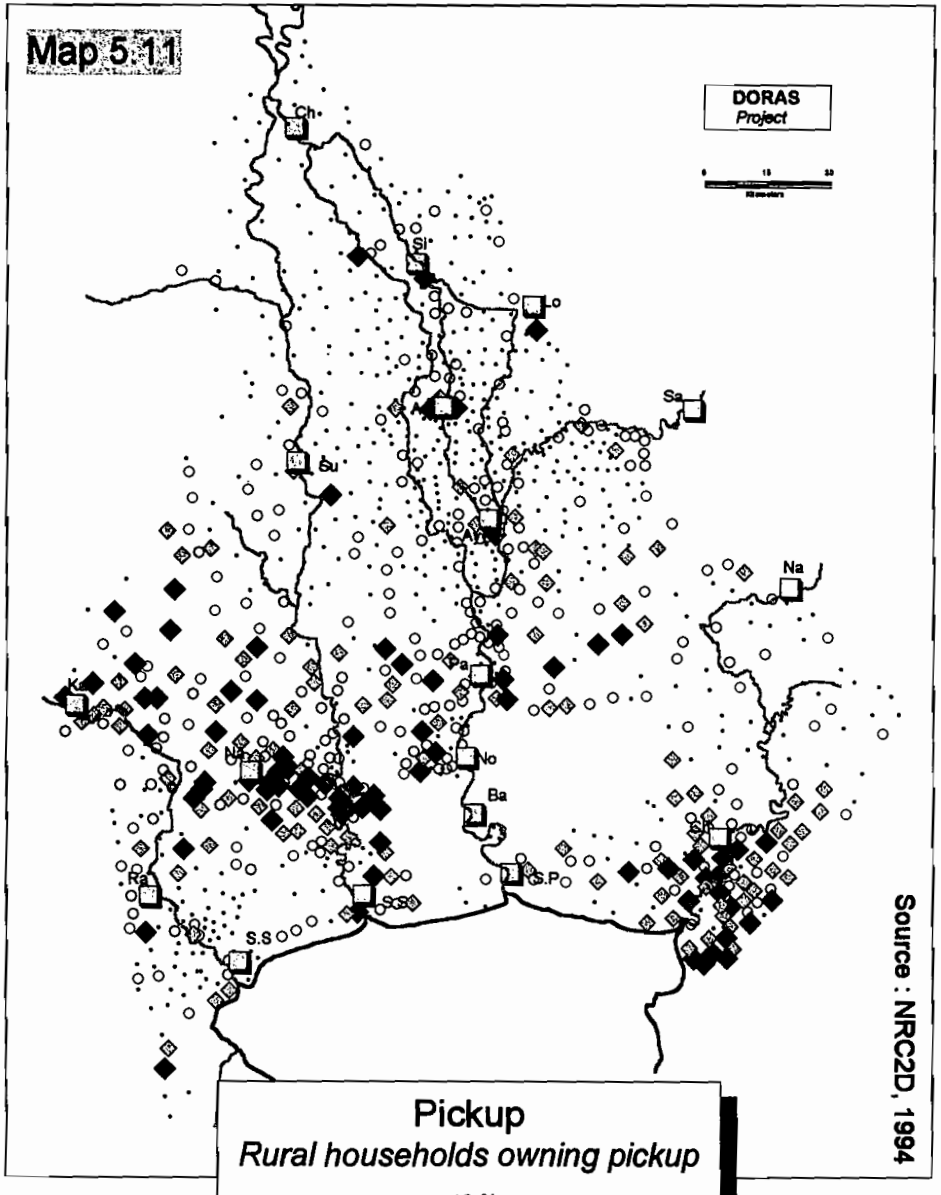
Pickups and trucks are counted in the rural population on the whole. They are evidence of two features linked with agriculture. Firstly, pickups are a major element of mechanization, enabling the labour force and materials to be conveyed to the plots. Farmers can sell vegetables, fruit and fish to the market. Secondly, many trucks in a region add to the economic environment of the farms. Although most of them are owned by non farming companies, trucks contribute to the vertical diversification of wealthy farmers, unlike horizontal diversification that rests on new crops. Trucks are used to carry bulky products such as sugarcane.

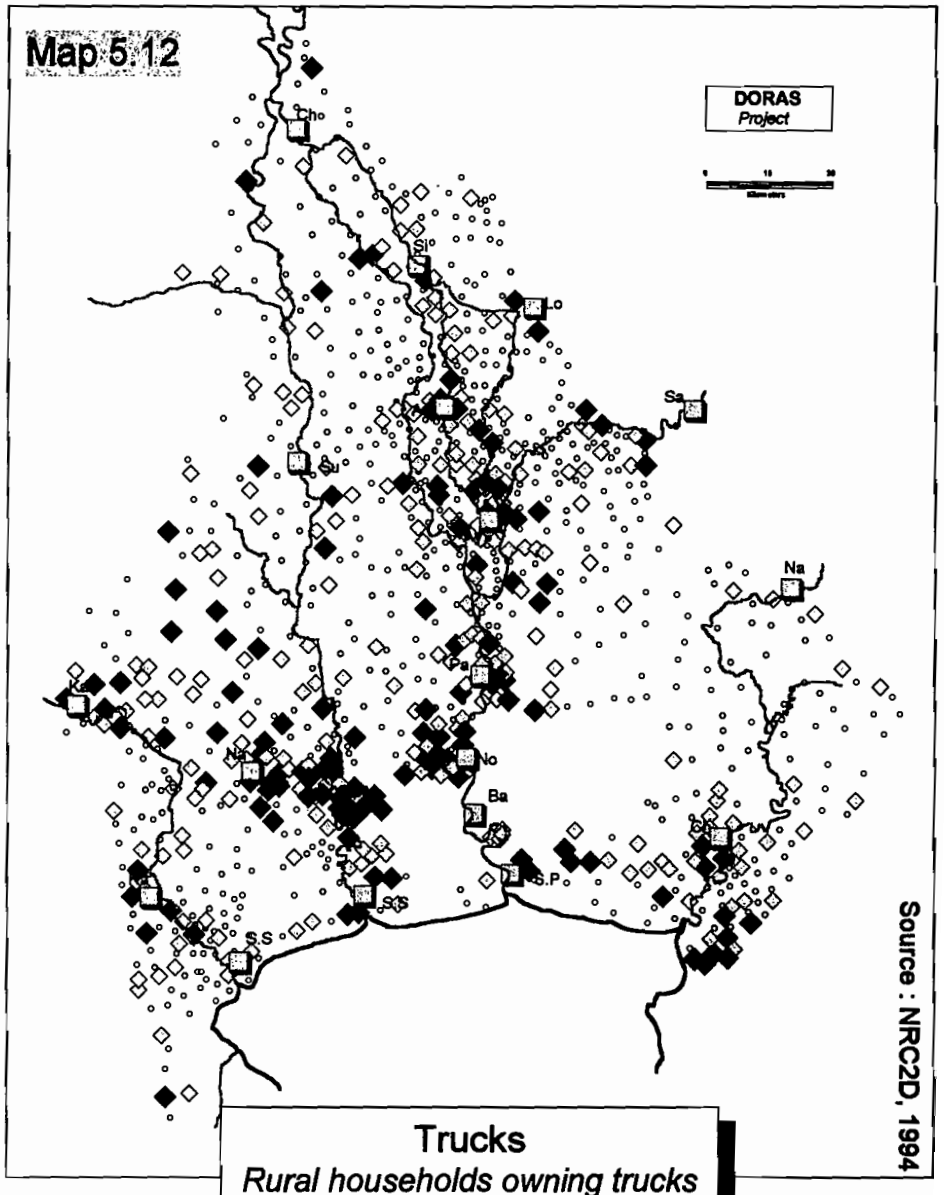
Pickups are found nearly everywhere in the delta (map 5.11) and particularly in a belt from the Mae Klong fan-terrace to Nakhon Pathom region and north of Bangkok. Many commercial vehicles are found in Chachoengsao and Chonburi area where shrimp farming is developing. By contrast, Tree Crops cropping pattern, all the old delta and Nakhon Nayok area are three regions which are poorly equipped. The distribution pattern of trucks is similar, although more clustered.

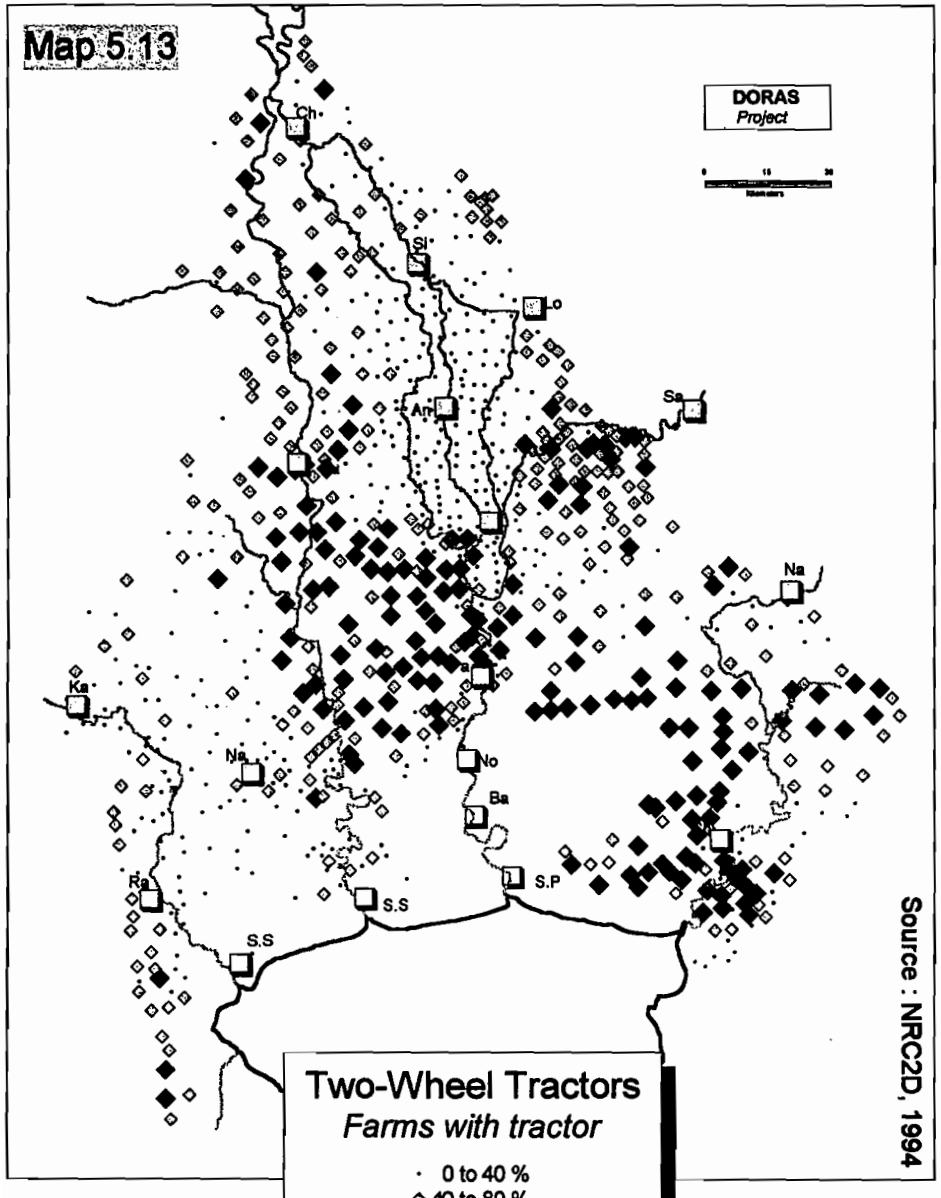
The presence of more vehicles indicates dynamic areas. Near Chonburi and Bangkok, trucks are mainly used in industries. In Nakhon Pathom, industrial goods as well as agricultural products and by-products are transported. For Mae Klong Sugarcane cropping pattern, sugar mills and heads of quota own trucks for cane transportation in January and February. During the rest of the year, they carry earth and sand for housing basements.

The level of tractor equipment is likely to be sufficient to cope with major agricultural operations. Hand tractors are private and two thirds of farms in Rice 2 have at least one. Big tractors can be rented to heads of quota or big farms since only 5.5 % of farms in Sugarcane have their own tractor. From the point of view of farmers, peak work periods in multiple crops farming can be difficult to manage.

As shown in maps 5.13 and 5.14, four-wheel tractors are generally associated with two-wheel tractors. Above Bangkok few tractors of any kind are found. North of Ayutthaya, floating rice farmers run mainly big tractors while double rice cropping is operated with hand-tractors.


Map 5.11
DORAS
Project
Ch
Si
Lo
Sa
Su
Na
Ba
S.P
S.S
Source : NRC2D, 1994
Pickup
Rural households owning pickup
> 10 %
10 to 15 %
15 to 20 %
> 20 %


Map 5.12
DORAS
Project
Ch
Si
Lo
Sa
Su
Na
Ba
S.P
S.S
Source : NRC2D, 1994
Trucks
Rural households owning trucks
0 to 4 %
4 to 7 %
over 7 %


Map 5.13
DORAS
Project
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No
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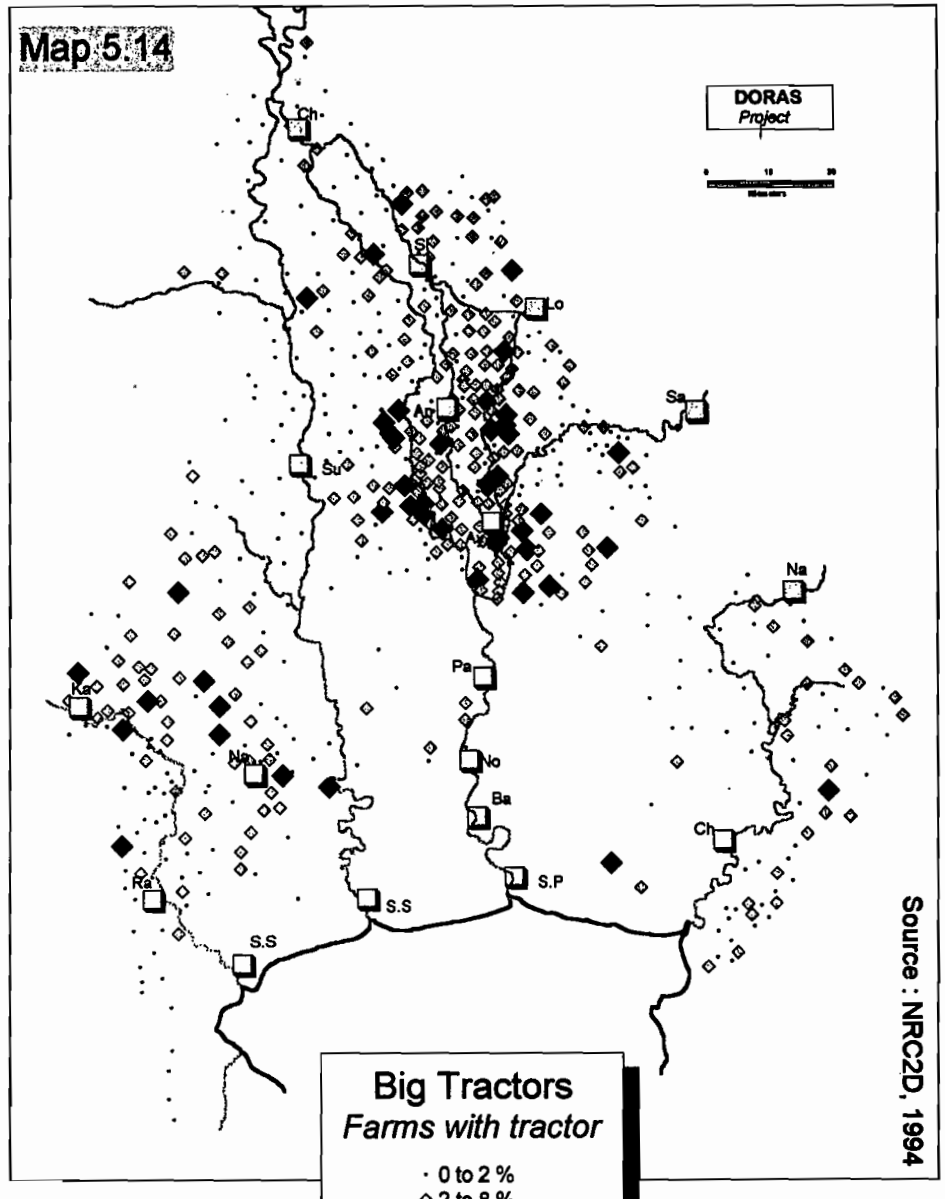
Ra
S.S
S.S
S.P
Two-Wheel Tractors
Farms with tractor
0 to 40 %
40 to 80 %
above 80 %
Source : NRC2D, 1994


Map 5.14
DORAS
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Ch
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S.S
S.S
S.P
Big Tractors
Farms with tractor
0 to 2 %
2 to 8 %
above 8 %
Source : NRC2D, 1994

Table 5.14 : Rural and farm equipment by cropping pattern

	Pickup	Truck	Draught cattle	Hand-tractor	4 wheel-tractors
Rice 2	11	4	0.5	66	0.8
Rice 3	11	4	1.6	67	1.6
Rice 1	10	4	1.4	40	2.2
Field Crops	14	4	3.9	33	2.5
Delta	11	5	1.0	43	1.9
Sugarcane	15	6	2.2	23	5.5
Tree Crops	12	5	0.2	8	0.3
Vegetables	14	6	0.2	8	0.4

Unit : Percentage of rural household and farms with the item.

As usual, many pickups, trucks and big tractors are used in the Sugarcane cropping pattern. Tractors are employed firstly for tillage and they are often rented out to asparagus and baby corn farmers. Rice farmers use hand tractors ; few pickups are encountered in Rice 1 cropping pattern. In Tree Crops and Vegetables & Flowers, farmers hold an average number of pickups required to sell the crops and there is little mechanization. Vegetable farming occupies mainly family labour. Some animals are still used for draught in Field Crops areas.

c. The case of the mechanized rice harvesting

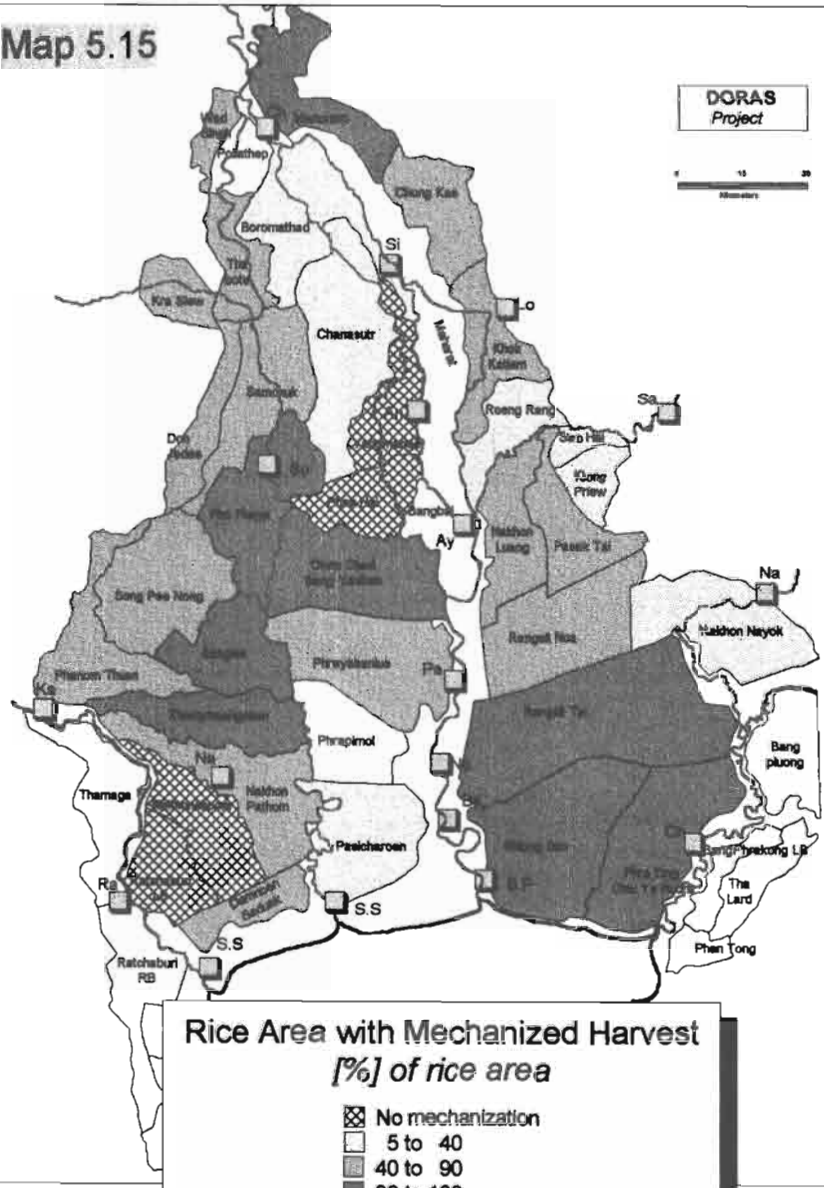
Under the patronage of sugar mills, sugarcane harvesting began to be mechanized few years ago. The increase in wages should speed up this trend. Rice harvesting began to be mechanized years before in the last 1980s (Trebuil, 1991). Many workshops, perhaps 10 nationwide, are assembling combine harvesters. This medium size, tracked vehicle is highly adaptable and can operate in small plots with low dikes. The 1995 flood led some farmers to use this harvester in 40 cm of water.

Wage increases and the decrease of the family labour led to this trend. In a 1995 survey, the last regions of the delta had just seen their first mechanized harvest while the first implement was introduced 7 or 8 years ago. In some places, manual harvesting still prevailed, either because of machine shortages or manpower was plentiful. As shown in maps 5.15 and 5.16, the mechanization of harvest is nearly finished in the south-eastern part of the delta around Banglen. The young delta close to the Banglen district saw the first attempts of mechanization and is presently fully equipped owing to several workshops with a capacity of 1 to 4 vehicles a month.

The data about rice mechanization have been collected from officers in the provincial agencies of the agricultural administration. Their assessment provides a consistent pattern, which suggests an oil-spilling diffusion from a core and a still limited mechanization because of low production capacities.

No public help was given to promote this change. Non-conducive conditions explain irregularities in the concentric pattern. Floating rice is excluded because of lodging at the harvest period.

Map 5.15



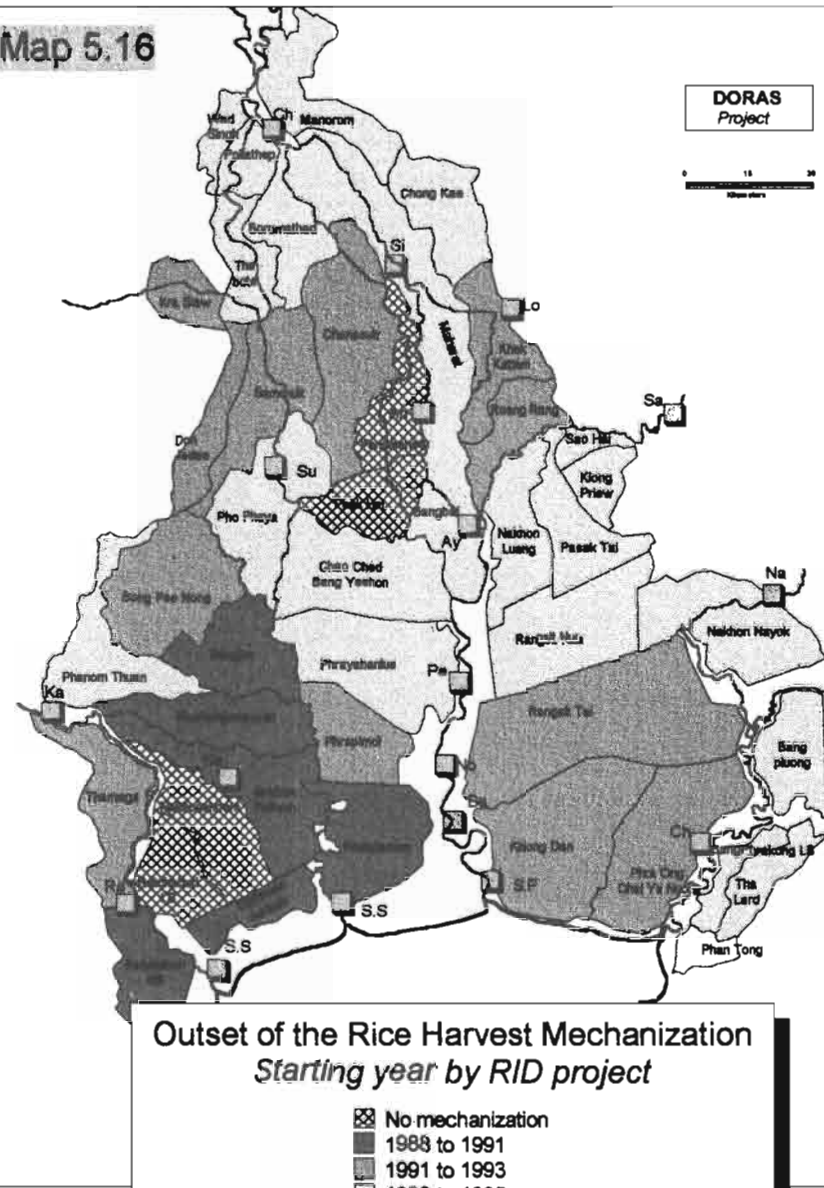
Rice Area with Mechanized Harvest

[%] of rice area

- No mechanization
- 5 to 40
- 40 to 90
- 90 to 100
- No data

Source : Assessment from provincial administration 1994-1995

Map 5.16



Outset of the Rice Harvest Mechanization

Starting year by RID project

- No mechanization
- 1988 to 1991
- 1991 to 1993
- 1993 to 1995
- No data

Source : Assessment from provincial administration 1994-1995

Farmers too poor in Rice 1, near Ratchaburi, recently still performed the harvest manually to reduce costs. In some areas, inadequate levelling or excess of water hindered the mechanization. Some traditional, lodging-prone varieties required a shift to short stem strains to allow for the mechanization. However, the kneeing ability of some deep water varieties once the water has receded, such as *Luang Pak Kiew*, allow the grower to take advantage of the combine harvester.

5.3 Economic environment of production

Together with farm structures, the economic and institutional environment determines crop type and crop intensity choice. New markets can give the impetus to develop new crops ; loans can finance a change or enable the smooth functioning of a cash intensive crop ; the role of cooperatives must not be disregarded since through them, farmers buy chemicals, sell farm produce and get training and information on the market. The economic environment is broader than these three points and includes : cost of equipment, availability of materials (e.g. chemicals and fertilizers), wage... Land prices induce elderly farmers without successors to sell ; off-farm employment encourages farmers or their sons to leave the land. More generally, the farm environment begins in the village : mutual aid, commercial networks, interdependence between head and tail of canals, and administrative supervision.

5.3.1. The credit institutions

Providing loans either for crops or equipment is a powerful instrument simplifying change. Many credit institutions are present in the delta, from family and friends to commercial banks. In the first instance, most farmers are granted loans from the Bank of Agriculture And Cooperatives (BAAC) or through Cooperatives. Secondly loans are often provided by commercial banks and middlemen (table 5.14). The amount, the collateral requirement, repayment period and interest rates differ from one institution to another. Commercial banks pay special attention to the solvency and collateral of their customers, in particular the kind of land title. Most moneylenders disappeared because of the rise of the financial institutions. As shown in various studies (e.g. Siamwalla, 1976 ; Rigg, 1986), because the middlemen perform competitively and commercial channels are efficient, there is little exploitation of farmers.

In the worst case, an indebted family can lose their land and eventually leave for the cities. Small sugar cane farmers seem to be in this sensitive situation (Srijantr, *pers.comm.*). Studies are needed to monitor this ongoing process, probably exacerbated by the 1995 flood. But these situations still remain rare. In fact, most farm departures are due to "Pull" factors linked with the appeal of the factory wages.

In general, equipment and intensification are within the reach of many farmers, above all when loans between friends or banking institutions are available. The high expenditures for the onset of market gardening has been affordable by many smallholdings. It is possible to assume that every farmer in the delta is hardly constrained by the problems of a technical change. Consequently, the choice of crop combination and intensity depends on other limitations, and on the objectives of the

farmer and his family. However, a light intensification yields a small raise in the income and, in many cases, the capitalization remains low. Under these conditions, a more serious flood or a drought in the flowering period, a price slump or an outbreak of pests (as happened with brown planthopper for rice variety "Suphan 60" in 1988) could jeopardize some budgets. In the past, low intensity farming limited the damage. For example, flooding in 1995 has not affected rice production as much as first thought, authorities assessing a decrease of 400 000 tons for an annual production of 18 to 20 million tons. High value added crops (mango and shrimps) have been more affected. Multiple occupations makes this less of a problem because an internal source of credit is a guarantee against agricultural hazards.

Maps from 5.18 to 5.20 display the main source of credit in every *tambon* and the diversity of financial institutions. In fact, because cooperatives and BAAC credit are widespread, we avoided their domination on the map by computing a weighted index of the main source of credit.

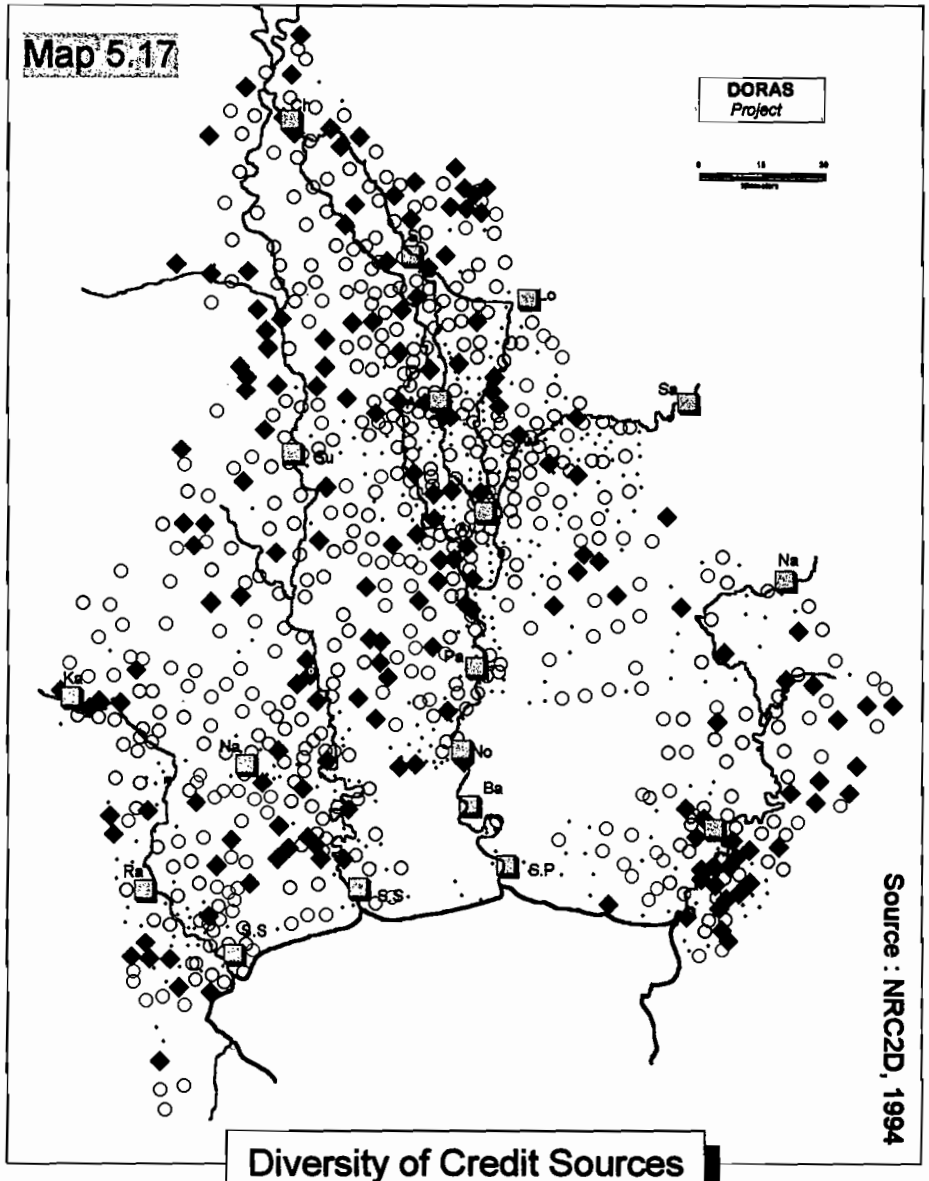
Firstly, map 5.17 shows an effective diversity of credit in the delta. BAAC is found everywhere and is the only institution in many *tambons*. Interest rates are low and in case of flood, they do not charge interest. Noteworthy is the importance of saving groups north of Ayutthaya and around Nakhon Pathom, and their absence in Nakhon Nayok region. Loans are also provided by rice mills (small industry), which deal directly with farmers in nearby villages. In this case as well, the credit is not diversified.

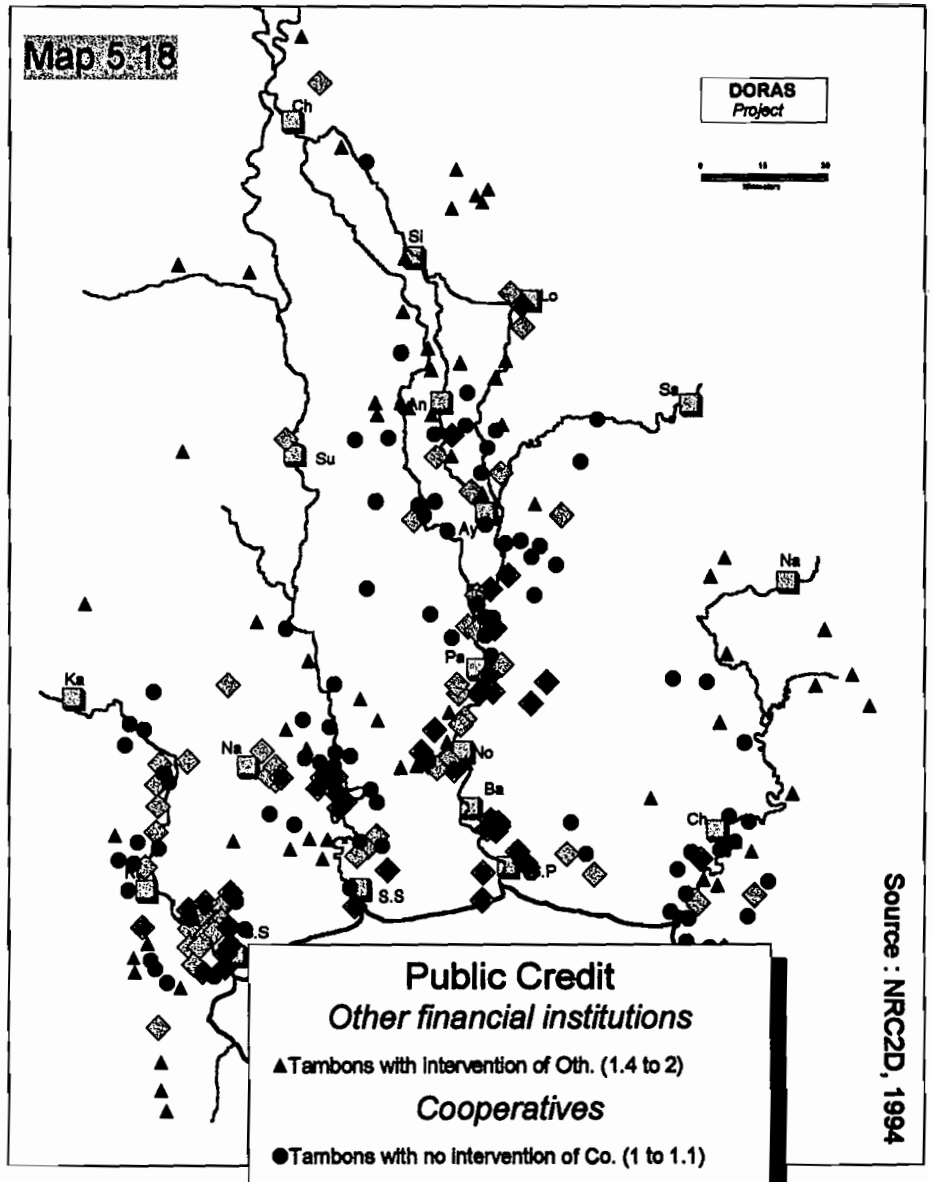
Table 5.15 : Farmers' opinion about credit accessibility by cropping pattern

		Private			Diversity	Public		Collective	
	Other	Comm. Bank	Middle-man	Small Industry	index (mean)	Public	BAAC	Coope -rative	Saving Group
Rice 1	0.12	**0.39**	**0.28**	0.01	0.35	0.08		0.70	0.28
Field Crops	0.13	**0.41**	**0.28**	**0.00**	**0.32**	**0.04**	0.87	0.65	0.21
Tree Crops		0.49	0.31	0.01	**0.33**	0.06	0.71	**0.47**	
Vegetables	0.17	0.55	0.38	0.01	**0.32**	0.07	**0.66**	**0.46**	0.24
Delta	0.16	0.48	0.38	0.01	0.36	0.08	0.89	0.65	0.25
Rice 2	0.19	0.53	0.52	0.01		0.09		0.70	0.22
Sugarcane	0.17			0.01		0.06	0.92	0.68	**0.11**
Rice 3	0.19	0.52							0.23

The figure between 0 (No) and 1 (Yes) is the average of answers to the question asked in every village : *Do villagers borrow money from* [list of institutions] *for production ?* Source : NRC2D, 1994

Table 5.16 shows a strong contrast between cropping patterns as far as credit is concerned. The "diagonalization" of the table brings together the private sources and opposes them to the public sources. In doing so, two groups of cropping patterns are discernible. Rice 1 and Field Crops farmers do not deal much with commercial institutions because of low solvency and high risk unlike in Rice 2, Rice 3 and Sugarcane. Public and group credits do not follow a clear pattern meanwhile BAAC gives credit to rice farmers, for either extensive or intensive farming. In Sugarcane and intensive rice growing, there is more diversity of financial institutions.


Map 5.17
DORAS
Project
Ch
Lo
Sa
Na
Pa
Ka
Ne
No
Ba
S.P
S.S
Ra
G.S
Source : NRC2D, 1994
Diversity of Credit Sources
Index : 10 = all, 0 = none
0 to 3
3 to 5
5 to 10


Map 5.18
DORAS
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Ne
No
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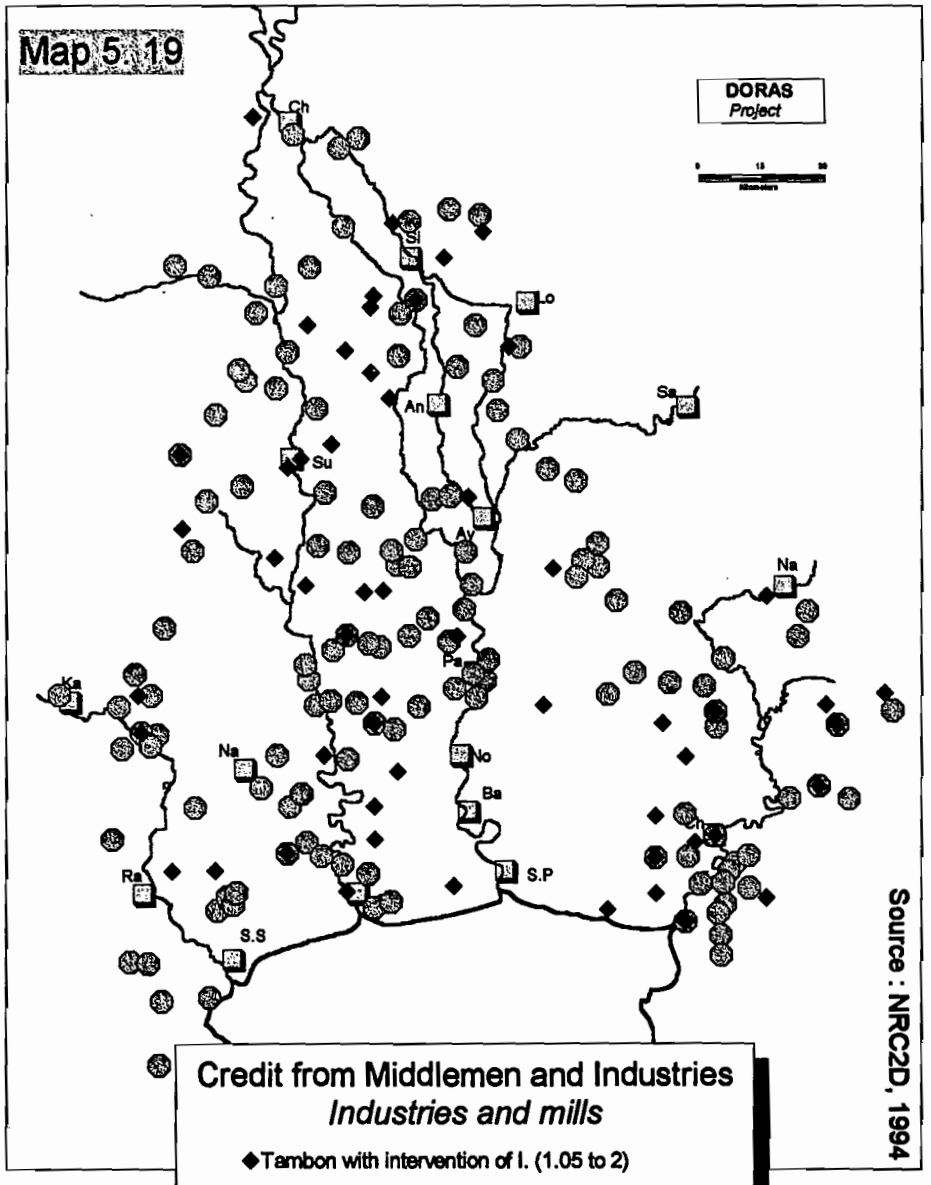
S.S
Source : NRC2D, 1994
Public Credit
Other financial institutions
▲Tambons with intervention of Oth. (1.4 to 2)
Cooperatives
●Tambons with no intervention of Co. (1 to 1.1)
BAAC
◈Tambons with low intervention of BAAC (1 to 1.6)
1 : No intervention; 2 : Intervention


Map 5. 19
DORAS
Project
Ch
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Ay
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Ya
No
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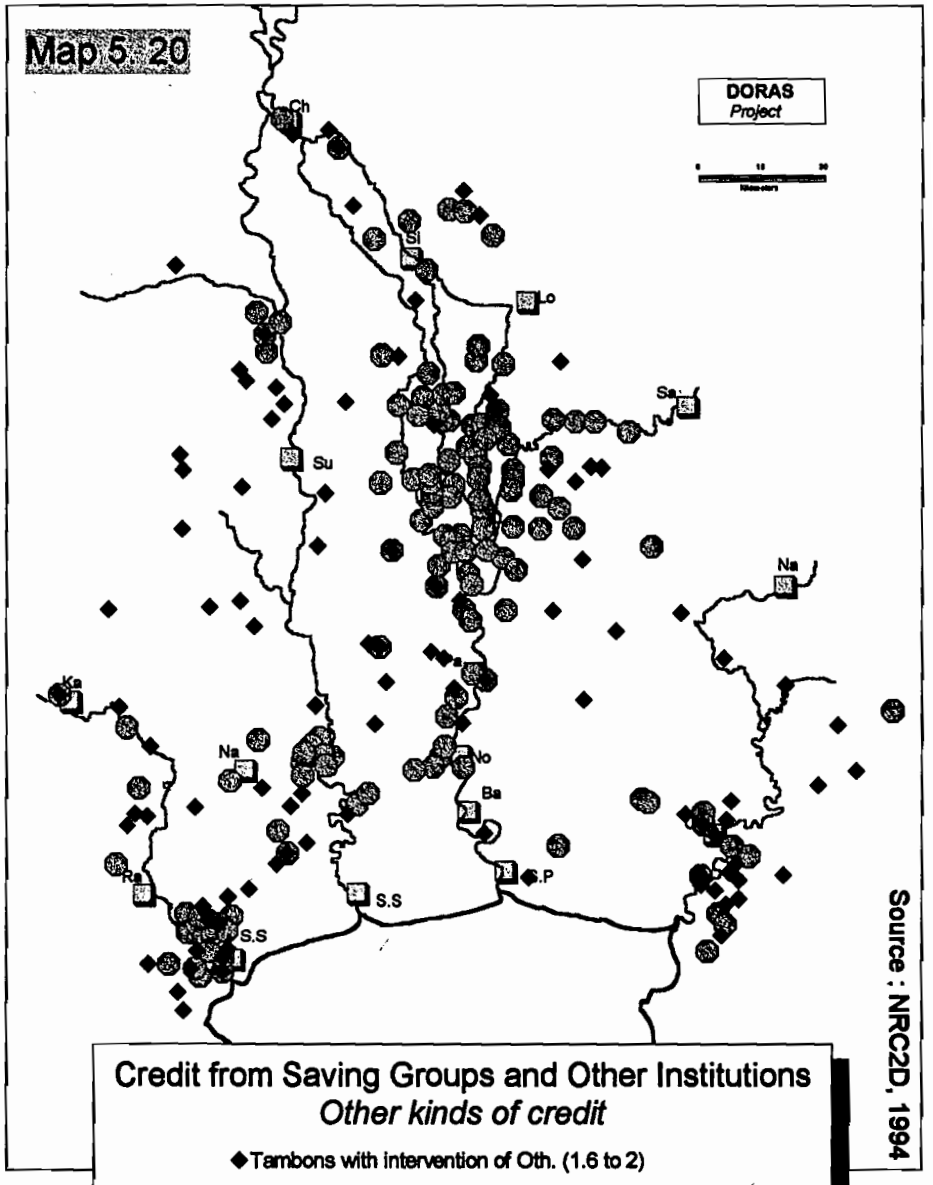
Ra
S.P
S.S
Source : NRC2D, 1994
Credit from Middlemen and Industries
Industries and mills
◆Tambon with intervention of I. (1.05 to 2)
Middlemen
Tambon with high intervention of M. (1.95 to 2)


Map 5. 20
DORAS
Project
Ch
Lo
Sa
Su
Na
Ya
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No
Ba
S.P
S.S
Source : NRC2D, 1994
Credit from Saving Groups and Other Institutions
Other kinds of credit
◆Tambons with intervention of Oth. (1.6 to 2)
Saving groups
Tambons with high intervention of S.G. (1.8 to 2)

In comparison, Vegetables & Flowers and Tree Crops cropping patterns show a smaller involvement by some financial institutions. Public bank and cooperatives show little interest although the agricultural policies announced a diminishing of aid to rice cultivation (as for cassava, coffee and pepper) and the promotion of diversification towards more valuable crops. Tree Crops pattern shows a high level of Savings Group and Other credit, which suggests solidarity within large families. Indeed, tree crops, in Damnoen Saduak area, are mostly grown by descendants of Chinese (see chapter on Demography) whose large families, showing a high level of trust between one another, could explain the volume of family credit (in "Other") and Saving Groups.

The difference between Rice 2 and Rice 3 is noticeable. Among the conditions of rice growing intensification, water characteristics are obvious. However, bad drainage and flood do not prevent some farmers from growing more than two crops a year. Factors such as credit are an explanation for this intensification. Rice 3 *tambons* are systematically favoured by credit diversity. In addition, loans from middlemen, rice mills and even public agencies are more widespread.

5.3.2. The cooperatives and organized groups of farmers

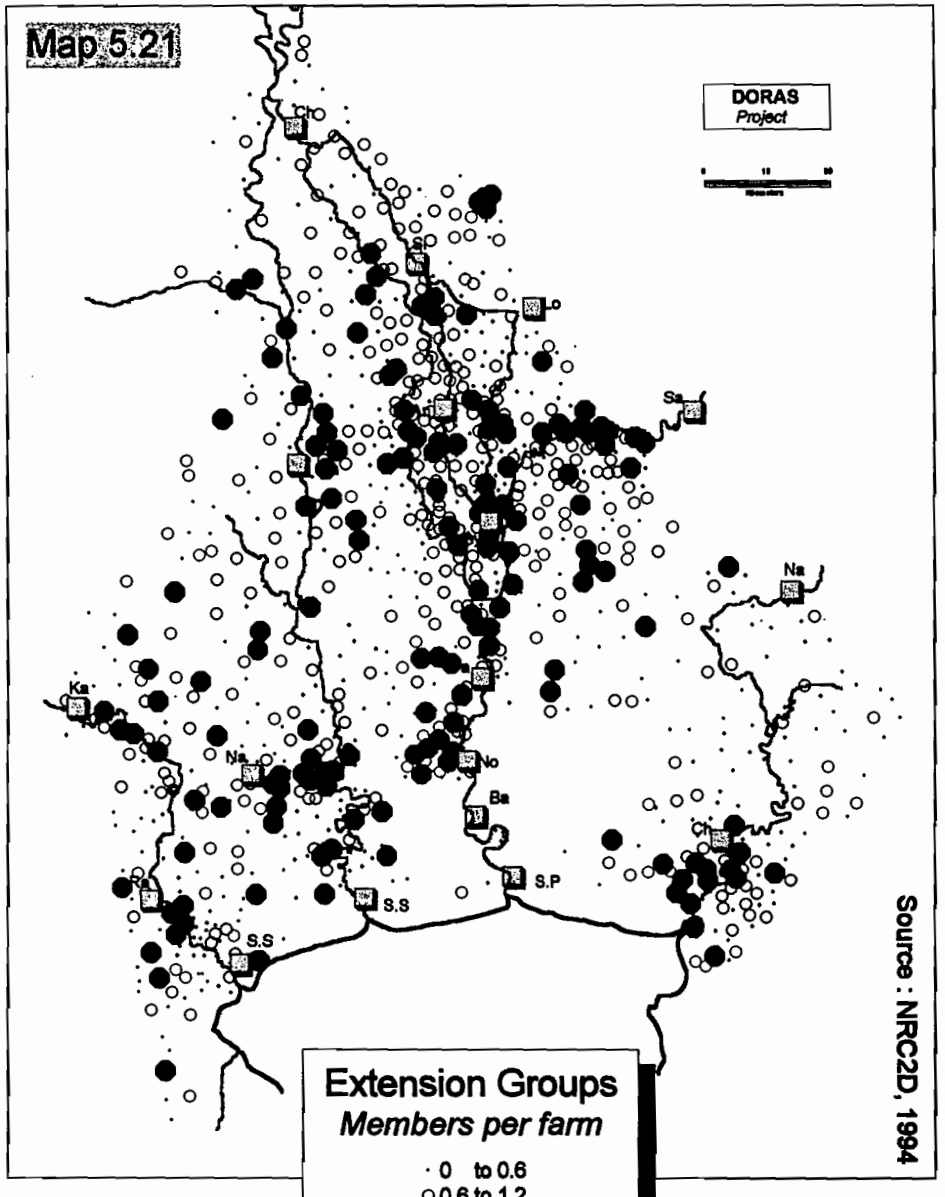
In Thailand, cooperatives and extension or farm groups are supervised by authorities. In the delta, water user groups deal with the Royal Irrigation Department (not included in NRC2D data). Almost all the agricultural families belongs to two main kinds of associations. Firstly, cooperatives are supervised by the Department of Cooperatives and Promotion. Through them, the government manages and provides credit and subsidies. Secondly, farmers groups are supervised by the Department of Agriculture and Extension, which is also under the Ministry of Agriculture.

Table 5.16 : Types of Cooperatives and extension groups

Cooperatives		Extension groups	
Federations of C.	Consumer C.	Paddy	Fish
Agricultural C.	Services C.	Upland crops	Water farming
Fishery C.		Horticultural C.	Mushroom
Land settlement C.		Livestock	Honey
Thrift and credit C.		Silk	

Though they work together in some projects, table 5.17 shows that cooperatives are organized by kinds of services, which address all production. By contrast, extension groups are organized by crops and activities.

There are many groups and cooperatives throughout the delta. Map 5.21 provides their predilection areas, with more farms joining such organizations around Nakhon Pathom, Ayutthaya and Chachoengsao. The distribution pattern is similar for cooperatives and groups.


Map 5.21
DORAS
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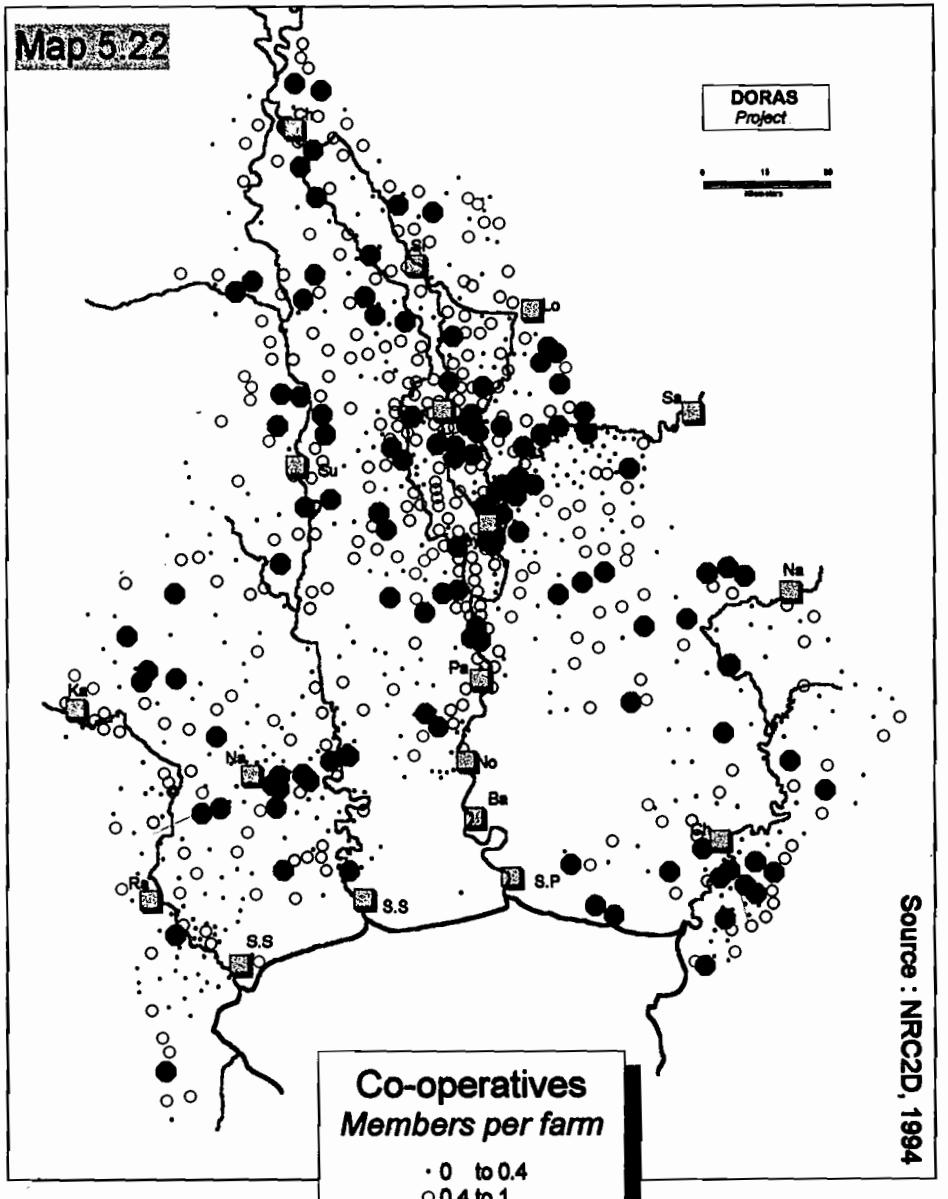
Extension Groups
Members per farm
0 to 0.6
0.6 to 1.2
1.2 to 4
Source : NRC2D, 1994


Map 5.22
DORAS
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S.S
Co-operatives
Members per farm
0 to 0.4
0.4 to 1
1 to 4
Source : NRC2D, 1994

Table 5.17 : Participation of farmers in cooperatives and extension groups

Number of per farm members of :	Extension Groups	Cooperatives
Sugarcane	0.9	0.5
Rice 3	0.7	0.6
Rice 1	0.7	0.5
Delta	0.7	0.4
Field Crops	0.6	0.7
Rice 2	0.6	0.4
Tree Crops	0.6	0.2
Vegetables	0.6	0.2

In the delta as a whole, 0.4 persons per farm is a member of a cooperative and 0.7 belongs to an extension group. The contrast is sharp between the poorly structured tree crop cropping pattern (public credit is less widespread and social structure rests more on the family) and highly structured rice area, specially Rice 1 and Rice 3. Sugarcane farmers take advantage of extension groups, which included the farmers also engaged in asparagus, baby-corn, dairy cattle, etc... In any case, the agencies of the Department of Agricultural Extension are everywhere to supervise the innovations and to help the farmers.

5.3.3. The commercial environment of farms

In the delta, the farmers began to grow cash crops many years ago. Before the Bowring Treaty they had to give rice production to landlords and tax farmers, the surplus being exported to China (Ingram, 1970). Moreover, sugarcane, tobacco, cotton were grown and sold. It was after the treaty that Siam became a single agricultural commodity exporting country. Nowadays, some farmers go on producing traditional rice for consumption, but these strains are suited to a particular environment.

As for technical issues, marketing raises two points. Firstly, when the commercial structure and the crops exist, the analysis of functioning is helpful for improving the commercial channel on the whole. Secondly, when there is a new demand or a new offer, the issue is how the marketing channel is built. Good all year roads with good accessibility to the markets allow many areas of the delta to diversify. However, 20 years ago, new crops flourished in some particular places. To assess the weight of commercial factors, we, first, described the two main marketing channels and, then, presented three data sets : markets (for crops and inputs), rice mills and merchants.

a. The marketing structure

From the local trader to the central market and retail stalls, internal marketing structure for agricultural commodities in Thailand is characterized by a privatized system. Free operating, according to the existing supply and demand conditions,

provides a high degree of competitiveness (Isvilanonda & Plangprapan, 1992). Government intervention has been minimal except for sugar and rice productions (Siamwalla, 1976).

The agricultural marketing structure varies from one commodity to another. Here emphasis is placed on the marketing of horticultural commodities, vegetables and fruit in particular, as this sub-sector has exhibited the most impressive growth. There is no doubt that the marketing channel has played an important role in mobilizing agriculture towards the emergence and the diversity of crops in the delta.

In comparison to other agricultural commodities, especially cereal crops, the marketing system of vegetables and fruit is relatively less complex (Isvilanonda & Plangprapan, 1992). However, being more perishable, transportation is probably the most crucial condition for market competitiveness of these commodities. In the past, production of vegetables and fruit was restricted to locations with good access to the central markets of Bangkok, in particular along never-dry canals. Today, with roads and transportation facilities, this restriction has been relaxed. The high cost of post harvest storage and the seasonal price fluctuations remain major problems.

Differential marketing channels are operating, from growers to consumers of fruit and vegetables. Such channels may be grouped into two categories, namely, middleman marketing and contract marketing channels.

Middlemen marketing channels

Traditionally, in the Central Plain, marketing activities were concentrated mostly at the two ***central markets*** in Bangkok, namely, Pak Klong Talad and Wang Mahanaka areas. ***Local traders*** or ***assemblers*** would buy products from growers on the basis of the daily price movement. Although this channel is still very active, what becomes increasingly common nowadays is the growers' ***direct contact*** with the Bangkok ***wholesale traders*** who have established a long association with the growers. In such cases, the price will be determined after product shipment. In recent years, ***traveling merchants*** provide another alternative channel through which farm products are collected and distributed directly to consumers without passing through the central market (Isavalanonda & Plangprapan, 1992). On the good side, the existence of different kinds of middlemen helps reinforce the marketing competitiveness of vegetables and fruit. Apart from these middleman channels , some growers sell directly to the wholesale and retail markets in Bangkok and nearby provinces. Such direct sales without middleman intervention become more possible now that new central markets have been established in other provinces apart from Bangkok (Rangsit, Nakhon Pathom, etc.)

Contract marketing and contract farming system

Contract farming was developed following the growth of the food industry since the implementation of the Sixth National Plan. To boost the agribusiness, the government promoted the use of contract farming by organizing a joint working group consisting of 4 parties, namely, the government sector, financial institution (Bank of Agriculture and Cooperatives), farmers, and private enterprise (the manufacturing industry).

Contract marketing is used by the manufacturing industry to insure a constant flow of raw materials to meet the processing capacity of certain export-oriented products such as pineapples, baby corn, asparagus, and bamboo shoot. A distinction is made between ***contract farming*** and ***contract marketing*** (Manarungsun, 1991). Contract farming is generally referred to as a vertical chain of production and marketing between the manufacturing industry and farmers of a specific commodity. Under this system, an advanced contract is made for the quantity and quality of products from farmers to feed the factory. As for contract marketing, farmers are guaranteed the minimum price of their product, but are free to manage their own production. Consequently, this is at their own risk. In the case of vegetables and fruit, contract marketing is more common, whereas for chicken and duck production, contract farming is more typical in Thailand. The contract system, in spite of its promising concepts, is often criticized as being beneficial only to the minority.

Under a free enterprise system as it is at present, the available marketing channels seem to serve as an adequately viable and dynamic marketing mechanism which fosters the growth toward diversified agriculture in the Central Plain. This conclusion applies best to the case of horticultural products.

b. The commercial places

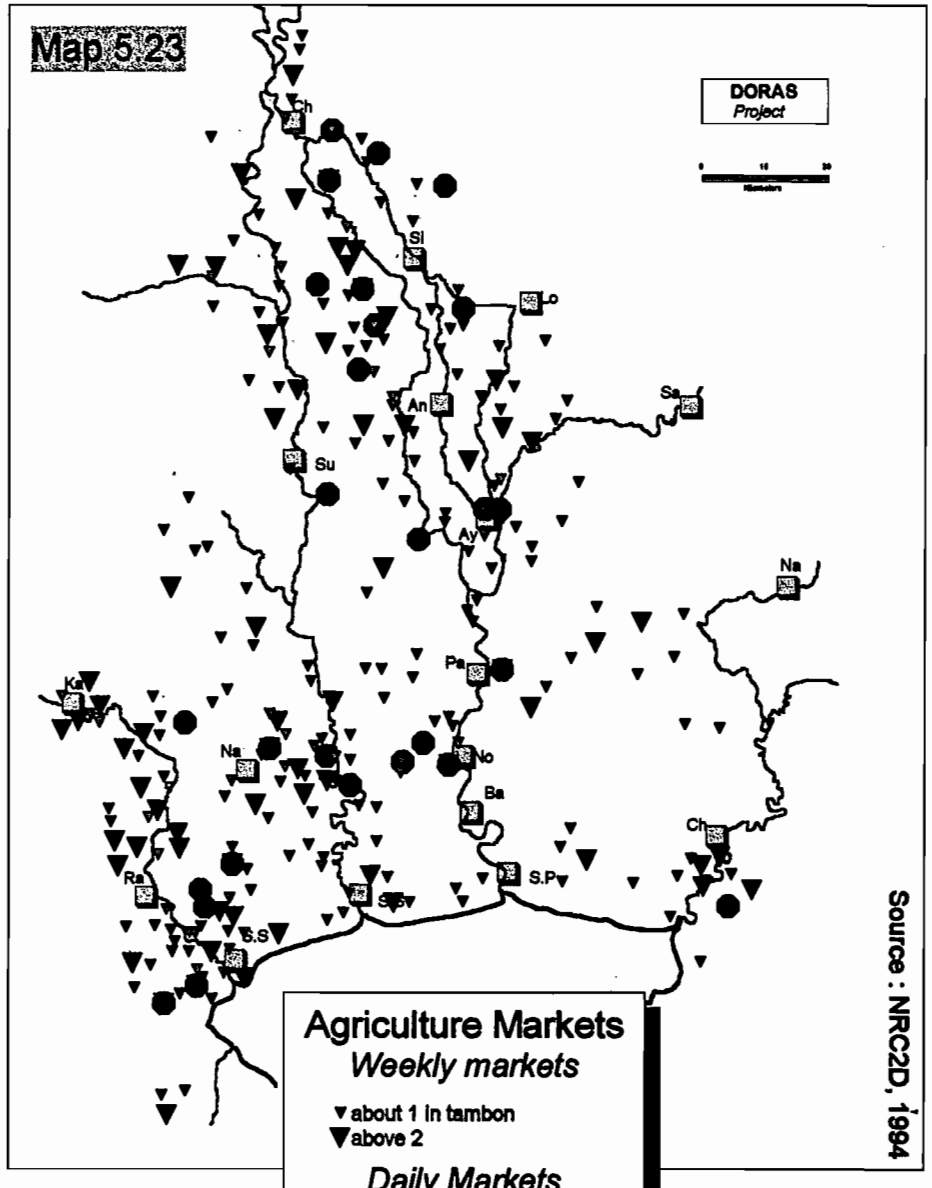
Agricultural markets

Seven percent of villages have a shop or a cooperative where materials can be bought. It means that nearly every *tambon* has one. However, the area west of Nakhon Nayok, once more, is poorly equipped. Cooperatives and groups complement the network of shops and markets, 13 % and 8 % of *tambons* having one of them.

The delta is a highly commercialized region where buying and selling commodities is easy and where a new crop can be cultivated with a high chance of commercial success. Weekly markets and commercial shops are widespread (map 5.23) and daily and wholesale markets are located in major production regions, such as Nakhon Pathom and the southwestern regions, on the main road along the Chao Phraya river and close to Bangkok.

Commercial places

Mills collect rice directly from the farmers or through collectors. Traditionally, they were situated along the rivers and Thailand's rice bowl has been well provided with mills for a long time. Three kinds of mills can be distinguished, each one having its own dynamic. Firstly, many traditional villages have a small processing unit for local consumption. Concentrations are found north of Kanchanaburi and near Chachoengsao and Saraburi (map 5.24). Second, medium-sized mills have problems competing in quantity and quality with modern mills. Third, large, modern mills have opened up with high buying power and are equipped to process vast quantities of rice for domestic and foreign trade. They are present near Suphan Buri and Nakhon Pathom.


Map 5.23
DORAS
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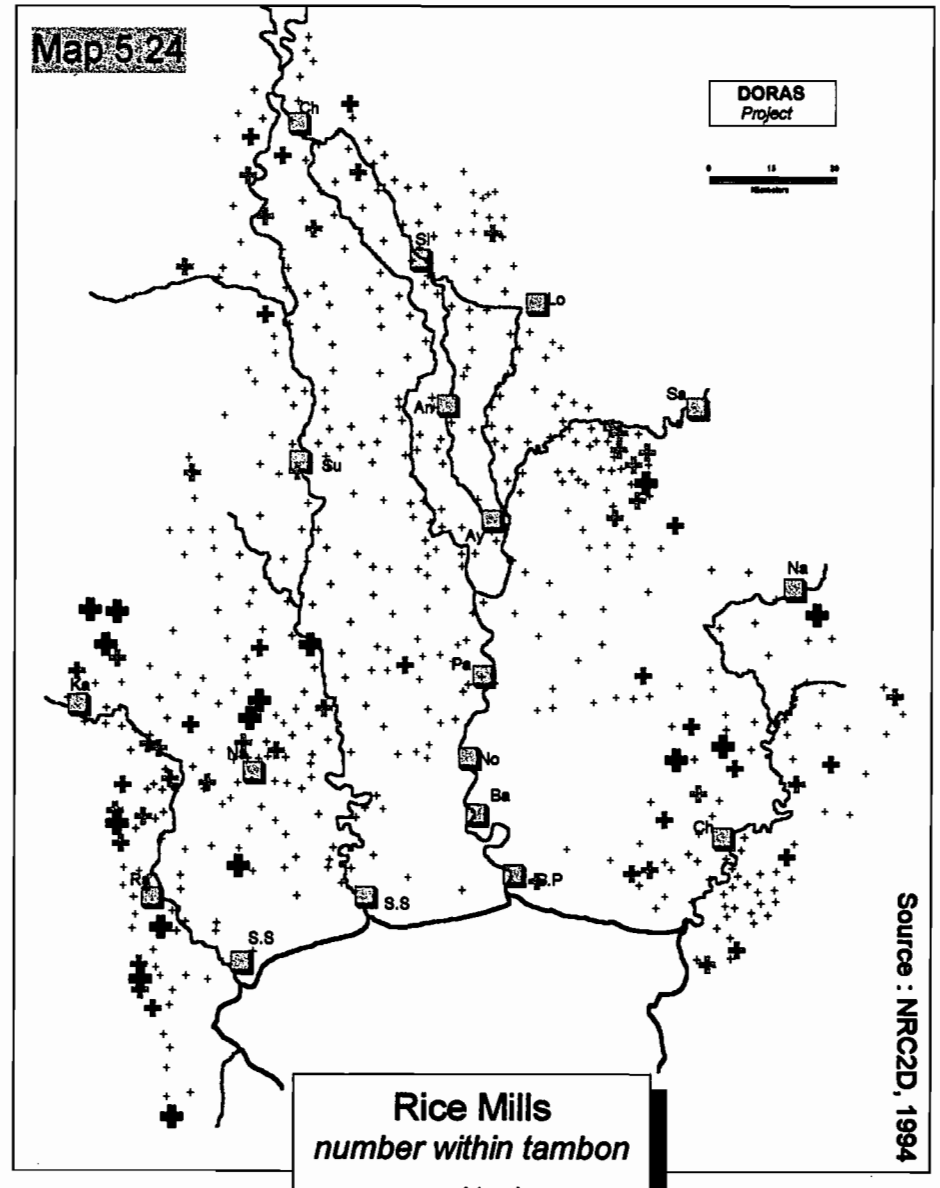
Ch
Ra
S.P
S.S
Source : NRC2D, 1994
Agriculture Markets
Weekly markets
about 1 in tambon
above 2
Daily Markets
at least 1 market in tambon
(urban markets excluded)


Map 5.24
DORAS
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No
Ba
Ch
Ra
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S.S
S.S
Source : NRC2D, 1994
Rice Mills
number within tambon
1 to 4
5 to 9
10 to 30
(village rice mills included)

Major towns are the main commercial places for marketing agricultural commodities. Besides, the density of the commercial network in the countryside is noteworthy. As usual, the dynamic, wealthy regions are better provided with merchants. Traders in Nakhon Pathom, Nakhon Chaisi and along the roads to Bangkok controls the flow from the south-western region. This infrastructure is favorable to market gardening farmers and the food industry (juice, milk, canned vegetables and fruit...). The flood plain, from Ayutthaya to Sing Buri, is more traditional, although field crops are developing and generating commercial flows.

5.4 Economic choice of farmers

Having described the structure and the environment of farms, attention is now paid to the economic incentives in order to understand the choice of crop combination and cropping intensity levels. Firstly, a scale of remuneration casts some light on the basis of the farmers' choice. In particular, any agricultural strategy, with its costs and advantages, is always compared with an alternative choice such as off-farm occupation or departure from the village. Secondly, we give some information about rice and sugar cane growers throughout the farming area and marketing channel. The analysis of the economic feasibility will cast light on other factors such as the physical suitability and farmer's family objectives. As seen before, the family's projects cannot be neglected, above all in the delta where many farmers get older, find themselves without successor and are ready to sell their land.

5.4.1. The economic incentive

Table 5.15 shows the discrepancy of income between the two extremes of the range : extensive one-rice crop and flower farming. Though the contrast is higher when the income is related to the surface unit, land is in fact not a problem for flower farming, but capital is. There is a steady substitution of capital for man power and land as income increases. The comparison between activities is useful at similar capital levels and has to be carried out between the closest rows in the table.

In the NRC2D questionnaire, the heads of village were asked the income most people get for the principal occupations. Each of them includes a broad diversity ; for instance, the category of merchants in fact consists of shopkeepers, collectors, middlemen and wholesalers. In spite of this difficulty, data illustrate the income scale. Not to give too much emphasis to farmers' opinions, we provided a relative index where single rice cropping is fixed to 100. Expenditures are not deducted.

For basic crops, gross income per rai is roughly similar for double rice and sugarcane cropping. Income per rai should not reach 5000 baht per rai. For extensive rice, income per rai should be 1300 baht with very low expenditure : little or no fertilizer, one tillage operation.

Table 5.18 : Gross income index for agricultural single occupations in the delta

Activity	Reference area	Income index	Income index per rai
Field crops	Field Crops area	81	
Single rice cropping	Rice 1 area	100	100
Double rice cropping	Rice 2 area	165	300
Sugarcane	Sugarcane area	180	350
Triple rice cropping	Rice 3 area	190	
Livestock farming	delta	230	
Other tree	Tree crop area	240	850
Vegetables	Vegetable area	240	2400
Fish and shrimp farm	delta	280	2800
Fruit tree	Tree crop area	360	920
1000 hens farm	delta	410	
100 pigs farm	delta	500	
Flower	delta	5500	above 5000

The comparison with an agricultural worker's wage shows that income for double rice cropping is not much higher considering production costs. We must point out that rice price was low in 1994 and increased in 1995 (3.8 baht to 4.7 from July to July). There is no doubt that factory job are attractive, at least for the farmer's children.

Table 5.19 : Gross income index for non farm single occupation

Activity	Income Index
Agriculture worker	96
Single rice cropping	100
Factory worker	135
Merchant	180
Home industry	250

The alternative for farmers is to shift to high value added cropping. For an average farm with a small labour force, coconut farming can be an interesting alternative ; when labour is available, fruit trees and shrimp farming also give a good return. The problem for orchardists is that during the first years the plantation does not yield return ; later, little flexibility prevents farmers to change when prices fluctuate. Whereas fruit trees are economically suitable, market uncertainty has limited investment in orange, guavas, mango or pomelo. Moreover, a major flood can always occur (as in 1995) and though groves are often protected by a dike, the risk is high for such a high investment. Unable to take such a risk, small farmers, with

adequate labour and limited capital, prefer market gardening. Lastly, wealthy families can afford pig or chicken husbandry, or even orchid farming.

5.4.2. The rice growers

a. Planting area by farm

Maps 5.25 and 5.26 show small and large farms according to 10 and 50 rai thresholds. Most of these small farms are concentrated in the southern part of the Mae Klong fan and close to Nakhon Pathom. Many small farms are north of Ayutthaya along the Chao Phraya river. Large farms are situated south of Ayutthaya and in the Nakhon Nayok region.

A low-intensity crop brings a low return per rai. Although expenditures are low as well, the net income is lower than that of an intensive crop. Consequently, extensive farming provides satisfactory income in large farms. If not, only old peasants with little expenditure or households with an extra income, can content themselves with a single rice crop. North of Ayutthaya, small farms continue to practice extensive farming. In fact, this region shows a high level of multiple occupations and in some cases, attempts to grow field crops. By contrast, south of Ayutthaya farmers have not the same opportunities and livelihood is satisfactory only because farms are large. The harshest situations are likely to be found in rain-fed area in the absence of off-farm occupations and diversified crops. Near Chachoengsao and Ratchaburi, small farmers began to give up agriculture a few years ago and much land is now uncultivated. Farmers with capital, sometimes from outer regions, settle to raise agricultural beds or to dig shrimps ponds.

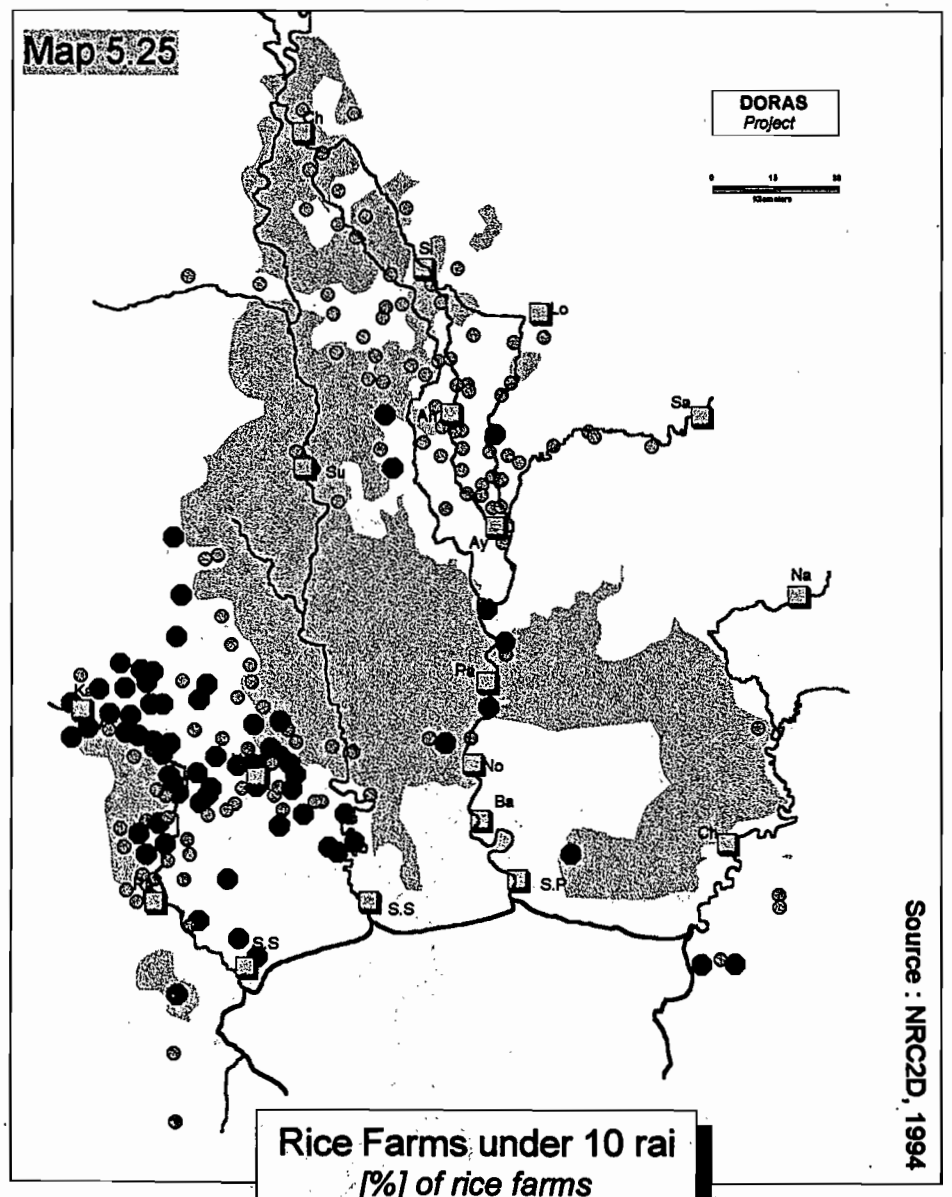
Further studies need to be undertaken to understand these peculiar dynamics. The newcomers dig or renovate canals and buy pumps. In the same area near Ratchaburi, special projects with banking institutions under governmental supervision are reclaiming large stretches of land (1000 rai e.g.) to sell or rent plots to small farmers for banana, asparagus, coconut, papaya, etc.

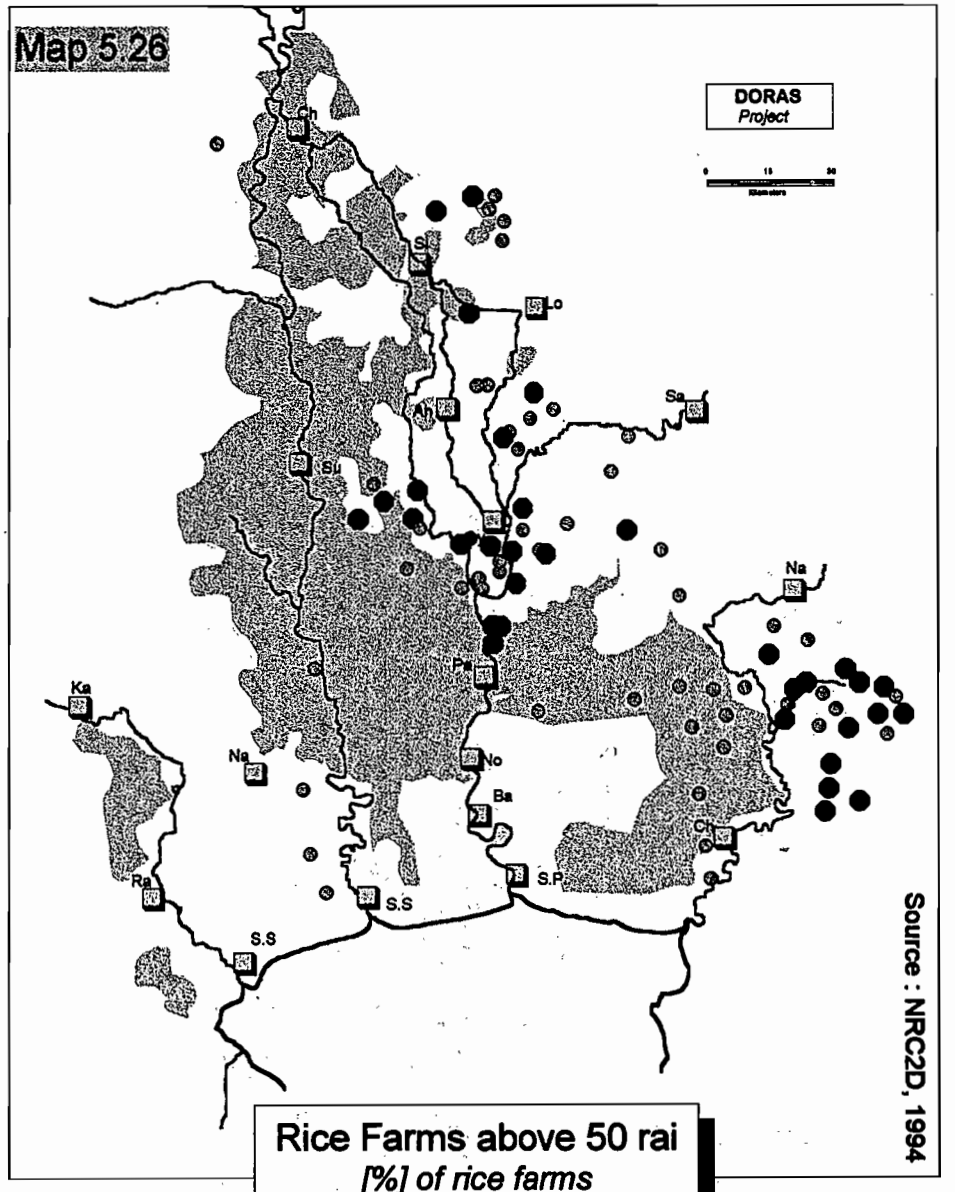
In double rice cultivation, average farm size per *tambon* ranges between 10 and 50 rai. No concentration of small or large farms can be found in the Rice 2 cropping pattern.

b. Price and marketing

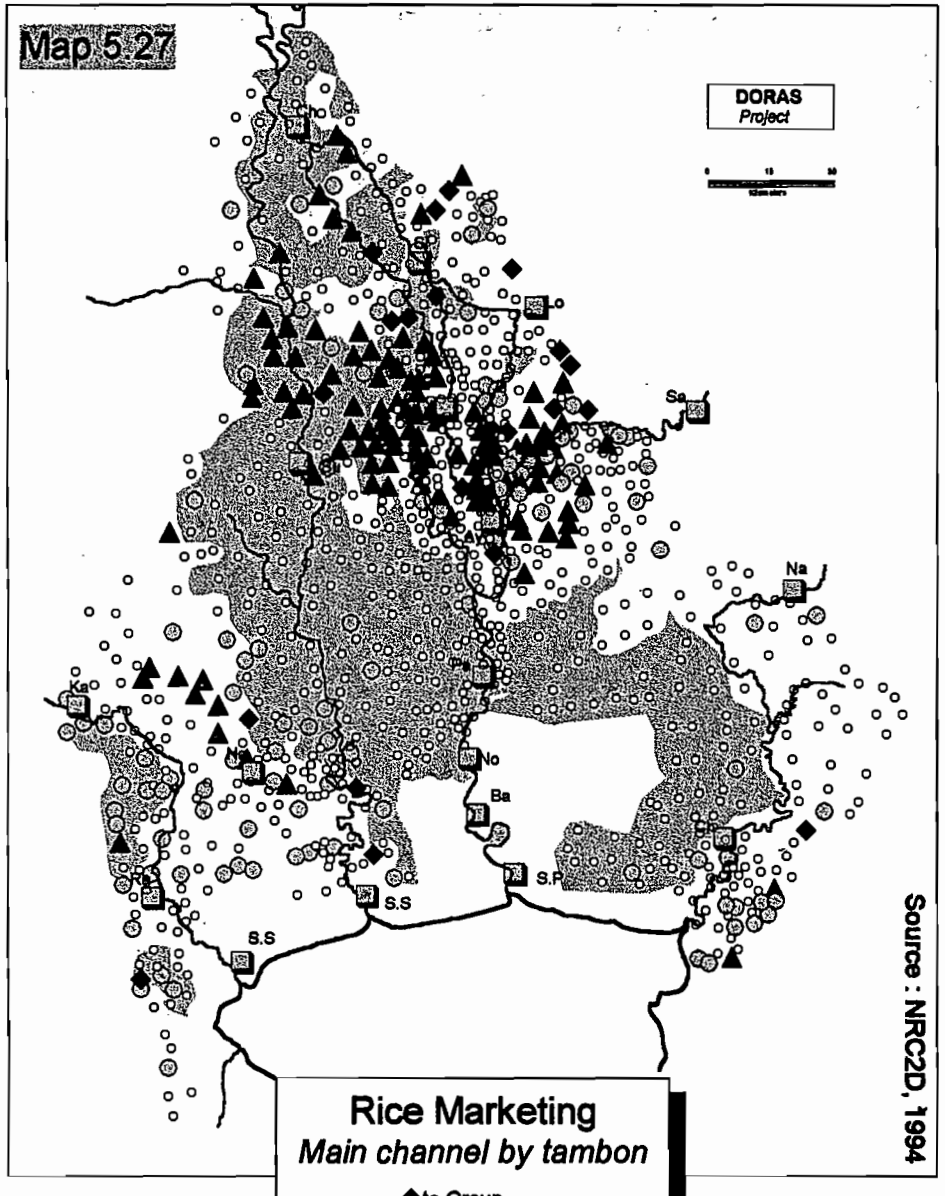
As shown before, rice mills are widespread throughout the delta. Traditional production areas near Ayutthaya have many mills located along the rivers. Nevertheless, the rice marketing presents two characteristics. Firstly, direct sale outside *tambon* and sale to groups and cooperatives are more common features than elsewhere. Secondly, the selling prices are the highest in the delta. It is not just a matter of better quality (gain humidity or jasmine rice) nor of sale period ; but rather, small quantities are marketed directly by farmers or their relatives.

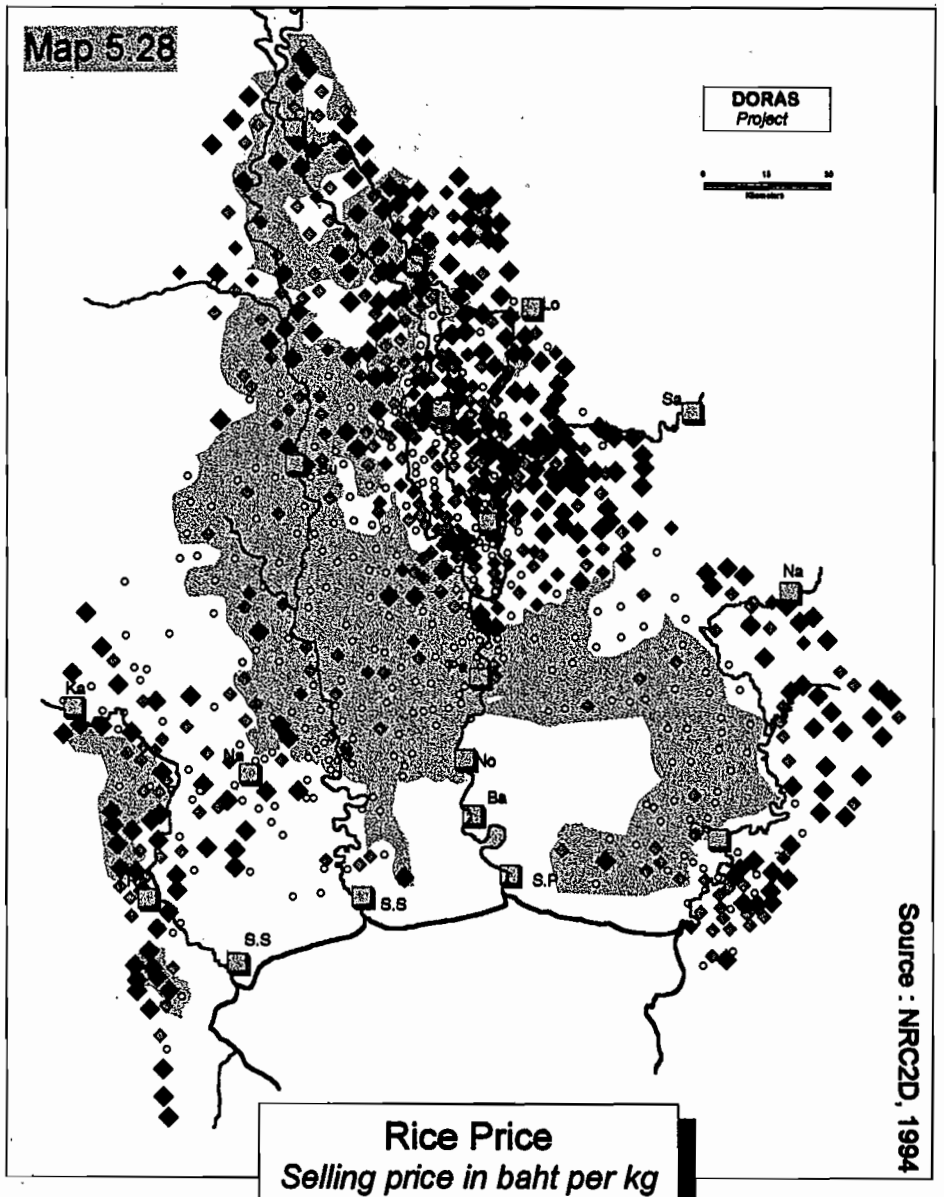
In Rice 2, the rice price is relatively lower in the main production area where mainly middlemen buy the crop at the exact time of harvest period. Financial or material advances are not common among rice farmers. As suggested in maps 5.27 and 5.28, marketing in the Rice 2 area of the old delta is characterized by groups and direct sale, and the farm price is higher.





Grey area =
2 Rice specialized cropping pattern





Grey area =
Rice 2 specialized cropping pattern

Table 5.20 : Average rice price by type of marketing channel in the delta

Marketing channel	Average price [baht per kg]
Middlemen	3.15
Mill	3.19
Group	3.29
Direct	3.32

Source : NRC2D, 1994

Farmers with a pickup take advantage of the higher price offered by retailers in the markets and also the cooperatives. On the other hand, they pay more attention to grain humidity and weed seed rate than some middlemen would do.

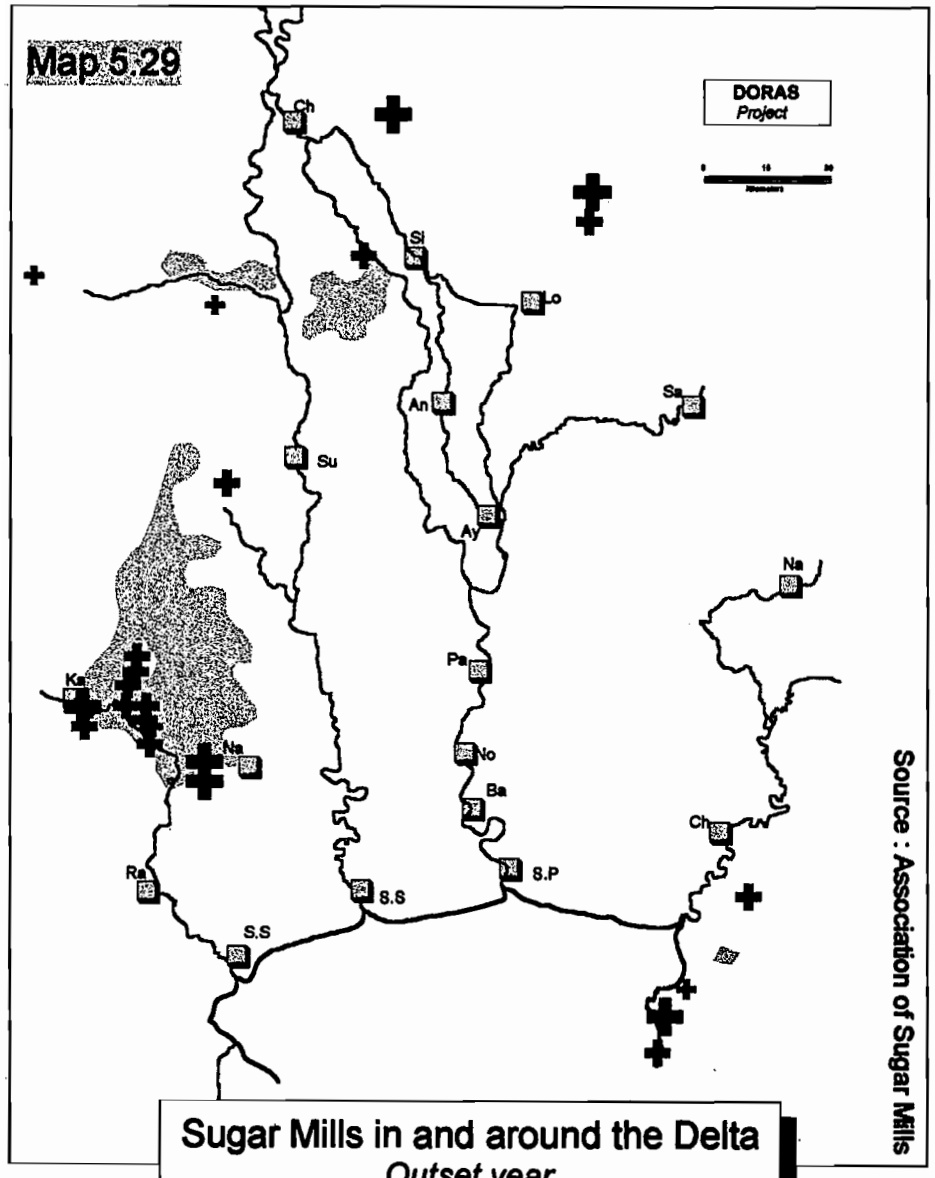
5.4.3. The sugarcane growers

Though average sized sugarcane farms are smaller than rice farms (respectively 21 and 25 rai), in fact, sugarcane is grown both in small and large farms. Map 5.31 highlights the distinction between the old delta, where the whole range of farm sizes are to be found, and the Mae Klong fan terrace. The latter can be subdivided in three zones :

- north of Mae Klong has many large farms ;
- in the middle, we find a mixture of small and big farms ;
-and in the south, near the river, where most farms are small.

Small farmers often grow vegetable or field crops, and sugarcane growing allows them to cultivate the remaining plots. The yield is average because nearly all the operations are implemented by the mill through the heads of quota.

Map 5.32 displays the marketing pattern of sugarcane. In general, the heads of quota collect the major part of the production, given that they are also large farmers ("direct sale" on the map key). Some agreement seems to have been reached with groups and mills, this latter being important downstream from Kanchanaburi and east of Sing Buri.



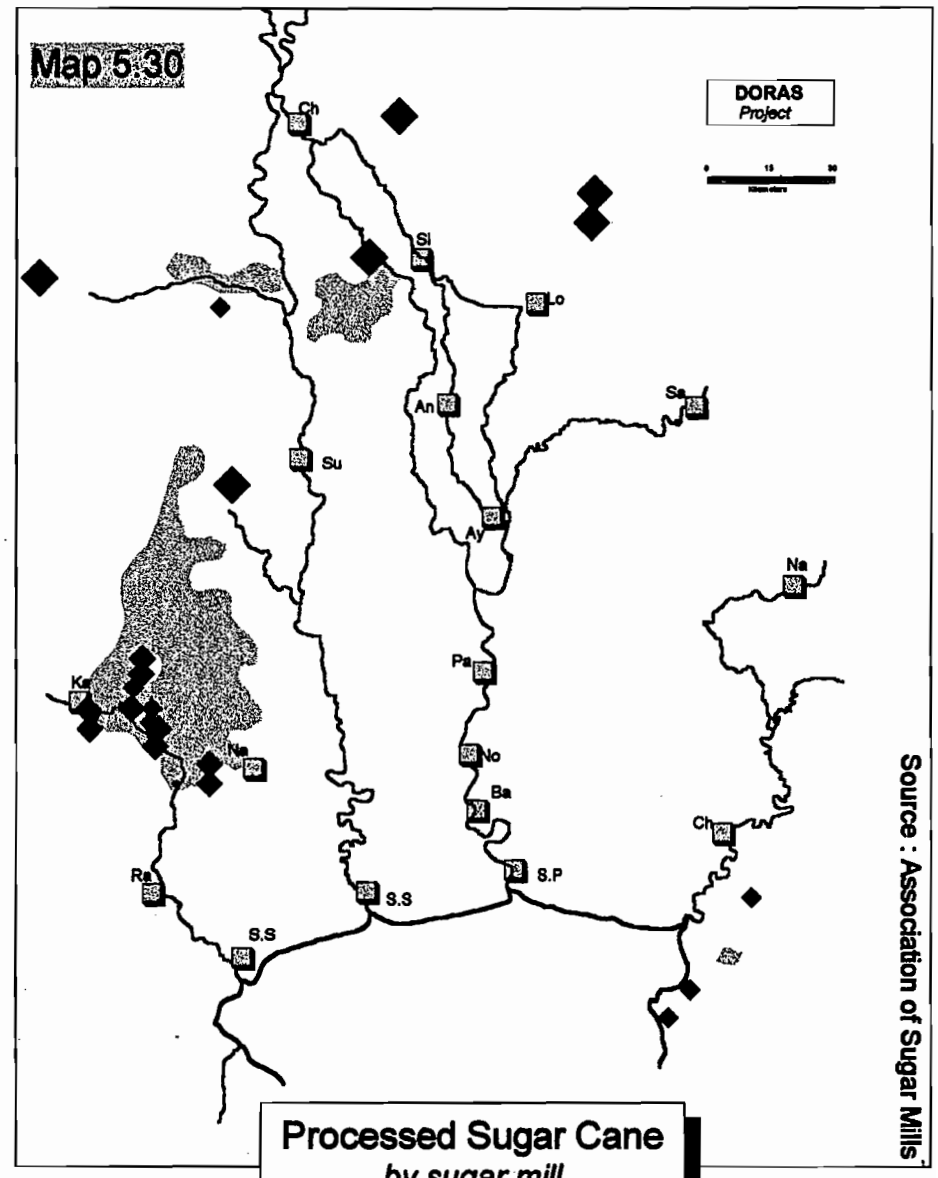
Source : Association of Sugar Mills

Sugar Mills in and around the Delta

Outset year

- 1956 to 1968
- 1968 to 1982
- 1982 to 1995

Grey area =
Sugar Cane specialized cropping pattern

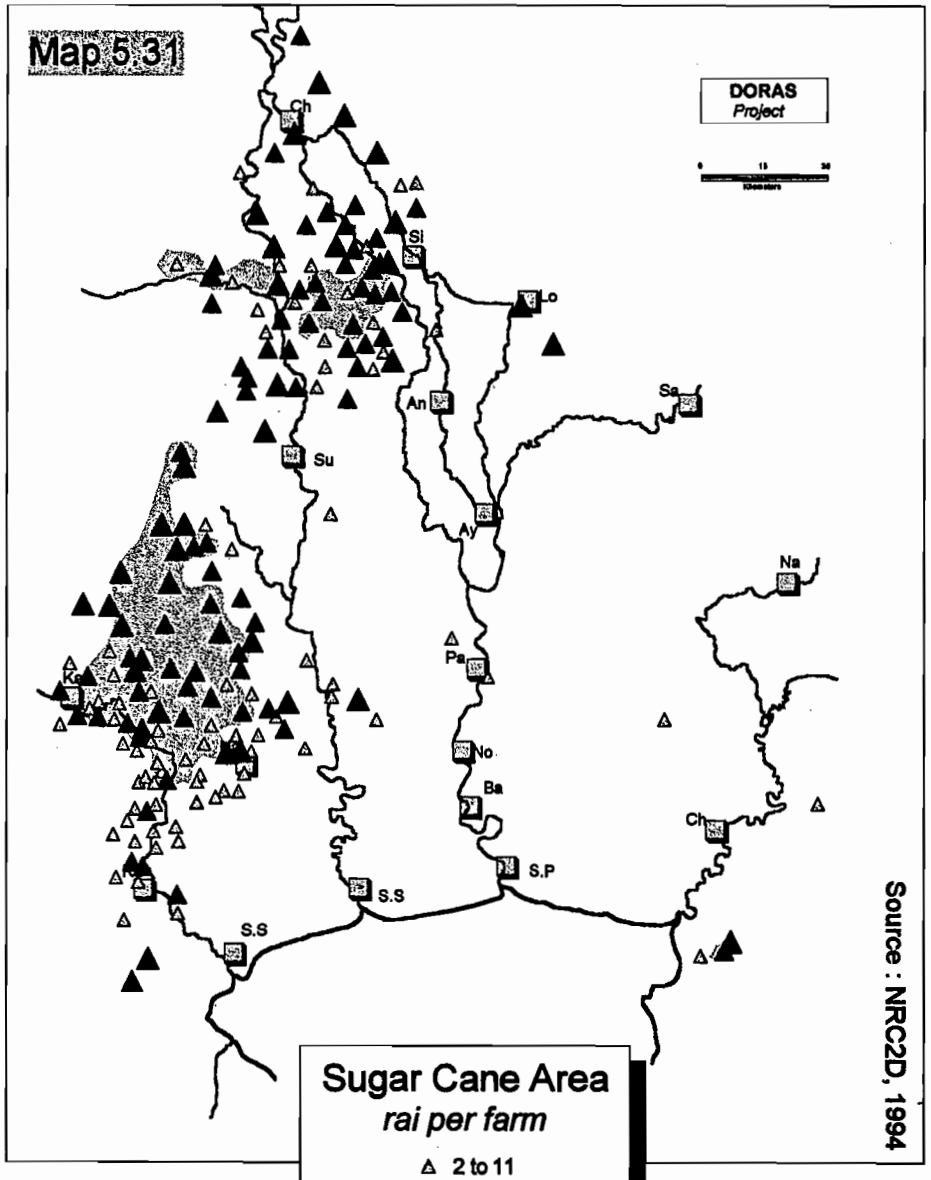


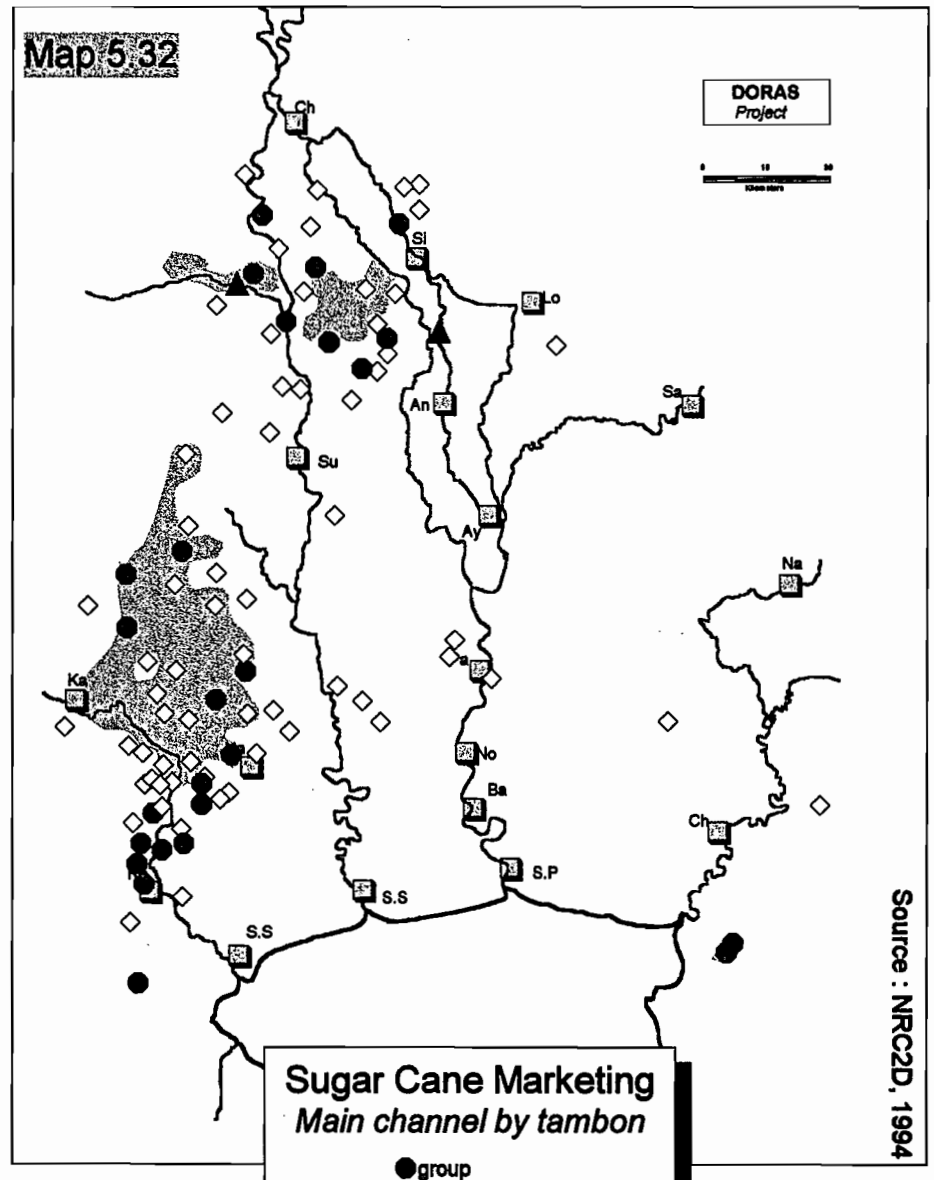
Source : Association of Sugar Mills

Processed Sugar Cane

by sugar mill

- 430 to 770
- 770 to 1560
- 1560 to 3940





Grey area =
Sugar Cane specialized cropping pattern

5.5 Farmers' perception of development issues

To conclude this chapter, we call on the opinion of farmers themselves, firstly about some particular limiting factors and then about more general issues, all information proceeding from the NRC2D dataset. As any methodology relying on opinion, the information has to be considered carefully. When possible, the distribution of opinions is confronted with the reality taken from the resource maps. Then, we try to judge the meaning of the responses.

5.5.1. Farmers' opinion on soil, land use and water

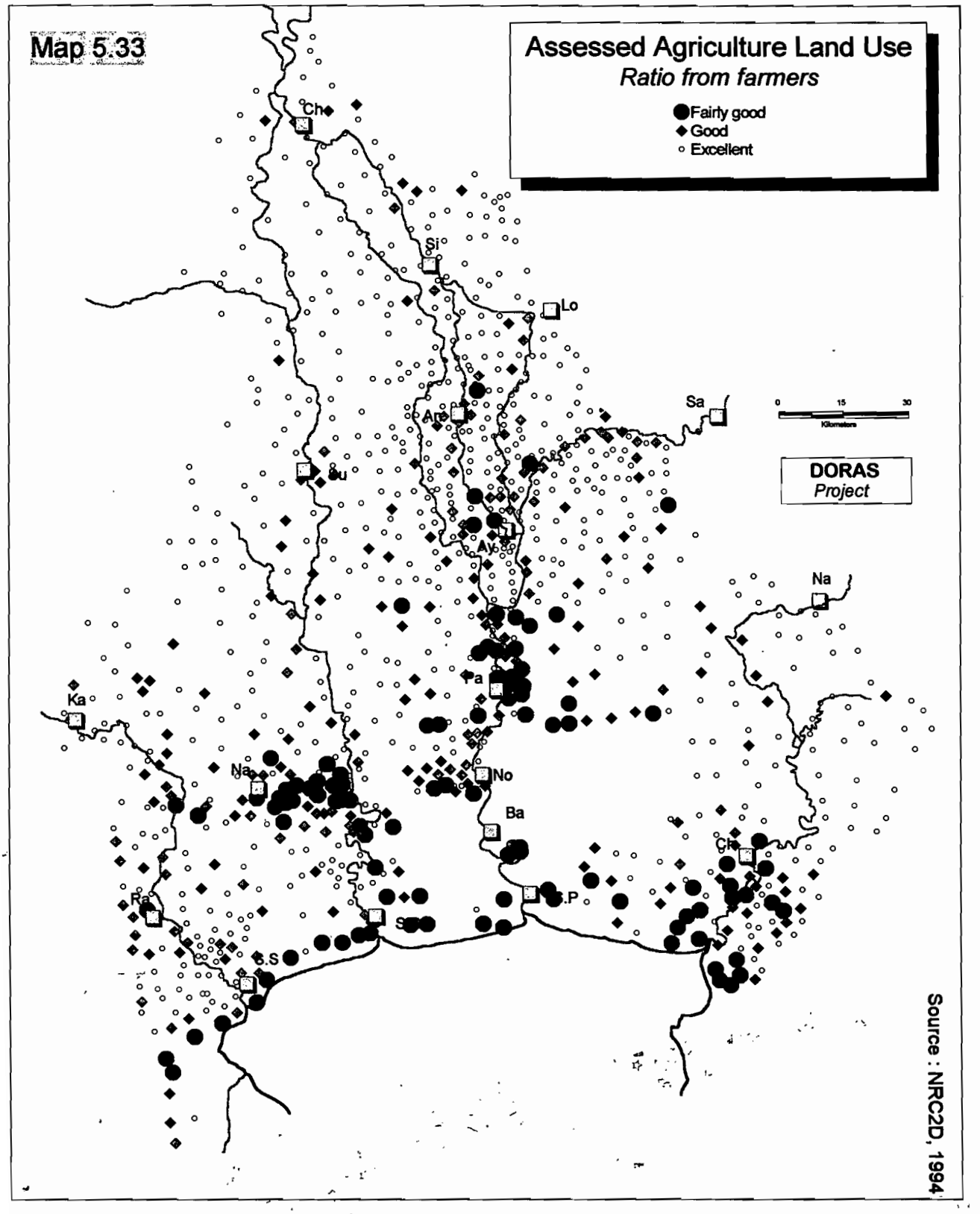
Map 5.33 displays an assessment of the ratio of the agricultural land use given by farmers. Firstly, the old delta shows an excellent use ratio. Then, the flood plain and the young delta sets out a mixture of good and excellent levels, "good" meaning that about 90 % of the usable farm area is cultivated. North of Ayutthaya, many tambons present only a good rate, perhaps revealing the first signs of abandonment in the low-intensity farming. Along the sea and upstream along the Tachin, Chao Phraya and Bang Pakong rivers, the ratio of uncultivated area is rather high. The same occurs along the roads between Nakhon Pathom and Bangkok and along the Chao Phraya above Bangkok. In this third area, the speculation for future development, urban or industrial, is an agricultural issue in the extent that agricultural production is lowered and farmers cannot afford a land strategy.

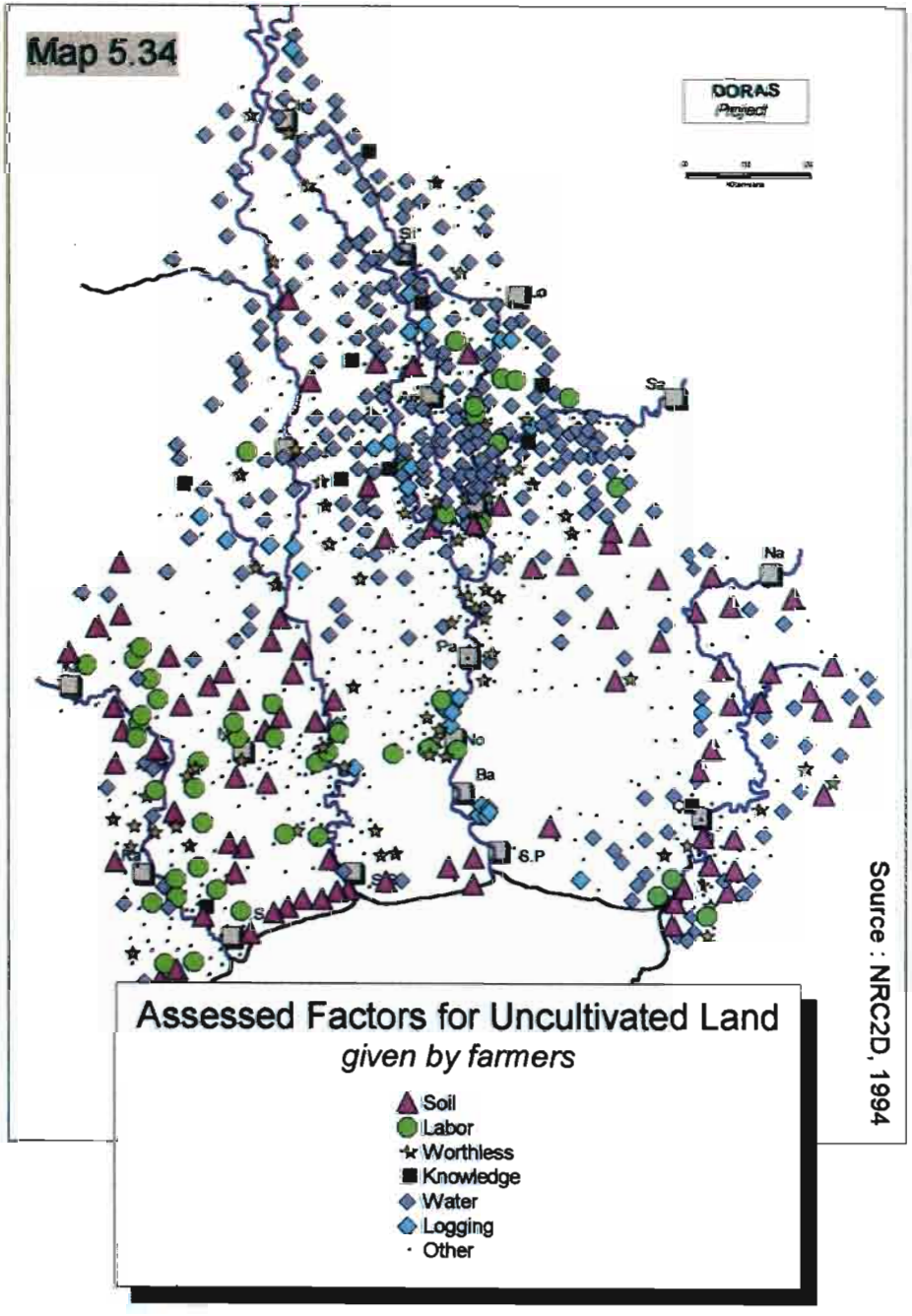
Map 5.34 shows the farmer's main explanation for uncultivated land. In the old delta, where not much land is given up, the main perceived problem is water supply. Labour and knowledge are also mentioned. A lack of labour can raise a problem for the harvest of floating rice. Lack of knowledge might mean that there is a tendency to change towards field crops.

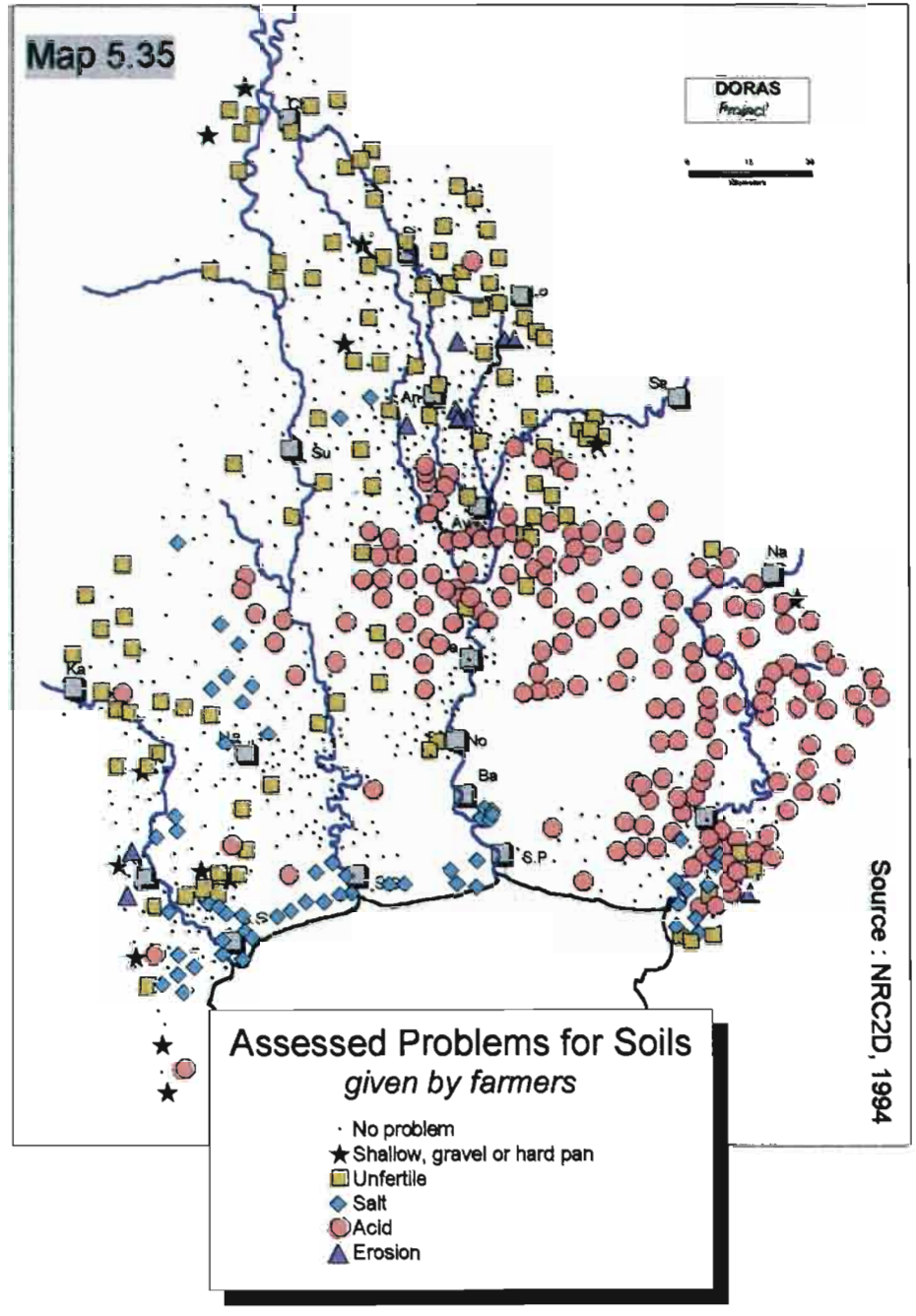
In the young delta, close to urbanized and industrialized areas, the rate of cultivated land is only "fairly good". Beyond the speculation and the industrial estates, water and soil are perceived as general concerns. Water issues are localized in a strip around the young delta, in the eastern, northern and southern borders. Soil presents a problem in the west, the east and near the seaside where it explained a part of the high rate of uncultivated land (see further). Because of high wages, labour is perceived as a problem mainly in the west where vegetables and sugarcane are grown. Flooding gives trouble in some villages and farming is worthless particularly south of Ayutthaya and Suphan Buri. We do not know the reasons for such an opinion.

Labour, soil and flooding bring problems in the more uncultivated areas. Near Bangkok, wages are high and near Nakhon Pathom, small market gardeners cannot contract high wage workers.

Map 5.35 gives details of the soil problems as perceived by the farmers. In the old delta, plots are characterized generally as having an "infertile" characteristic. Erosion occurs in some areas. In the young delta, farmers recognize the acidity and the salt constraint. Near the sea, the abandonment of land is clearly due to the salt intrusion.


Map 5.33
Assessed Agriculture Land Use
Ratio from farmers
Fairly good
Good
Excellent
Ch
Si
Lo
Sa
An
Bo
Ay
Na
Pa
Ka
Na
No
Ba
Ra
S
S.S
S.P
Ch
0 15 30
Kilometers
DORAS
Project
Source : NRC2D, 1994


Map 5.34
DORAS
Project
Assessed Factors for Uncultivated Land
given by farmers
Soil
Labor
Worthless
Knowledge
Water
Logging
Other
Source : NRC2D, 1994


Map 5.35
DORAS
Project
Assessed Problems for Soils
given by farmers
No problem
Shallow, gravel or hard pan
Unfertile
Salt
Acid
Erosion
Source : NRC2D, 1994

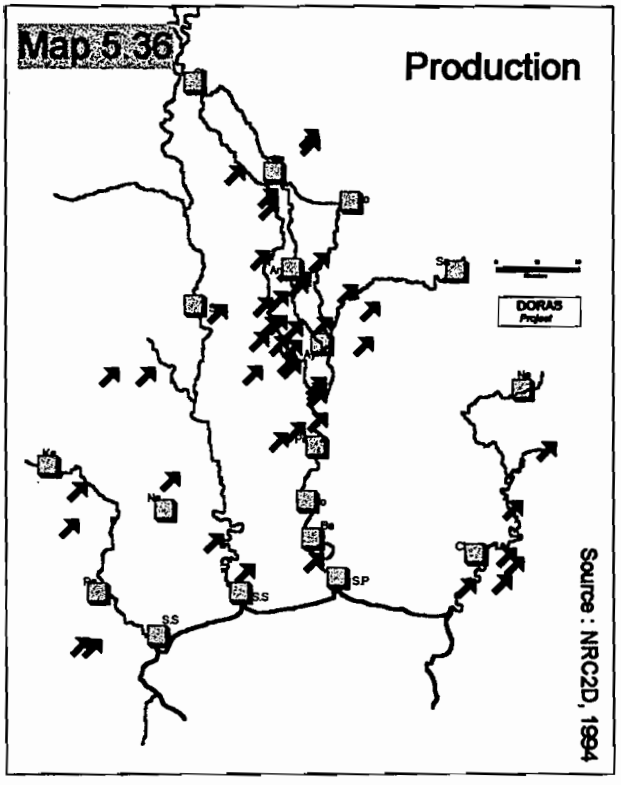
5.5.2. Farmer's opinion on development issues

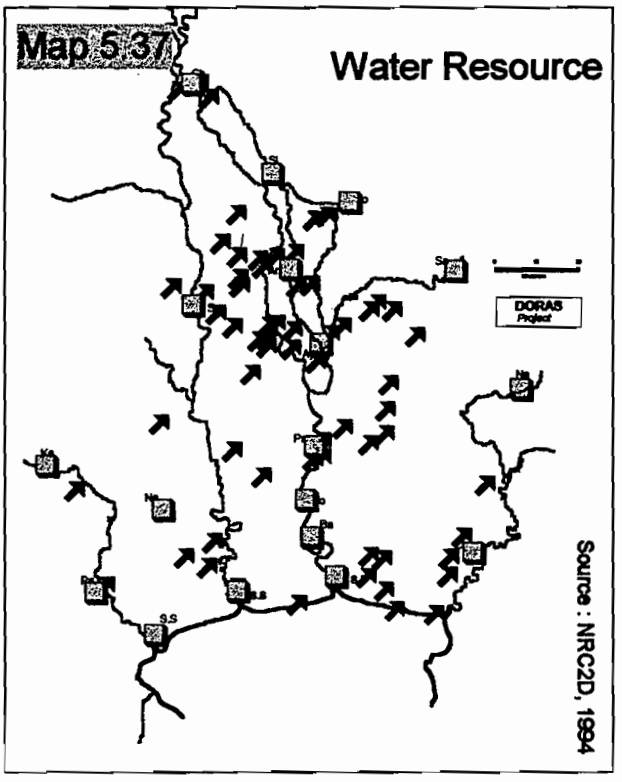
Answers to the questions about technical aspects of production, environment issues, infrastructure and water allow us to obtain some clues about the perception of farmers in the delta.

The 4 maps from 5.36 to 5.39 display an index relative to the total weight of opinion. Indeed, mapping of the absolute answers show similar patterns whatever the topic : health, transport (not displayed), production, etc. Though the absolute level of the problem cannot be appreciated, the order of the problems can be.

Water is a problem in the flood plain. Nevertheless, due to the annual flood and because farmers have adapted to such a situation (for example, extensive packaging, multiple occupations, etc.), water shortage, either in the dry season that prevents the growing of field crops or in the rainy season that hinders the production (map 5.37). Moreover, map 5.36 shows that a general "production" problem is perceived mainly in this area. It is worth pointing out that a problem of water exists in the core of the old delta where farmers practice relatively intensive sugar cane farming. In scattered areas in the young delta, water shortage, irregularity and flooding are the major concerns to be addressed for development. In summary, the map of perceived problems raise two kinds of development : firstly, small operations to enable the farmers to adapt or achieve a light intensification and secondly, large projects at the watershed level to upgrade the delta on the whole and give particular situations the improvement required for a global intensification.

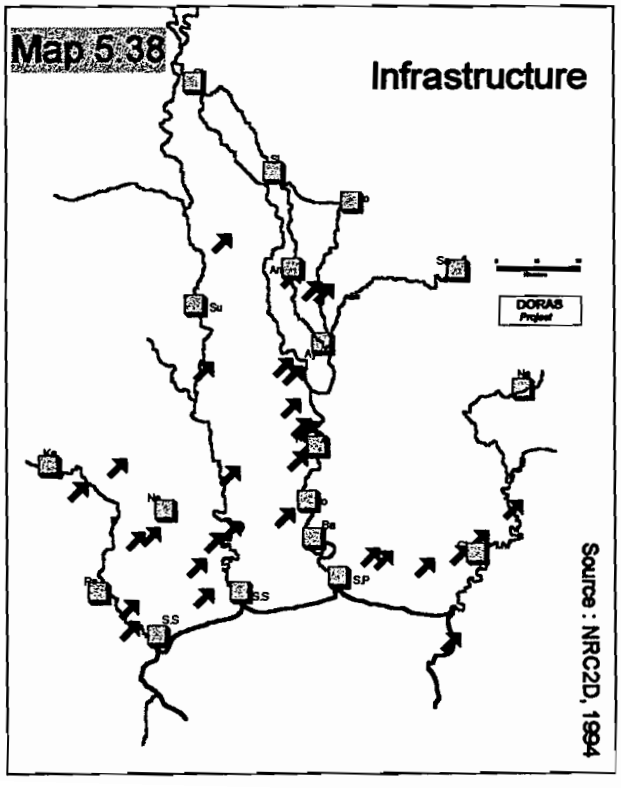
Lack of, or inadequate infrastructure is spotted as a development issue along the major rivers. It is presumably due to a low control of water. Environmental problems are detected in the young delta, in particular near the major towns and where crop diversification has led to an overuse of chemicals. There are no particular complaints where shrimps, fowl or pig husbandry is widespread.

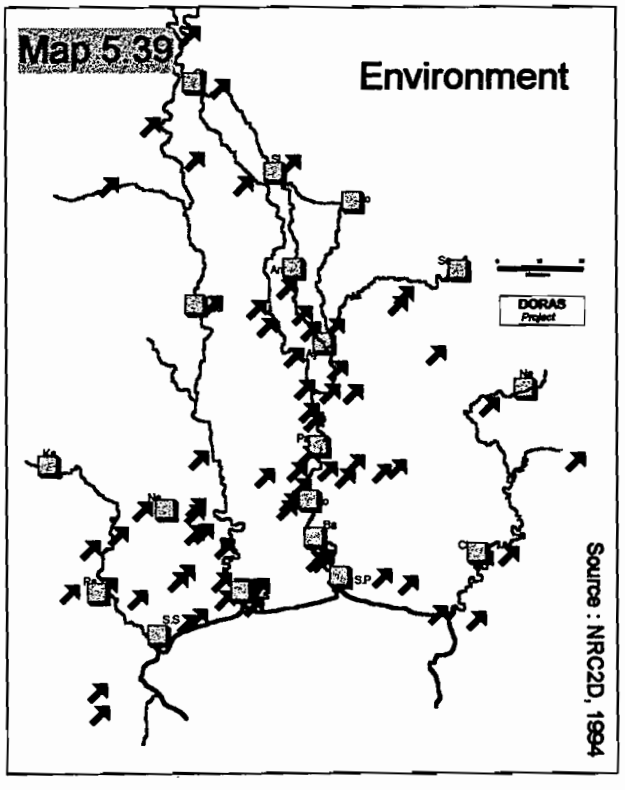




Some Relative Problems for Development

given by farmers





Chapter 6

New dynamics and emerging issues

The previous sections have attempted to highlight the main features and contrasts regarding physical and human conditions, water use, agricultural patterns and farm characteristics in the Central Plain of Thailand. We have also recalled some general historical benchmarks and described recent evolutions.

In the introduction, the importance of the Central Plain in Thai agriculture has been emphasized. This region not only constitutes an area with considerable agricultural output but is also a laboratory for diversification, innovation, intensification, mechanization, which undergoes deep transformation.

This exploratory study has allowed us to gather extensive information and numerous documents, and to establish a geographic database of the Central Plain. As mentioned in the opening section, this first phase analysis has been mainly restricted to a macro level and must be used to identify emerging issues and process, and to derive priorities for in-depth research to be carried out during the second phase.

6.1 Interrogations and emerging issues

From the preceding descriptions of the current agricultural and human dynamics, several main issues can be outlined. Almost all the ongoing processes being in interaction within their physical and socio-economic environments, the actual situation can be looked at and analysed through different scopes. We can, for example, chose the three following main axis:

➲ The farmers

An initial interrogation could be put in a simple manner : who, in the near future, is going to carry out agricultural activities in the Central Plain ?

This question is first of all derived from the observation that the rural population engaged in agriculture is ageing, specially in some areas such as the flood plain (see §2). Farms run by a single couple over 50 years old are quite common, which is mostly possible because of increased mechanization.

Such a situation is due to the great attractiveness of urban areas, where incomes are, in addition, often higher than in the agricultural sector. The rural-urban migrations nevertheless may present contradictory and entangled causes. On one hand the development of the industrial and service sectors, together with a

somewhat slow but continuous increase in the educational level, create opportunities for new jobs. As these sectors also tend to develop in main cities located out of the Bangkok Metropolitan Area, a complex pattern of pluriactivity, mixing on-farm and off-farm activities is often observed.

On the other hand, hectic and low quality levels of living in urban areas are not unlikely to counterbalance these trends. Some movements are already observed from Bangkok towards neighbouring *changwats*.

In addition, the development of diversification towards highly profitable activities may provide greater attractiveness and better opportunities in the agricultural sector. As these activities are sometimes labour consuming, they may also contribute to fix people in rural areas.

Farms with ageing owners, with no descendant willing to take over their farmland, may lead in the future to a decrease in farm land price, at least in areas far from the capital and main communication lines. So far, this price has been, on the contrary, very much inflated because of speculation and acquisition by owners living in urban centres.

The labour constraint is likely to keep on being a driving force of the mechanization process. This, in the future, could go together with the appearing of larger scale farms, counterbalancing land partition by heritage.

The agricultural population decreased from 3 million, in 1960, to around 2.5 million nowadays. This trend is likely to proceed and to remain an important cause of agricultural change.

➲ **The agricultural activities**

Another simple and broad questioning concerns the future of cropping patterns and farm production : what activities are going to develop, what are their limitations and consequences ?

Diversification of rice based agricultural systems is probably the most prominent feature of current dynamics in the Central Plain. However, its causes and consequences, specially at farm level, seem to be poorly known. Many issues are at stake in this process, among which we can distinguish:

- the government policies, which have recently strongly emphasized the necessity to grow crops with higher values and consuming less water than rice, and allocated corresponding credit facilities;
- the responsiveness of farmers to the demand of the national and export markets - and vice versa -, in which middle-men play an important role;
- the risk (linked to low production or market uncertainty), which increases together with indebtment and higher levels of input and investments;

- the innovation requirements, with the corresponding different patterns of dissemination and skill acquisition;
- the physical and technical constraints to diversification, specially regarding soil properties, access to water and water management;
- the environmental threats, with the impact of the decreasing water quality, especially upon some production like shrimps or orchids;
- pest pressure threats, linked to overuse of pesticide, specially in the raised beds areas of the southern delta.

All these aspects will contribute to shape the dynamics of agricultural systems towards diversification. These dynamics also have great repercussion on social change and social differentiation as they dilate the range of the traditionnaly rather low farm income.

Rice cropping, on the other hand, is likely to maintain itself in the future, although reduction in acreage due to encroachment of urban areas and diversification will probably continue - with an approximate rate of 0.5 % per year. The main issues will concern :

- the future of dry-season cropping, mostly linked to water availability (and, therefore, to improvement in water management), and to the sustainability of ground water irrigation.
- its overall profitability, with questioning about word market prices and increase of production in neighbouring countries.
- the margin for increase in the level of intensification : this, in particular, raises concern about issues such as :
  - water control at plot level (on farm development)
  - improvement of overall water regulation in order to allow flooded areas to shift from traditional varieties to High Yield Varieties.
- the development of the production of high quality rice, as this marketing trend is likely to continue.

Profitability of rice cropping will be a key factor : it will govern the sustainability of rural livelihood and the main dynamics of change in the delta : intensification in larger farms; diversification for farmers with sufficient capital and convenient location regarding markets and water resources; pluriactivity, migration or land sale for areas located in the surroundings of Bangkok and/or deprived of water control.

➲ Water : a key factor of production

Water is a key factor of production in the Central Plain, as the greater part of its agricultural land is provided with some kind of irrigation facility or flood regulation. Its availability is, in particular, the core of diversification and of multi-cropping. Water resources in the Chao Phraya basin are coming under pressure, as their utilizations are diverse and sharply on the rise. Their management is also a challenge for the future, involving the main following aspects:

- water quantity, which governs, for example, the possible extension of second rice cropping and the pressure on underground resources through increasing well digging;

- water management, which must aim at achieving higher equity and efficiency in water deliveries. It can be addressed at various levels : the macro level, which deals with water management at the basin level, considering the different uses (irrigation, navigation, domestic and industrial use, etc). The Project level, in which regulation by officers and technicians is concerned; and the on-farm level : at this level, farmer organization is questioned, with related issues such as water-fee and turnover.

- flood control and warning; the management of floods is increasingly demanded by urban areas where flooding generates high damage and prejudice. Nevertheless, the hydrological risk can never be reduced to zero.

- water quality, sustainability; problems related with poor water quality (pollution from industries) or salinization (in some parts of the Mae Klong Project) have a negative impact on agriculture and may jeopardize its development.

- patterns of land development, which have a clear impact on rice productivity (through increased water control), and on the possibility of diversification. On-farm development is questioned, both at a technical and economical levels, with its different possible patterns of land transformation. Diversification, as well, raises questions on appropriate soil and water management.

In brief, all the agricultural activities - not to mention the industrial ones - in the Central Plain fully rely on water supply. This implies that its future management and partition between its different uses will be of paramount importance for the wealthiest region of the country. In addition, the trend observed towards diversified activities implies that a growing demand will be manifested towards improvement in terms of water quality and timeliness in delivery, which are demanded by activities such as aquaculture, orchids or vegetable farms.

6.2 Outline of priorities for research

From these brief comments, it is possible to derive many issues and priorities for research. Some of the main themes can be outlined according to the following topics, some of which overlap due to their interdependency, as observed above.

➲ Topic A : patterns of water control and impact on the conditions of production

From the zoning of water regimes in the Central Plain described in Chapter 4, we can distinguish the main modes of water use and control. Nevertheless, further analysis at farm and plot level must be carried out in order to assess the variability of situations when local topography and soils, together with local characteristics of the irrigation network and of its management, are taken into account. This should allow us to refine the typology in some representative areas and to improve the zoning of

water control situations, highlighting the specific constraints faced by each main zone. One in-depth study, possibly involving precise monitoring, should be carried-out in each of these situations :

① Poldered area with predominant diversification (raised beds areas; e.g Damnoen Saduak, Rangsit)

② Conservation areas, with pumping irrigation and predominant rice-based systems (e.g West bank, Rangsit)

③ Areas with classical gravity irrigation and good on-farm development (land consolidation)

④ Areas with classical gravity irrigation (poor on-farm development, rotational system in the dry season; e.g. parts of the northern delta)

⑤ Flooded areas (deep water and floating rice)

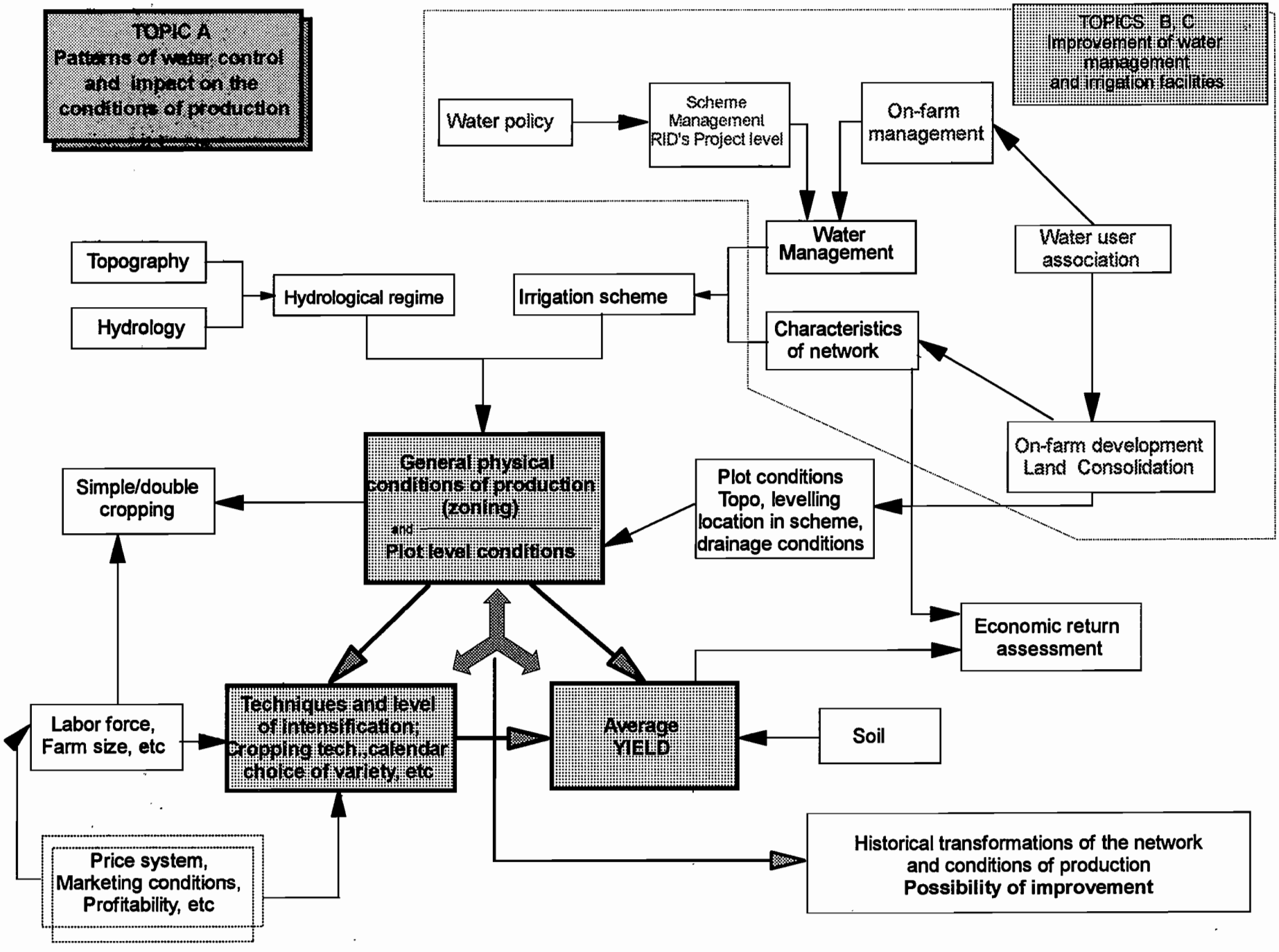
These studies would aim at understanding the relationship between (see fig. 6.1):

- the natural or physical constraints in the Central Plain (soil, topography, hydrology);
- the patterns of land development (canals, embankments, dikes, the irrigation and drainage network), the patterns of hydraulic regulation, their limits and flaws;
- the main patterns of rice cropping techniques, as governed by the hydrologic regime : choice of variety, cropping calendars and cropping technique;
- the average productivity and the potential for production .

These relations should be described in **space** (zoning; varying conditions in each zone) and in **time** (historical evolution of the canals and irrigation networks, its characteristics and management; change in water use and availability in the water basin, evolution of the main types of rice-cropping, etc).

The diversity of situations would be enhanced and **margin for progress and improvement** would be shown. An example of such possible evolutions is given by some drainage deficient areas where deep water rice is grown and supported by regulators located in the main drains. The betterment of the drainage system and/or improved regulation may allow a change in water management, from a "water retention" policy towards a "maximum drainage" one. Such a change was observed four years ago in the south of the Borommathad Project and deep transformation of the agriculture have occurred in over 10,000 ha. These changes include :

- shift from deep water rice to HYV
- large expansion of double and triple rice cropping
- marked increase of sugar cane (+ 100 %) which can now be planted in lower areas.


TOPIC A
Patterns of water control and impact on the conditions of production
TOPICS B, C
Improvement of water management and irrigation facilities
Water policy
Scheme Management RID's Project level
On-farm management
Water Management
Water user association
Topography
Hydrology
Hydrological regime
Irrigation scheme
Characteristics of network
On-farm development Land Consolidation
General physical conditions of production (zoning)
and
Plot level conditions
Simple/double cropping
Plot conditions Topo, levelling location in scheme, drainage conditions
Economic return assessment
Labor force, Farm size, etc
Techniques and level of intensification; cropping tech.,calendar choice of variety, etc
Average YIELD
Soil
Price system, Marketing conditions, Profitability, etc
Historical transformations of the network and conditions of production
Possibility of improvement

Research must determine if similar evolutions are possible in larger areas, such as the Roeng Rang and Khok Katiem Project, in order to increase the area cropped with HYV.

At the same time, increased understanding of the current flood regime should be attained through modelling, and confronted with farmers' decision making and assessment of risk.

➲ Topic B : improvement of water management

Water resources, as stressed before, are becoming rare during the dry season (not allowing full development of the agricultural potential), and there is also a risk factor in the rainy season (with occurrence of floods). Although impressive land development has already been achieved, the overall water management needs to be upgraded : water management can be conveniently considered through its different relevant scales (fig. 6.2) :

➢ At the basin level, the allocation of water must consider all the current utilizations of water together with the projection of their growth; a GIS should be undertaken to allow better representation of related spatial dynamics.

At this level, there is also a clear concern about the policy for water allocation. One of the questions which could be addressed is the policy concerning allocation for dry season cropping. The zoning presented in chapter 4 has shown how some areas have tried to avoid a possible lack of water in the beginning of the "official" dry season by shifting their cropping calendars, starting the second rice as soon as the flood regime allows it. Studies should investigate which Projects could possibly adopt a different calendar for the dry season (by conducting it just after major rice) and how much water could be saved by thus reducing the water requirements of land preparation.

A related issue is the question of the sustainability of a dry season cropping relying on underground water resources, as observed in the northern delta : in the last two years, most farmers have had to deepen their wells in order to be able to continue exploiting this water source. Of concern is the future situation than one may expect from the recent digging of several thousands of wells.

➢ At the Project level (the Central Plain comprises 45 Irrigation Projects), the command function of the central offices should be strengthened by the use of computer technology, regarding data collection, management and analysis.

Daily monitoring can be improved by using GIS software for the visual monitoring of:

- the water allocation in each hydraulic unit (WASAM sections, zones, etc), by comparing real delivery and computed requirements;
- the water level in the main waterways (river, main canals)
- the setting of the regulators

Improved data management would allow data to be recorded and stored for further automatic time analysis, especially in-season and post-season performance assessments. A software is under development in the Kamphaengsaen Project. Its application to the monitoring of the Central Plain is also initiated.

➢ At the tertiary (or ditch level), efficiency is related to on-farm development (see next topic) and water management among users. This issue poses in particular the question of the apparent non-activity of Water User Groups, at least in the administrative definition of such groups. Little is known about the reality of water management and access to water, at the farm level.

➲ Topic C : benefit, limits and constraints of on-farm development

Over more than one century, but especially during the last 50 years, irrigation development in the Central Plain of Thailand mainly concentrated on the construction of the main canal network. Thus, primary and secondary canals, in areas where gravity irrigation was possible, as well as a network of improved channels in the conservation area, have been developed throughout the region.

Official policy gave priority to the overall extension of main water distribution facilities considering that limited budget did not allow the development of on-farm structures at the same time. The impact of on-farm development has so far been very variable, depending on many local factors of different kind (economic, physical, social, agronomic, etc). Land consolidation (either intensive or extensive) has been achieved in only around 10 % of the whole irrigated area (but this proportion reaches 30 % when only gravity irrigation is considered).

Nevertheless, the necessity to improve water use efficiency and to raise productivity in order to increase competitiveness in the world rice market should raise the debate about the benefits, limits and constraints of on-farm development.

Although much debated in the seventies, this issue has received little attention in the last fifteen years. Research should seek to make a diagnosis of the current situation, focusing on some specific on-farm development projects in order to design perspectives and outline relevant policies for the future. The impact of on-farm development must be assessed according to different criteria, considering the farmer's point of view as well as the consequences for irrigation efficiency and for the country's economy (economic return, within the scope of national policies and priorities).

➲ Topic D : causes and constraints of agricultural diversification

Agricultural diversification has been identified as the main current dynamic in the Central Plain. At the national level, it has been targeted as a priority by governmental policies.

Although diversification is not a recent phenomena (fruit orchards, for example, exist since long time ago), its actual magnitude raises several important questions. Among its limitations and constraints, the **responsiveness and stability of**

markets, the **risk** to involve in activities with high level of input and initial investment, and perishable production, seem to be little known. Possible negative impacts such as indebtment or change in tenure (land sale), should in particular be addressed.

Studies should point out what categories of farmers, with which particular physical and socio-economical environment, are engaging in diversified activities and what are their economic performance and constraints. Such information should thereafter be forwarded to decision makers of the administration to orientate policies.

Diversification is also governed by physical constraints, in particular regarding soil and water. The problem of accommodating field crops in low land or/and heavy soils usually dedicated to rice growing, such as commonly encountered in deltaïc areas, is often solved by the transformation of the land through the construction of alternate ditches and raised beds (or "Chinese beds"), generally combined with a surrounding polder dike, on which crops are further planted.

A *regional approach* should focus on **how the technique** of construction (which will fix the different physical parameters of the beds and ditches), together with the management **are adapted to each local situation** of topography, soil and water. The comparison between different situations will bring out the constraints faced in each case and, in particular, show differences in cost of investment which partly account for the choice of the areas where raised beds are constructed. Most of the diversification (specially fruit trees) presently relies on this technique which already covers a very large area in the Central Plain. The precise assessment of its limitation and problems is therefore of great importance. The Damnoen Saduak area should receive particular attention for being by far the largest area with such patterns of land development. The question of the constraints and requirements related to its past and present expansion would highlight the conditions for further development.

A s*pecific monitoring at farm level* should also be carried out in order to answer questions about water management, water requirements, water quality issues,etc.

Apart from the specific case of the raised-bed technique, diversification also faces varied problems such as access to water, timeliness of delivery or levelling (for furrow irrigation). These questions should be addressed during the research carried out at farm level.

➲ Topic E : environmental sustainability

Water quality has already become an important issue, especially in the lower delta where the proximity of industrial parks has an extremely negative impact on agriculture, up to the point of making some activities impossible. Pig farms also contribute to pollution, especially in Nakhon Pathom Province.

The quality of underground water resources, particularly at a time when this resource is increasingly solicited, may also be an issue to consider : little seems to

be known about the impact of uncontrolled garbage deposits in numerous sand pits of the region.

The risk of salinization seems to be limited to some parts of the upper delta and to the Mae Klong area, where it is caused by specific geological conditions together with a rise of the water table due to dry-season irrigation. Although presently restricted to a few hundred of rai, this phenomena must be analysed in order to assess if it is likely to spread and how it can be solved. As one million additional hectares of irrigated land in the world is said to be affected by salinity each year, prudence is strongly recommended. Scientific understanding of this phenomena should be acquired with no delay.

Environmental and health hazards also include the growing over use of agro-chemicals. Pesticides have impact on human health, water quality (superficial and underground) and on crop profitability. Environmental concerns and pest pressure may well contribute to have such topics coming under increasing scrutiny in the near future.

➲ Topic F : demographic and social evolutions

The crucial importance and impact of both population features (density, ageing, sex ratio) and migration patterns have been evidenced in this study.

Labour availability has been clearly linked, on one hand, to change in rice cropping techniques and mechanization and, on the other hand, to patterns of pluriactivity and migration. This interaction between the agricultural sector and the industrial one (together with services) is of high importance. Not only because constraints and change originate from it, but also because it more generally foreshadows the evolution of the Thai society from a rural - rice growing - one to an industrialized one.

Therefore, reflections on the future of farming in the Central Plain must consider key factors such as demography, labour and mechanization, farm size evolution and land tenure.

Further insight should be provided on these interactions, with a necessary integration of the research into a wider national scope, in which migration and industrialisation find their logic.

An overall understanding of current dynamics in the Central Plain of Thailand requires broad and interdisciplinary research. In addition, the rapidity of change observed demands a permanent adaptation of reflection, up-to-date data collection and real time transfer of the results and recommendations. Some of the topics mentioned above will be addressed in the next phases of DORAS Project, under increased interaction with other researchers concerned with related issues.

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ANNEXES

1 - Comments on the NRC2D database

2 - Yield data by amphoe (Office for Agricultural Economics)

3 - Matrix of inter-provincial migrations flows

4 - Wet and dry season rice cropping areas by Project (Royal Irrigation Department)

Comments on the NRC2D database

One of the major source used in this report comes from a dataset called NRC2D. Some explanations about it are useful to understand the variables retained by the designers of the questionnaire and to assess the quality of some answers.

1. Objectives

The National Rural Committee form 2, namely NRC2D, is a co-operation between four organisations :

- The Committee of Rural Development and Wealth in the Provinces, Ministry of Interior.
- The Community Development Department, Ministry of Interior.
- The Information Development Department, Ministry of Interior.
- Six main ministries in every amphoe.

Data has been collected on a bi-annual basis since 1990. The committee's objectives are as follows :

- Survey the people situation in each village throughout the country.
- Use the above data to set planning and policy.
- Use the data for evaluation.
- Define priorities for village development.

The questionnaire is applied in non municipal areas, which corresponds more or less to the rural area. Four parameters are used to define a municipal area :

- Real income locations with more than 300,000B defined at the amphoe office.
- If not in the amphoe office, area with real income (tax) more than 400,000 B.
- Area under 13 sq.km
- Population above 1500 persons.
- People agreement.

2. Quality of data

The mapping of data is a first way to control the quality of the dataset. Indeed, clear spatial patterns cannot be the result of random. Secondly, a control with external sources has revealed a good matching : land use map and irrigation maps, census of population and agricultural census (often provided by amphoe). Whenever possible, extra data was used to confirm the NRC2D information.

No major inconsistencies, internal or with external sources, has been found for major features such as land use, population, tenure... This led us to assume a satisfactory quality of the remaining data in the extent that our goal is to describe the main contrasts in the delta. On the other hand problematic data are, for example, the ones related with income and prices. The main sources of mistakes seem to originate from keying data into the computer. Obvious mistakes has been found and corrected.

Lastly, a problem related to the insufficient definition of some variables (agricultural holding, well for agricultural use) has brought about some inconsistencies. It is not clear, for example, whether the landless peasants or some part time farmers are included in farm holdings. Although the difference is never big, some tambons show that the number of holdings can be slightly different with the sums of holdings according to tenure, crops, multiple and single occupation.

3. Methodology

The questionnaire is "robust" in the extent that the information is grasped through the number of holdings (with the small drawback of lack of definition for some classes). It means that questions do not refer to land area. For our purpose, information by holding has been converted in land use percentage. However, the sum of agricultural uses differs from the agricultural area.

We have not been able to solve this issue, but from the beginning of the process, a good matching between the computed land use and external source has been observed. For that reason we have supposed the processing bias is even in all the delta. However, as the absolute data are not completely reliable, cropping areas are not considered.

These reasons must lead one to be cautious about the meaning of the maps and the tables. Although villages have been aggregated and a high number of tambons handled, the information about one particular tambon on the map must not to be considered as reliable. Nevertheless, a group of 5 or more close tambons is likely to mirror a meaningful difference with another group. If there is no such group on a map, the conclusion is not about the few involved tambons, but about a probable scattered pattern which factor is not linked with a geographical variable.

4. Accessibility of the database

The database is originally under Dbase-format. To simplify its use, we used an Excel and Access format, the first one for tambon information and the second one for village information.

Source : Office of Agricultural Economics

1994/95 - 2537/38

		harvested area WS94	yield YiWS94	harvested area DS94	yield YiDS94
Chaiyo	Ang Thong	24253	356		
Muang Ang Thong	Ang Thong	31.367	375	246	565
Pa Mok	Ang Thong	24087	344		
Pho Thong	Ang Thong	91750	423	8250	620
Samko	Ang Thong	29234	590	2433	688
Sawaengha	Ang Thong	39113	572	1727	612
Wiset Chai Chan	Ang Thong	104743	442	1897	632
Ban Khun Thian	Bangkok				
Bang Kapi	Bangkok	169	337		
Bang Khen	Bangkok	3308	615	3371	637
Bang Rak	Bangkok				
Bangkok	Bangkok				
Bangkok Noi	Bangkok				
Bangkok yai	Bangkok				
Dunsit	Bangkok				
Khlong San	Bangkok				
Lat Krabang	Bangkok	20527	471	12136	601
Min Buri	Bangkok	28164	399	13231	685
Nong Chok	Bangkok	87608	658	21187	503
Nong Khaem	Bangkok				
Pathum Wan	Bangkok				
Phasi Charoem	Bangkok				
Phaya Thai	Bangkok				
Phra Kanong	Bangkok				
Pom Prap Sattru Phai	Bangkok				
Rat Burana	Bangkok				
Samphanthawong	Bangkok				
Taling Chan	Bangkok	435	455	682	667
Thon Buri	Bangkok				
Yan Nawa	Bangkok				
Ban Pho	Chachoengsao	33625	558		
Bang Nam Prieo	Chachoengsao	236568	587	181705	571
Bang Pakong	Chachoengsao	33312	576	1224	725
Muang Chachoengsao	Chachoengsao	164653	500	101478	707
Hankha	Chainat	213254	570	33567	569
Manorom	Chainat	74269	694	18133	725
Muang Chainat	Chainat	84978	692	12944	704
Sankha Buri	Chainat	159343	613	27357	627
Sap Phaya	Chainat	107614	662	8247	596
Wat Sing	Chainat	174310	419	12350	626
Muang Chon Buri	Chon Buri	8002	278		
Phan Thong	Chon Buri	34389	293		
Phanom Thuan	Kanchanaburi	146327	314	53760	580
Tha Maka	Kanchanaburi	34625	656	47828	670
Muang Lop Buri	Lop Buri	121717	428	270	415
Tha Wung	Lop Buri	121255	341	331	444
Ban Na	Nakhon Nayok	88139	335		
Ongkharak	Nakhon Nayok	127576	526	32486	533
Bang Len	Nakhon Pathom	169454	793	173727	803
Don Tum	Nakhon Pathom	23988	507	15085	595
Kamphaeng Saen	Nakhon Pathom	49652	639	34427	616
Muang Nakhon Pathom	Nakhon Pathom	22760	444	11087	669
Nakhon Chaisi	Nakhon Pathom	34840	723	37895	837
Sam Phran	Nakhon Pathom	7368	702	8606	786
Bang Bua Thong	Nonthaburi	28279	813	44454	845
Bang Kruai	Nonthaburi	81	395		
Bang Yai	Nonthaburi	12864	775	18348	796
Nonthaburi	Nonthaburi	354	624	431	761
Pak Krek	Nonthaburi	8634	823	13332	789
Sai Noi	Nonthaburi	62821	769	82750	799
Khlong Luang	Pathum Thani	57224	458	29583	583

Lam Luk Ka	Pathum Thani	95982	646	72060	728
Lat Lum Kaeo	Pathum Thani	60166	856	64128	884
Muang Pathum Thani	Pathum Thani	16942	801	11164	850
Nong Sua	Pathum Thani	34191	638	7171	526
Samkhok	Pathum Thani	29298	816	21269	841
Thanya Buri	Pathum Thani	2376	557	366	694
Ban Phraek	Nakhon Sri Ayudhaya	19391	419		
Bang Ban	Nakhon Sri Ayudhaya	41827	226		
Bang Pahan	Nakhon Sri Ayudhaya	54122	262		
Bang Pa-in	Nakhon Sri Ayudhaya	51220	285		
Bang Sai (1)	Nakhon Sri Ayudhaya	68488	532	39717	664
Bang Sai (2)	Nakhon Sri Ayudhaya	35127	574		
Lat Bua Luang	Nakhon Sri Ayudhaya	70508	772	65583	712
Maha Rat	Nakhon Sri Ayudhaya	42055	279		
Nakhon Luang	Nakhon Sri Ayudhaya	39319	322		
Phachi	Nakhon Sri Ayudhaya	49153	447		
Phak Hai	Nakhon Sri Ayudhaya	79093	196	2878	516
Phra Nakhon Sri Ayudhaya	Nakhon Sri Ayudhaya	29525	272		
Sena	Nakhon Sri Ayudhaya	72717	549	56104	612
Tha Rua	Nakhon Sri Ayudhaya	50161	375		
Uthai	Nakhon Sri Ayudhaya	96930	418	847	528
Wang Noi	Nakhon Sri Ayudhaya	76320	334		
Ban Pong	Ratchaburi	65756	632	80083	620
Bang Phae	Ratchaburi	68360	289		
Damnoen Saduak	Ratchaburi	12807	395		
Muang Ratchaburi	Ratchaburi	45953	397	21744	495
Pak Tho	Ratchaburi	88170	418	18549	583
Photharam	Ratchaburi	64564	493	30618	545
Wat Phleng	Ratchaburi	9077	476	2216	518
Bang Bo	Samut Prakan	39858	637		
Bang Phli	Samut Prakan	19300	512	9536	441
Muang Samut Prakan	Samut Prakan				
Phra Samut Chedi	Samut Prakan				
Pra Pradaeng	Samut Prakan				
Ban Phaeo	Samut Sakhon	13700	432	3708	547
Krathum Baen	Samut Sakhon	17609	641	10368	620
Muang Samut Sakhon	Samut Sakhon	5564	531	2317	550
Amphawa	Samut Songkhram	3969	482	160	700
Bang Khonthi	Samut Songkhram				
Muang Samut Songkhram	Samut Songkhram				
Ban Mo	Saraburi	44152	451		
Don Pud	Saraburi				
Nong Don	Saraburi	32619	455		
Nong Khae	Saraburi	52092	435	753	594
Nong Saeng	Saraburi	57991	429	24	458
Sao Hai	Saraburi	42774	430	86	686
Bang Rachan	Sing Buri	92608	738		
In Buri	Sing Buri	121243	468	1128	709
Khai Bang Rachan	Sing Buri	25951	717	5908	465
Muang Sing Buri	Sing Buri	37004	484	20	650
Phrom Buri	Sing Buri	32307	352	170	653
Tha Chang	Sing Buri	14570	656	813	792
Bang Pla Ma	Suphan Buri	94316	678	141057	662
Doembang Nangbuat	Suphan Buri	113518	581	47467	727
Don Chedi	Suphan Buri	70746	440	6769	613
Muang Suphan Buri	Suphan Buri	115649	544	65400	648
Nong Ya Si	Suphan Buri				
Sam Chuk	Suphan Buri	94770	747	19158	643
Si Prachan	Suphan Buri	103947	742	42817	630
Song Phi Nong	Suphan Buri	109558	670	101078	696
U Thong	Suphan Buri	104017	507	54995	611
Muang Uthai Thani	Uthai Thani	41817	378	4030	557
Nong Khayang	Uthai Thani	57606	381	3767	467

Migration matrix by Changwat (1985-1990)

from \ to	Ang Thong	Bangkok	Chachoen	Chainat	Chon Buri	Kanchana	Lop Buri	Nakhon N	Nakhon P	Nonthaburi	Pathum Th	Phra Nakh	Prachin Bu	Ratchaburi	Samut Pra	Samut Sa	Samut So	Saraburi	Sing Buri	Suphan B	Uthai Thani	others
Ang Thong	0	5294	94	101	173	248	985	68	237	485	1032	878	34	89	710	233	7	373	340	385	99	2152
Bangkok	1554	0	2943	640	9951	2868	2807	5099	8508	56924	21314	4072	1816	4119	37125	6231	725	3934	655	2396	473	110895
Chachoengsao	13	8172	0	24	2882	154	136	124	132	455	352	122	1354	158	1624	211	47	193	22	150	9	4918
Chainat	166	4770	83	0	387	164	1190	24	221	605	612	304	31	50	541	281	16	372	375	728	898	5685
Chon Buri	38	10173	3102	69	0	193	147	198	331	677	329	166	866	243	1678	413	87	340	41	214	56	14199
Kanchanaburi	77	7807	62	106	337	0	94	71	2084	536	384	121	128	2406	612	819	86	229	16	1964	56	10175
Lop Buri	385	6259	178	310	703	405	0	213	479	887	1756	920	1308	277	1303	739	20	3046	598	213	194	9529
Nakhon Nayok	33	5496	270	6	458	85	111	0	111	305	834	193	870	67	439	74	5	616	16	49	5	1857
Nakhon Pathom	61	10536	114	31	419	1826	204	102	0	961	538	175	60	2157	789	1339	205	148	31	770	37	6528
Nonthaburi	39	10045	112	44	351	169	152	150	743	0	2119	211	92	239	932	287	12	297	6	158	74	4014
Pathum Thani	51	8550	49	30	268	127	208	150	359	1788	0	645	101	166	888	264	67	428	44	213	2	2342
Phra Nakhon Sri Ayudhaya	694	15246	159	210	878	266	441	233	408	2202	3643	0	348	254	1347	462	33	811	19	207	78	4984
Prachin Buri	146	11821	2380	74	1873	186	203	642	290	745	974	216	0	122	1427	477	43	2499	133	506	154	9020
Ratchaburi	385	11861	180	31	594	3079	111	151	3833	754	380	124	113	0	993	1983	744	278	50	552	19	7723
Samut Prakan	135	11797	740	13	1631	100	94	110	340	976	674	291	96	119	0	590	44	215	71	98	20	4759
Samut Sakhon	53	4870	15	33	254	169	35	12	861	323	166	58	27	387	640	0	175	25	13	143	35	2352
Samut Songkhram	16	3467	59	11	381	139	55	6	354	332	118	55	3	890	457	1013	0	98	31	20	2	1794
Saraburi	97	7849	166	43	583	207	1852	601	298	609	1328	1040	1373	124	795	309	20	0	76	120	33	6841
Sing Buri	326	3789	36	391	197	91	1385	36	156	430	435	457	108	120	468	179	14	185	0	297	143	2421
Suphan Buri	616	13045	62	313	548	3977	481	49	1768	1068	772	499	129	647	975	772	90	358	162	0	619	6860
Uthai Thani	99	3323	51	388	236	90	352	56	89	220	245	244	136	58	290	135	7	75	73	229	0	5036
others	4376	551710	17649	3597	35109	14588	15206	3318	20525	31996	20452	10973	27028	16101	54830	29768	2982	16582	2854	11051	6106	0

Rice cropping area in the wet season (by Project)

PROJECT	DSC74	DSC75	DSC76	DSC77	DSC78	DSC79	DSC80	DSC81	DSC82	DSC83	DSC84	DS85	DS86	DS87	DS88	DS89	DS90	DS91	DS92	DS93	DS94	85-94 DSC(av)	all DSC(av)	85-94 Average %	all Average %
Bangbal	0	2835	2875	368	1567	4277	1417	3440	3216	2992	3776	3568	432	0	653	288	72	0	80	85	64	186	1524	1	8
Banglane																									
BangPhrakong LB	0	0	0	0	0	0	0	0	0	0	0	0	54	0	0	0	8	16	0	0	0	9	4	0	0
Borommathat	3441	4617	8456	9847	11740	25893	1071	29469	24723	23441	21769	21772	23269	20267	21455	15980	25632	2793	9171	4852	5061	14276	14987	25	27
Chanasutr	14979	18821	30713	27940	12324	41846	3018	39360	42140	50575	30923	32088	22416	31778	32734	38590	29530	14662	9763	5387	2567	20859	26355	36	44
Chao Ched Bang Yeeho	11584	12136	16067	21304	20952	32698	29312	31000	37229	33644	36045	38868	41459	38999	34797	40253	42350	42483	40589	40719	39926	40176	32448	134	108
Chong Kae	329	497	370	2389	2880	6914	170	4539	2601	2030	4827	5955	4732	5656	4906	4611	3680	0	54	10	0	2628	2679	7	7
Damnoen Saduak							13	0	0	160	288	762	480	680	1003	1103	1059	1062	1341	0	920	850	591	16	11
Don Jedee	6329	9793	10028	10378	9503	10058	24	14114	15326	15216	15232	10851	13764	15203	16096	14655	16144	8495	2323	2060	2883	10068	10356	48	48
Khamphaengsaen	3530	5358	9450	7402	11542	7428	11345	13977	15370	13706	15075	16004	15758	17596	16663	16243	14148	15408	15421	15145	15145	15725	12939	107	88
Khlong Dan	4347	6948	6985	14054	13388	10431	7986	25946	19769	18630	22916	18497	15314	14844	11220	12626	10514	12749	11109	9937	7976	11810	13151	34	38
Khok Kathem	292	383	537	1366	1837	4090	0	3012	7654	4039	8476	7050	4944	2992	6346	4482	6226	1448	1847	31	13	3037	3146	9	10
Klong Priew								938	3704	960	19200	2240	1212	800	198	285	1348	166	0	22	6	449	2220	2	11
Kra Siew												5414	4108	5951	943	11613	8167	138	320	11921		5395	5397	38	38
Maharat	496	1548	1359	1940	3810	13160	90	15613	18480	3975	20836	3140	12592	2003	14783	3072	20889	1171	1117	316	424	6241	6695	9	9
Manorom	1869	5381	3733	9226	2858	13386	280	6986	8808	9926	13171	12464	8160	10000	10610	13790	26325	373	5932	3969	3946	9234	8152	24	21
Nakhon Pathom							8901	12402	12171	14497	10754	12941	14106	14454	15019	13236	14239	9920	9298	11680	6296	11917	11928	59	59
Nakhonchoom							677	674	5395	552	509	589	613	613	999	644	1144	811	1177	891	891	854	1065	3	4
Nakhonkuang	184	166	419	1024	453	1336	92	1239	122	130	106	325	367	0	135	209	574	38	328	44	19	190	348	1	1
Nakhonnayok	0	0	0	0	0	0	0	0	0	0	0	132	0	0	105	222	1943	588	400	312	186	417	185	1	0
Pasak Tai	1571	1170	749	761	1357	4045	198	5650	7469	6096	6640	6656	6230	4897	6321	3816	7031	3119	5795	380	0	4177	3807	12	11
Pasicharoen	10880	12368	17620	16485	20805	16250	7606	14723	14592	15856	12995	11728	11331	9852	5851	6642	5497	5468	7920	4666	3927	6906	11093	70	113
Petchaburi							9024	90	12448	8160	4970	2448	3716	2178	570	9336	196	0	4573	67	0	2304	3858	4	7
Phak Hai	1040	1002	1135	1120	756	1472	906	2336	2347	1564	1688	2105	1782	1108	1059	954	1445	1256	1291	1436	1812	1349	1410	5	6
Phan Tong																									
Phanomthuan													4558		13407	9392	14320	10433	12016	7027	3128	9285	9285	67	67
Pho Phaya	8433	12553	16173	25547	21581	34402	7826	26185	36125	36498	40782	38477	35877	28403	17793	34141	25272	19628	24962	24829	27620	26503	25957	82	81
Phra Ong Chai Ya Nuc	4312	12041	24274	34267	37323	36561	29390	39978	42484	45408	49846	47916	50656	46226	47809	44235	43817	39092	37512	35685	34324	42161	37293	72	63
Phraplmol	33360	35632	35536	35632	35129	33444	33630	34848	33344	34496	34481	33740	33576	31280	32535	31287	31143	30914	31005	30982	30640	31485	33168	100	106
Phrayabanlue	50315	55432	63112	49066	63680	67183	65282	65981	64682	59571	59270	56208	54060	52451	50309	49049	52023	49226	49467	49390	48575	50516	56401	113	126
Pollathep	1801	1879	2876	4044	324	5037	1021	6523	10703	10327	11444	10277	9496	9312	4674	12560	8683	5899	7528	5952	7417	8280	6704	55	44
Rangsit Nua	7828	12218	10587	14765	17845	18614	4111	18667	23802	23094	19674	22380	20166	21340	13743	21905	19366	10307	13099	10905	6307	15127	15701	41	43
Rangsit Tai	17100	27119	37606	37884	37624	49911	13630	54199	51026	50832	33427	29570	27551	20832	27648	41041	28670	13128	40152	38713	27229	29440	33561	42	47
Ratchaburi LB							480	1680	80	160	160	320	0	0	42	84	106	0	0	0	0	26	207	0	1
Ratchaburi RB			0	96	0	0	0	0	0	0	0	0	0	0	3769	12454	18003	13917	15655	18745	14769	10813	6127	41	19
Roeng Rang	212	466	622	694	856	1552	0	3928	1400	800	1440	1920	0	0	2416	1840	2559	131	1141	37	5	903	1044	3	4
Samchuk	3877	21058	23285	23520	13546	29296	3528	26233	34807	37194	29017	18312	26284	16500	24916	32092	37344	12984	24522	16402	11843	22432	22169	55	54
Sao Hai																									
Song Pee Nong															1681	12241	12803	9780	14368	12672	13037	10940	10940	96	96
Tha Lard												77	79	85	32	200	8	16	7	19	0	50	52	0	0
Thabote	3877	6079	4530	9481	6338	16121	757	21566	20646	23764	20032	21299	13568	14120	12761	21823	13682	6207	7060	9128	5141	11498	12284	42	45
Thamaga							168	532	944	336	2906	3770	5517	10510	16504	20279	26400	24848	26082	24364	8607	18009	11382	68	36
Yangmanee	1053	1377	2218	3471	614	6346	292	8045	6637	4483	5797	6553	1867	5131	3607	7295	4395	3761	2614	906	433	3333	3661	11	13
TOTAL	193039	268877	330115	354071	350529	490731	242144	533773	582233	553112	568470	505515	490072	455059	474103	564572	576555	372625	437119	402680	329239	459643	456278		

Rice cropping area in the wet season (ha by Project)																									
PROJECT	WSC74	WSC75	WSC76	WSC77	WSC78	WSC79	WSC80	WSC81	WSC82	WSC83	WSC84	WS85	WS86	WS87	WS88	WS89	WS90	WS91	WS92	WS93	WS94	All Average	All Average %	85-94 Actual year	85-94 Average %
Bangbal		1600	1672	21553	20614	22323	23072	19616	19520	19920	17835	18352	21553	21920	21920	21760	21552	21328	19088	15360	18080	18432	80	20091	87
Bangkane																									
BangPhrakong LB														14450	14450	14450	14450	13368	13368	12267		13829	133	13829	133
Borommathat	58400	58400	58400	58400	58400	57830	58400	58400	58400	58400	58294	58370	55894	57867	56836	57617	55892	56360	55350	55192	64243	57378	98	56322	96
Chanasutr	75384	76271	74764	74764	74560	74848	74512	74292	72500	70792	70770	68339	68978	66828	62555	66549	63517	66643	57492	5802	55588	65940	87	57229	75
Chao Ched Bang Yeah	50895	52415	48237	42337	29862	19057	9501	7651	10155	15765	24024	29076	20133	23346	21290	34111	42302	37952	23814	35198	32928	29050	45	30016	46
Chong Kae	36918	25506	36918	36816	46786	38441	38162	38001	37214	36207	36604	37924	34016	38121	37222	38150	36308	38012	38070	37917	37928	37201	98	37367	98
Damnoen Saduak	9683	9683	9891	9373	8128	8128	9280	10560	7216	7200	7520	6869	7040	5630	5130	5082	5062	4627	3667	4312	4842	7091	19	5226	14
Don jedee	21289	21401	21188	21295	23030	23035	23112	23112	23096	22872	23112	23111	23112	23112	21806	19649	24137	21354	20202	20532	19589	22055	104	21660	102
Khamphaengsaen	13535	13680	11395	10317	10549	9906	11688	10189	14362	11267	12605	13607	14204	14346	15409	15876	14360	15554	16006	14730	14310	13186	33	14740	36
Khlong Dan	61302	66394	48982	59000	58112	54061	56195	45304	48729	45948	48329	43769	42951	40859	40859	37499	38915	32145	26570	24432	21935	44871	53	34993	42
Khok Kathiem	32867	30882	32875	32174	35227	27969	32888	32876	32875	32875	32872	32872	32875	32794	32712	32875	27033	32856	32861	32961	32875	32328	103	32271	103
Klong Priew												21649	21649	19483		21649	21649	19883	21104	21560	20894	21058	143	21058	143
Kra Siew												17064	15216	15216			14489	13685	13968	12154	10820	14076	68	14076	68
Maharat	75244	64051	76208	76208	72286	76131	76112	76200	76179	76208	76128	76208	61998	76208	75587	69823	76208	65563	74622	73599	68891	73317	96	71871	94
Manorom	36918	36604	37760	37124	37124	37124	36575	37124	37124	37124	37760	38737	38737	38737	36840	38714	41526	36219	39908	40645	40548	38048	101	39081	103
Nakhon Phathom	12019	27712	28934	27784	24490	28568	25812	23933	24070	26611	23410	23768	25259	24831	23762	21117	16880	14880	16280	15408		22726	39	20132	35
Nakhonchoom	10266	4624	4192	10668	23197	22871	22997	26514	25020	24339	26376	26192	26466	26781	26349	26566	27491	26935	26819	26362	20725	21989	52	26070	61
Nakhonluang	42658	42149	42658	42728	40971	42602	42591	42660	42548	42132	41656	40303	41446	42388	42048	26766	35980	28185	38577	38303	34619	39713	113	36861	105
Nakhonnayok												95216	46222	45970		45024	41734	27678	39726	37861		47429	52	47429	52
Pasak Tai	34624	37840	38496	38496	38496	38146	37875	37618	32017	38128	37647	37563	33440	37120	37088	21998	34489	34356	32085	34069	32363	35426	92	33457	87
Pasicharoen	31976	31976	31976	31976	31976	23192	21528	24915	23768	20999	19184	13342	14162	14080		10576	8648	9414	8086	6440	3927	19107	60	9853	31
Petchaburi	51720	51720	51720	51722	51548	51722	51720	51722	51704	51722	50630	54442	52063	59214	59481	59424	56555	50870	51895	53409		53250	99	55262	103
Phak Hai	31920	29372	32725	32000	32307	31700	32106	31218	30984	29984	29224	29879	30936	30850	23922	29891	29590	29206	29206	30708	14583	29523	100	27887	94
Phan Tong																5184	5014	2440	4062	2952	3323	3829	59	3829	59
Phanomthuan										13920	2378	15072	8768	12808	14238	14382	13538	15330	14997	16287		12793	27	13824	29
Pho Phaya	56103	54394	54311	49746	44298	41630	46482	42971	38095	34936	39512	31566	26922	26922	24202	26400	26853	25390	44663	44663	45516	39256	66	32190	64
Phra Ong Chai Ya Nuc	70814	70814	70814	70828	58180	70814	70814	70814	70814	70574	70814	70814	70814	70542	57368	65393	59757	48019	46801	45429	42875	64472	79	58781	72
Phrapimol	8000	9120	5600	4354	6752	4880	7656	16760	19920	28550	33440	33024	32480	31045		31638	31184	31526	30918	31014	30494	21417	50	31480	74
Phrayabanlue	16098	22958	4463	3314	4728	4307	7985	20164	17206	28080	28200	45280	28800	41358	40821	44680	49790	49136	49594	49347	48675	25808	41	44748	64
Pollathep	15411	15411	15411	15411	15411	15411	15411	15411	15368	15411	15411	15411	15360	15360	15360	16200	13744	15195	15326	14901	15014	15255	100	15087	99
Rangsit Nua	67012	64781	66696	62638	62638	60478	57663	56893	62478	57268	47501	46413	45647	43609	41176	38178	38144	34009	29598	27846	21399	49141	68	36602	50
Rangsit Tai	48000	48000	48000	48000	48000	84468	84468	83293	84163	71448	78375	79981	76700	71076	71076	69203	68121	66816	68773	68778	66240	68237	95	70677	98
Ratchaburi LB	26016	30144	26815	26815	26815	27808	30672	26797	22481	22233	21993	23785	23044	22632	19548	19897	18508	18155	17821	18247	18555	23242	76	20009	66
Ratchaburi RB		13376									31558	31326	31473	24178	26089	28730	27672	28304	27628	23847	17728	25992	63	26698	64
Roeng Rang	28640	24528	28640	28640	28640	29282	28292	28640	28640	28840	28832	28800	28944	28160	28160	27926	24224	27589	27264	28169	28160	27953	106	27640	105
Samchuk	42983	42105	43615	43325	43216	37268	44012	44367	43582	42477	43761	44252	43077	42203	42709	34654	42164	40844	39812	39541	37952	41791	86	40691	83
Sao Hai																									
Song Pee Nong															14037	10080	9998	7784	12420	12506	13037	11409	21	11409	21
Tha Lard														21831		21061	20987	20986	20986	19454	10976	19469	99	19469	99
Thabote	24907	25679	25709	25725	25725	25628	25517	25571	25004	25567	28698	29177	24260	30575	30675	24165	27116	28300	28310	25628	26763	26604	103	27496	107
Thamaga			12592	34363	18307	28632	34837	36736	14920	37334	37520	36325	32481	30359	29527	30906	32997	30935	31094	28928	28901	29878	66	31243	69
Yangmanee	30242	31115	31092	31561	31064	31064	31026	30123	29500	29921	30152	29812	29704	29458	29553	29582	28661	25469	29352	29576	29727	29893	89	29089	87
TOTAL	1121844	1133505	1122550	1159254	1131235	1149323	1168851	1170425	1139648	1174732	1212125	1357690	1246801	1312167	1149605	1251438	1223052	1048867	1197185	1221730	882918	1296562		1267822	

MAP 3.1

N

0 15 30

Kilometers

Main cropping patterns

in the Central Plain of Thailand (1995)

- r1a / TV dry broadcasting
- r1b / TV namtom
- r2a / TV dry broadcasting + HYV > 50 %
- r2b / TV namtom + HYV <50% or with rotation
- r3a / HYV + HYV > 50% without rotation
- r3b / HYV + HYV > 50% with rotation
- r3c / HYV + HYV < 50% with or without rotation
- sc / sugar cane
- v1 / fruit trees
- v2 / horticulture (predom. vegetables)
- v3 / mixed cropping pattern
- v4 / rice and aquaculture
- w1 / freshwater aquaculture
- w2 / brackish water aquaculture
- w3 / brackish water aquaculture + salt pans
- w4 / mangrove, swamps
- w5 / urban areas, miscellaneous

Chainat-Pasak main canal
Chai Nat
Chao Phraya river
Sing Buri
Noi river
Krasiew river
Lop Buri
Lop Buri River
Pasak river
Ang Thong
Suphan Buri
Chao Phraya river
Ayutthaya
Nakhon Nayok
Aerc
K.U
The chin river
Pathum Thani
Bang Pakong river
Kanchanaburi
Mae Klong river
Nonthaburi
Nakhon Pathom
Bangkok Metropolitan Area
Chao Phraya river
Chachoengsao
Samut Prakan
Ratchaburi
Samut Sakhon
Samut Songkhram
Chon Buri
Petchaburi river

DORAS Project

Kasetsart University / ORSTOM

Gulf of Thailand

Additional information on dry season cropping calendar

- Beginning of dry season cropping : October / mid November
- Beginning of dry season cropping : mid November / December
- Beginning of dry season cropping : January / mid February

- Floating rice (With secondary deep water rice)
- Main canals (gravity irrigation area)
- Main canals (conservation area)
- Limits of irrigation projects (RID)

Spot activities

v : vegetables — t : trees
bc : baby corn — co : coconut
as : asparagus — ci : citrus
p : pasture land — w : tree plantation
h : horticulture + rice — or : orchid farms
s : salt pans — sh : shrimps farms

i : idle land, fallow
u : urban areas, built up, industrial park

tp : areas with some transplanting

golf courses