

Development of Commercial Cultivation of Field Crops in Thailand: A Case Study in Saraburi and Lopburi Provinces

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Abstract

Rice and rubber were major farm products for export from Thailand before the 1950s. Maize and other field crops were added to them in the 1960s. They were cultivated in newly opened lands. This paper describes the process of reclamation and the changes thereafter in a typical area of commercial cultivation of maize, and analyzes the land, technological and economic factors related to them.

The fieldwork was carried out in an area extending between Saraburi and Lopburi provinces, which was reclaimed in the 1950s. Within the area, significant variations in cropping pattern, technology and productivity were observed. These spatial variations were largely governed by such physical conditions as rainfall and soil until around 1980. Thereafter, various modern technologies were adopted within a short period, which resulted in greater diversification in crops and the farming system.

I Introduction

The acreage of field crops for export such as maize and cassava started increasing in the 1950s. Maize-growing is centered around the Passak Basin or the Central Highland separating the Chao Phraya Basin from the Khorat Plateau. This area is sometimes dubbed the "corn belt" of Thailand (Fig. 1). The area was formerly covered with dense forests.

The development of maize production in Thailand is significant in view of (a) the sustainability of upland farming in the tropics, (b) the dominance of small-holders and (c) the possible danger of environmental deterioration caused by agricultural modernization.

Of the major agricultural crops in the tropics, only lowland rice, tree crops and sugarcane are commercially produced. Tubers and grain crops other than rice might be important as subsistence crops but are seldom cultivated for the outside market. Cassava in Thailand and soybean in Brazil are rather exceptional. The sustainability and productivity of grain-bearing annuals other than lowland rice in the tropics are still questionable.

In the case of Thai maize, reclamation was in some places initiated by the

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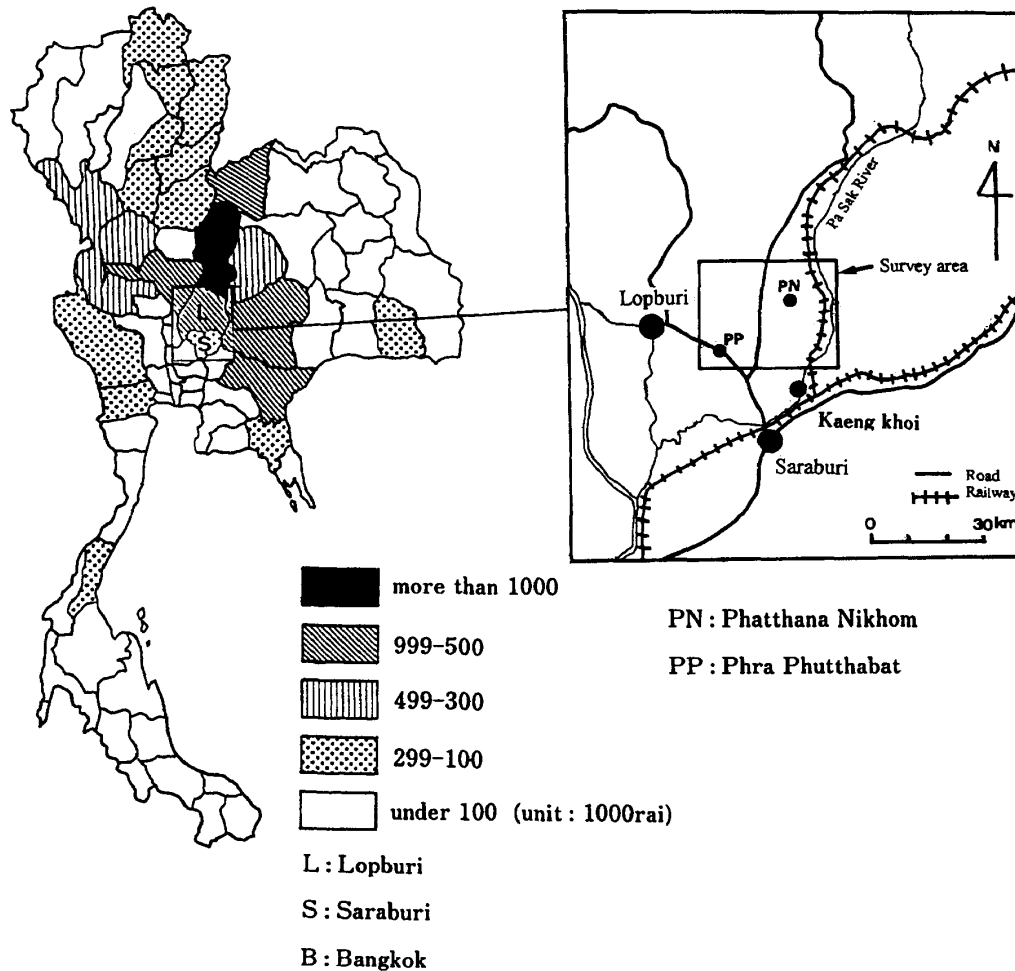


Fig. 1 Acreage of Maize by Province in Thailand in 1992, and Location of the Survey Area
Source: Agricultural statistics of Thailand, crop year 1991/1992

government. But regardless of who initiated it, it is always small-holders who cultivate the crop. Elsewhere in developing countries, commercial production for export might be in the hands of large plantation owners or public agencies. The dominance of small-holders is an important characteristics of commercial crop production in Thailand.

In developed countries in the temperate zone, economic growth and agricultural modernization proceeded side-by-side, resulting in high-input-high-output agriculture. The sustainability and adverse effects on the environment of this mode of agriculture are a hot issue today. The accelerated economic growth of Thailand after the late 1980s is well known. And its impacts on farming are also evident in maize cultivation, as we will see later. A study of this topic should also have implications for the future of agriculture in developing countries.

Against this background, the present study describes and analyzes the development

of maize cultivation in Thailand.

The study area is a rectangular area of 40 km × 30 km covering Phra Phutthabat District (PP) in Saraburi Province and Phatthana Nikom District (PN) in Lopburi Province. It is about 130 km north of Bangkok (Fig. 1). The area was once covered with dense forests. Reclamation and settlement started at the initiative of the government in the 1950s, one of the earliest cases of this kind of land development in Thailand [Nonaka 1968: 27]. The area provides an example of successful field crop farming by small-holders. The major crop was and still is maize, but many other crops such as sorghum, legumes and sugarcane are also cultivated.

The field survey was conducted intermittently between November 1992 and December 1994, and the total survey period was about 8 months. It included interviewing farmers, 37 farm households in PP and 86 in PN, and observing their fields. The interviews covered cultivation methods (crops and cultivars, the cropping calendar, tools and machines, manuring and others), and crop growth and yield. Information was also obtained from various institutions such as district offices, the Department of Agricultural Statistics and the Meteorological Department.

II Reclamation and Settlement

According to a vegetation map [Royal Thai Survey Department 1977], the forest covering the study area before reclamation is classified as Dry Upper Mixed Deciduous Forest.¹⁾ At Present, tall *Dipterocarps* stand here and there in the maize fields. Farmers who actually cleared the forest call it “*paa dip*” (meaning “deep forests”) or “*paa phaenchaphan*” (meaning “miscellaneous deciduous forests”). They remember that the forests were rich in wild animals such as elephants, tigers and deer, and they sometimes had to protect their crops from elephants. The forests were also the source of malaria, which killed many early settlers.²⁾

Although the area was mostly covered with dense forest before the reclamation, there were also several villages: Manao Wan, Khok Salung, Dilang and Nong Na (Fig. 2). As we will see later, the area is dominated by undulating, well-drained terrain with isolated hills, and the soils are deep and fertile. Thus, the land conditions are generally suitable for upland field crops but not lowland rice. Nevertheless, there are several pockets of sandy lowland along rivers and streams. All of the old villages are situated there, and their economies depended on lowland rice cultivation. The paddy lands of

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- 1) The 1: 50,000 map of the Thai army also shows the area as a thick forest. Takaya [1987: 100] wrote that this area harbored tall trees with large buttress roots in 1966.
 - 2) The railway connecting Bangkok with Nakhon Ratchasima in the Northeast runs through the east of Phatthana Nikhom District (PN). Seven Japanese laborers are known to have worked on its construction in the middle of the Meiji Era (the railway was completed in 1900). All of them died of malaria. A monument is dedicated to their memory at Kaeng Khoi District, a district southeast PN [Ishii and Yoshikawa 1987: 193-197].

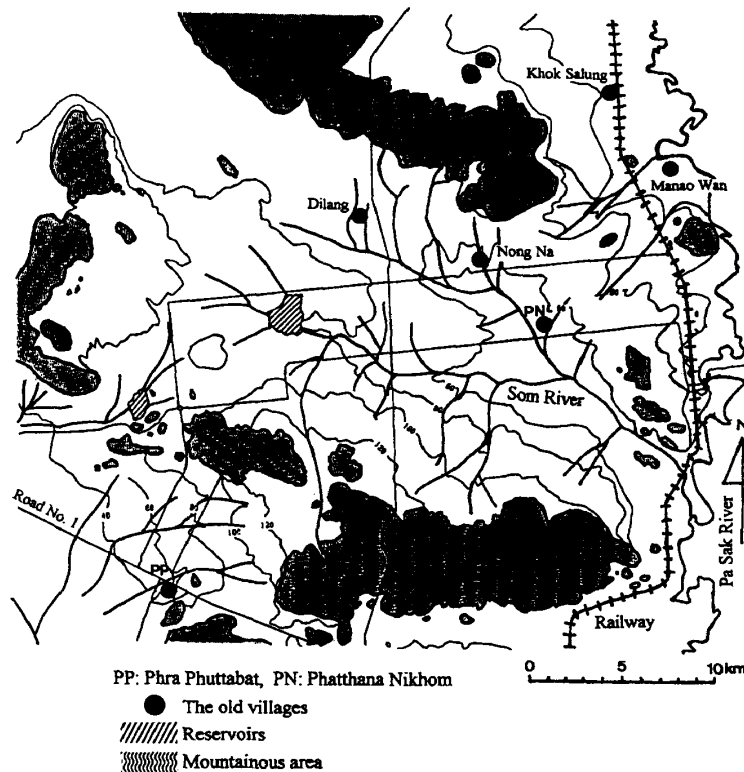


Fig. 2 Topography and Old Villages in the Survey Area

these villages were once surrounded by thick forests with excellent soils for cultivation of upland field crops, if not lowland rice. But reportedly the uplands were hardly used for crop production, by either the slash-and-burn method or any other manner. The villagers hunted wild animals and insects, and gathered various herb, e.g., sweet basil, and other wild plants, e.g. taro, in the forests. They also reported that they did not go deep into the forests. This suggests that many of the wild plants might actually have been semi-cultivated in the vicinity of the settlements. The vast area with fertile soils was left untouched until the 1950s.

The Thai government's Self-Help Settlement Project started in the 1940s [Phra Phutthabat District 1983].³⁾ But extensive reclamation took place only in the mid-

3) The main objectives of the project were as follows [Phra Phutthabat District 1983].

1. Economic purposes
 - to promote agricultural production
 - to develop unused lands
 - to conserve forests in the watershed areas in the North by attracting settlers to the Central Region
 - to solve the problems in land business
2. Social and cultural purposes
 - to move population from urban to rural areas

1950s.⁴⁾ The government announced the project and invited rice-growers in the Central Region and tricycle (*samlah*) drivers in Bangkok to participate. Of 46 interviewed families who settled before the mid-1950s, 23 came from Saraburi, 8 from Lopburi, 6 from Bangkok, 5 from Ayutthaya and 4 from other provinces. Twenty-eight of the interviewees or their parents had been rice farmers and 5 tricycle drivers. Most of them had held little or no farm land. In one case, the informant's parents faced financial ruin due to gambling. Acquisition of a large tract of farmland was the greatest attraction which motivated them to apply for settlement.⁵⁾ Some came to settle for marriage.

The project allocated a lot of 25 *rai* (ca. 4 ha) to each family. Five hundred baht in cash and the necessary tools for clearing the forest were also provided. The government constructed roads and reservoirs for domestic water supply. The project area was checkerboarded by farm roads at intervals of 1 km in the north-south and 2 km in the east-west direction. Forty families occupied a block of 1 km × 2 km and built their houses along the roads. Reservoirs and canals were constructed for dry-season irrigation, but these did not function. Crop-growing has relied almost totally on rainwater from the very beginning.⁶⁾ In the following years, public facilities such as local markets, hospitals, agricultural extension offices and wells were gradually provided.⁷⁾

Clearing work was left to the settlers. It is said that they could clear only about 5 *rai* in a year. Big trees were seldom sold but used for house construction and furniture making, while medium-sized and small trees were used for firewood. Charcoal making was an important source of income other than farming in the early years. It continued until the supply of trees was exhausted.

Maize was cultivated from the first year of settlement. Few farmers cultivated food crops such as upland rice for their own consumption. Even in the early years, maize

- to reduce crime and troubles in the land business
- to promote self-help by providing inheritable land assets
- to provide houses
- to improve security in rural areas
- to improve marketing of agricultural commodities

3. Political purposes

- to establish local communities
 - to improve social welfare in local communities
- 4) The Land Code of 1954 appears to be related to The Self-Help Project. It allowed landless farmers to acquire ownership [Lert and Henry 1986: 77].
 - 5) The settlers were given the ownership of allocated lands including the right of inheritance, but not the right to sell. Actually, however, many did sell land. In the early years, some settlers cleared their allocated lands, sold them and moved deeper into the forest to clear new land. Many of the tricycle drivers from Bangkok sold the lands they had cleared and returned to tricycle driving.
 - 6) Construction of a large irrigation system with a reservoir on the Passak River started on 2 December, 1994. The site is east of PN.
 - 7) Lopburi Agricultural College opened in PN at the beginning of the project. Phra Phutthabat Field Crop Experimental Station was established as a cooperative project with Japan in August 1978 [JICA 1985: 78-139].

could easily be sold and rice and other food purchased. Within several years, the settlers reclaimed the whole area allocated to them and started incorporating other crops such as sorghum and legumes into the cropping system.

III Land Condition

Precipitation

Fig. 3 compares the amount of annual rainfall in PP and PN over 12 years. It is clearly greater in PP than PN though the rain gauges are only about 25 km apart. Farmers in the area are keenly aware of this difference.

There is a distinct seasonality in rainfall, giving rise to dry and rainy seasons. Lack of irrigation in the area permits only rainy-season farming. Cultivation of two crops in a season, maize as the first, followed by a different second crop, is common in the area. Most critical are the time of onset and the amount and pattern of rainfall throughout the rainy season. Earlier onset allows earlier harvesting of the first crop, which, in turn, offers greater choice of the second crop. Later onset, and hence later harvesting of the first crop, restricts the choice of the second crop to those with a short growth period and great drought tolerance, such as sorghum and sunflower. The early onset of the rainy season alone, however, does not guarantee a bumper crop. The amount and distribution of rainfall throughout the season must be adequate.

In view of these factors, the rainfall was analyzed by the pentad method [Jackson 1977: 33-70], in which the rainfall in each 5-day period (pentad) was calculated and a pentad was assumed to be "rainy" when it satisfied the following two conditions:

(1) the total rainfall of three consecutive pentads centered on the pentad in question exceeds 76 mm, and

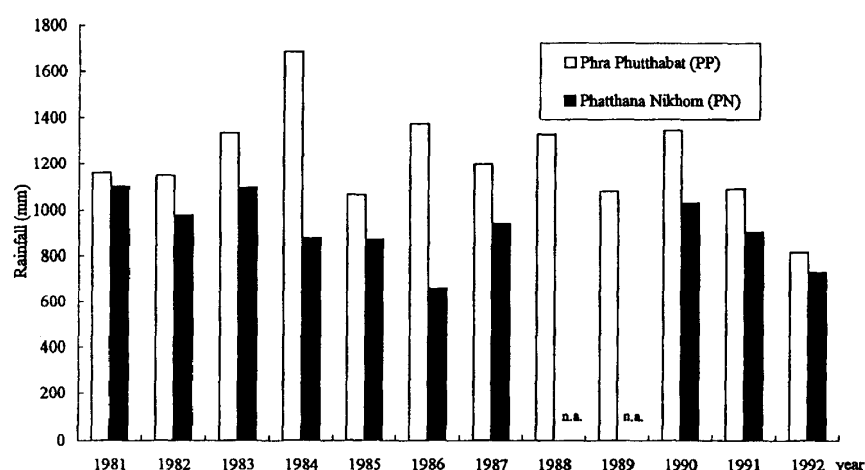


Fig. 3 Annual Rainfall in Phra Phutthabat and Phatthana Nikhom

Source: Meteorological Department

n.a.: Data not available

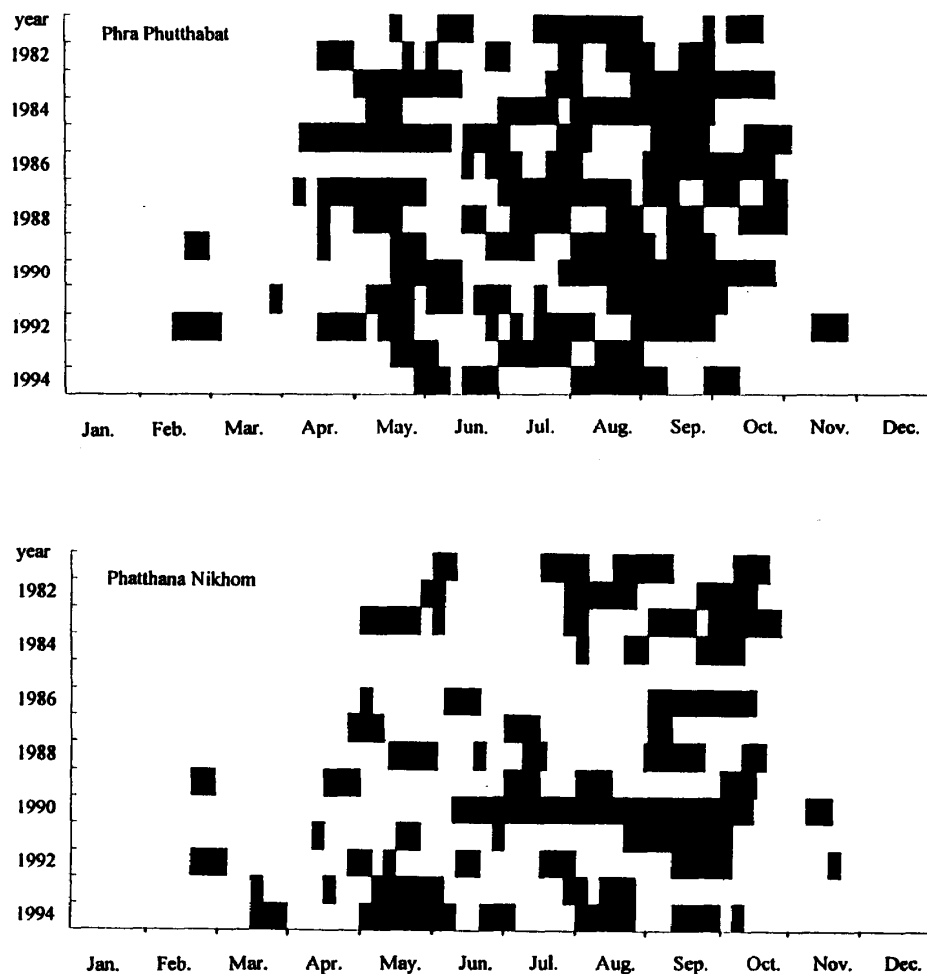


Fig. 4 Rainy Pentads of Phra Phutthabat and Phatthana Nikhom

Source: Meteorological Department

No data: from Sep. to Dec. 1993 and from Nov. to Dec. 1994 in both districts.

Notes: If three consecutive pentads satisfy the following two conditions, the central pentad is defined as "rainy" [Jackson 1977: 33-70].

- (1) Total rainfall of the three pentads is more than 76 mm.
- (2) Rainfall in at least two of the three pentads exceeds 7.6 mm.

(2) the single pentad rainfall of at least two of the three exceeds 7.6 mm.

Fig. 4 compares the rainfall of the two districts in terms of pentads. It is evident that once the rainy season sets in, rainfall is more reliable in PP than PN. Farmers in PN are well aware of the unreliability of rainfall after the onset of the season. According to local people, the boundary between the two different patterns of rainfall is rather clear, being a hill dividing the two districts (Fig. 2).

Topography and Soil

The study area consists of a flat to gently undulating plain, isolated steep hills and limestone-rich monadocks. The plain is about 50 to 130 m above MSL and slopes gently

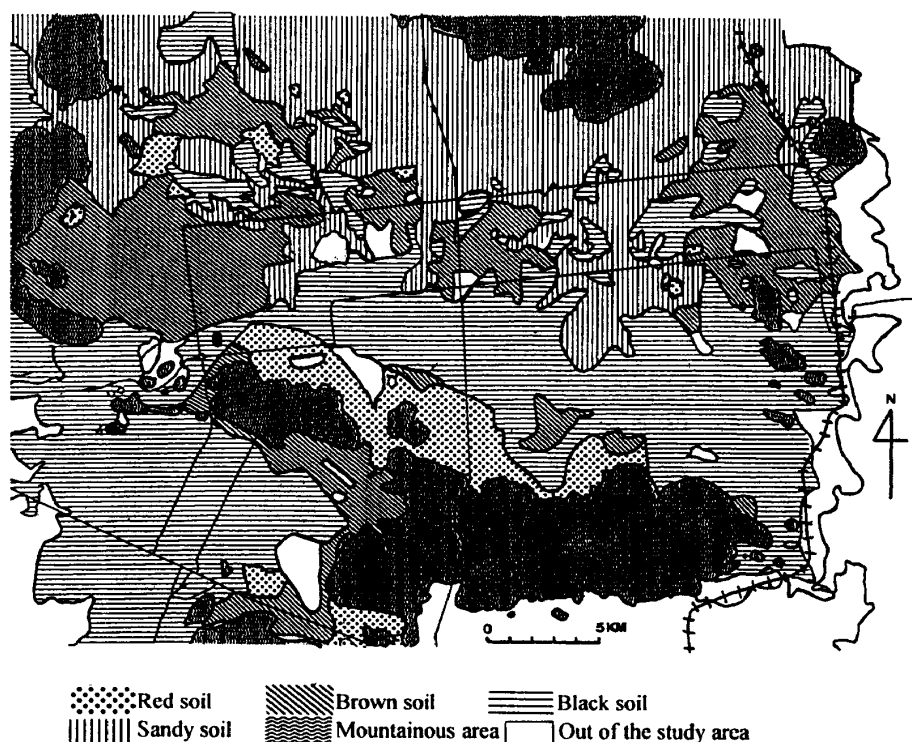


Fig. 5 Soil Classification by Color

southwestward toward the Chao Phraya Delta in PP and southeastward toward the Passak Valley in PN (Fig. 2). Tributary rivers and streams form shallow valleys along which are several pockets of lowland. As stated previously, the old rice-growing villages were established there long before reclamation began in the 1950s. Only the mainstream of the Som River flows during the dry season, while other rivers dry up.

The soils in the area are diverse. Soils of different colors often occur within a single field. How diverse they are is clearly shown on the soil maps of the Land Development Department [LDD 1975 and 1977]. Farmers in the area are also familiar with this. They distinguish three kinds of soil by color, and relate color to moisture-holding capacity: black, high; red, low; and brown, intermediate capacity. According to local farmers, the red soil dries up after a single rainless week and plants start wilting after two, while in the black soil, they do not wilt after two weeks.

The black soil corresponds to the Lopburi and Takhli series in the LDD classification system and is characterized by not only high moisture-holding capacity but also high cation exchange capacity (CEC) and high content of available phosphate, being fertile soil. The red soil of the local taxonomy includes the Pak Chong series, which is usually acidic and low in available phosphate, suggesting less fertile soil.

The distribution of these soils in the area is related to, on the one hand, geology, that is, the occurrence of different underlying base rocks, and on the other, micro-relief, which effects drainage (the soil catena).

IV Cropping Patterns and Their Distribution

As described above, the climatic and land conditions are remarkably variable within the study area. This has resulted in variable cropping patterns. In 1992, a total of 19 patterns (A to S) were recognized (Fig. 6 and Fig. 7). The localities where each was dominant are indicated in Fig. 6. The area was divided into five rain/soil units and shown in the same figure. The cropping patterns are related to the rain/soil units as follows.

Rain/Soil Unit	Rainfall	Soils	Cropping Pattern
1	good	good	A
2	good	poor	B
3	poor	good	F, G, H, J, L, M, Q
4	poor	poor	C, D, E, I, K, R, S
5	poor	very poor	N, O, P

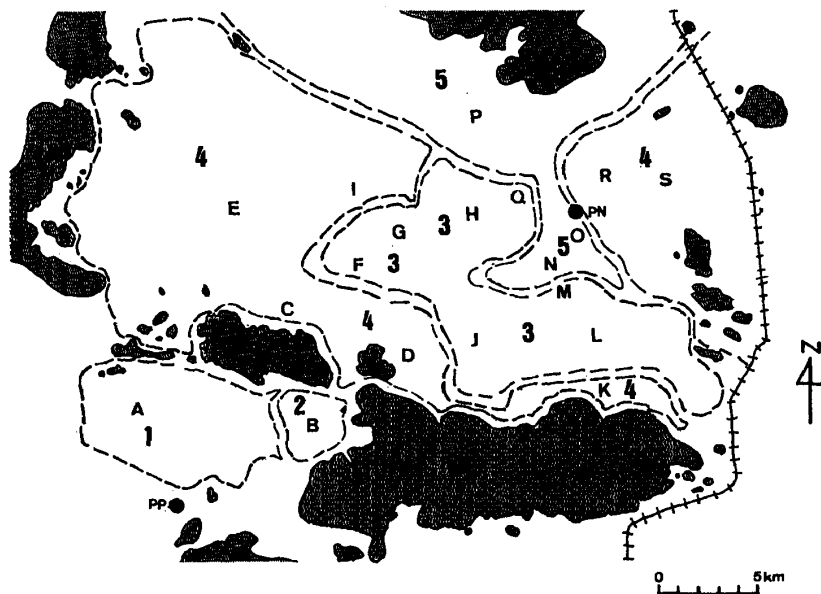


Fig. 6 Land Classification by Cropping Pattern in 1992

Notes: A-S corresponds to that of Table 1. 1-5 is a classification by rainfall condition, soil color and cropping system or farming system in 1992.

Dashed line: boundary of classification by rainfall condition, soil color and cropping system or farming system in 1992.

Table 1 Cropping Pattern in 1992

Rain/Soil Unit	Cropping Pattern	Cropping and Farming Systems in Each Plot
1	A.	Maize - sorghum. The yields of both are high.
2	B.	Maize (single) and maize - mungbean. Cotton (single) in some years.
3	F.	Mixed cropping of maize and pumpkin. The latter is harvested one month earlier than the former.
	G.	Maize - yambean.
	H.	Dairy cattle since about 10 years ago. Promoted by the government. Some fields are planted to sorghum (single), maize (single) and pasture plants.
	J.	Maize followed by either sorghum, sunflower, yambean, groundnuts, or mungbean, depending on the rainfall or farmer's speculation of it.
	L.	Sugarcane since 1990, when a sugar mill opened in Saraburi. Two ratoon crops after a new planting. Before 1990, maize - sorghum or maize - mungbean.
	M.	Maize (single)
	Q.	Cotton (single)
4	C.	Maize (single). Some fruit trees (mango), beef cattle, and poultry.
	D.	Maize followed by either groundnuts, mungbean or other beans. The groundwater level is high.
	E.	Rice in depressions and maize in uplands. The boundary between them fluctuates yearly depending on the rainfall.
	I.	Dairy cattle, poultry and pigs. The landuse is similar to Pattern H.
	K.	Seed maize (single).
	R.	Maize followed by either sorghum, sunflower or mungbean.
	S.	Soybean (single).
5	N.	Rice (single).
	O.	Abandoned bushland used for grazing only. Formerly planted to maize and sorghum.
	P.	Rice in lowland and cassava in upland.

The details are shown in Fig. 7 and Table 1.

There are two rain/soil units (Units 1 and 2) in PP District, where rainfall is favorable. In the former, the soils are also excellent. Here, the basic cropping pattern is maize followed by sorghum (Pattern A) and this pattern did not change from the earliest time of reclamation and settlement till 1992. The yield of maize is relatively high. In the latter, the moisture-holding capacity of the soils is relatively low which restricts the growth period. Early-maturing glutinous maize is sometimes cultivated instead of the usual fodder varieties. In the past, single cropping of cotton was practiced.

The rest of the area mostly lies in PN District, where rainfall is less than in PP. It

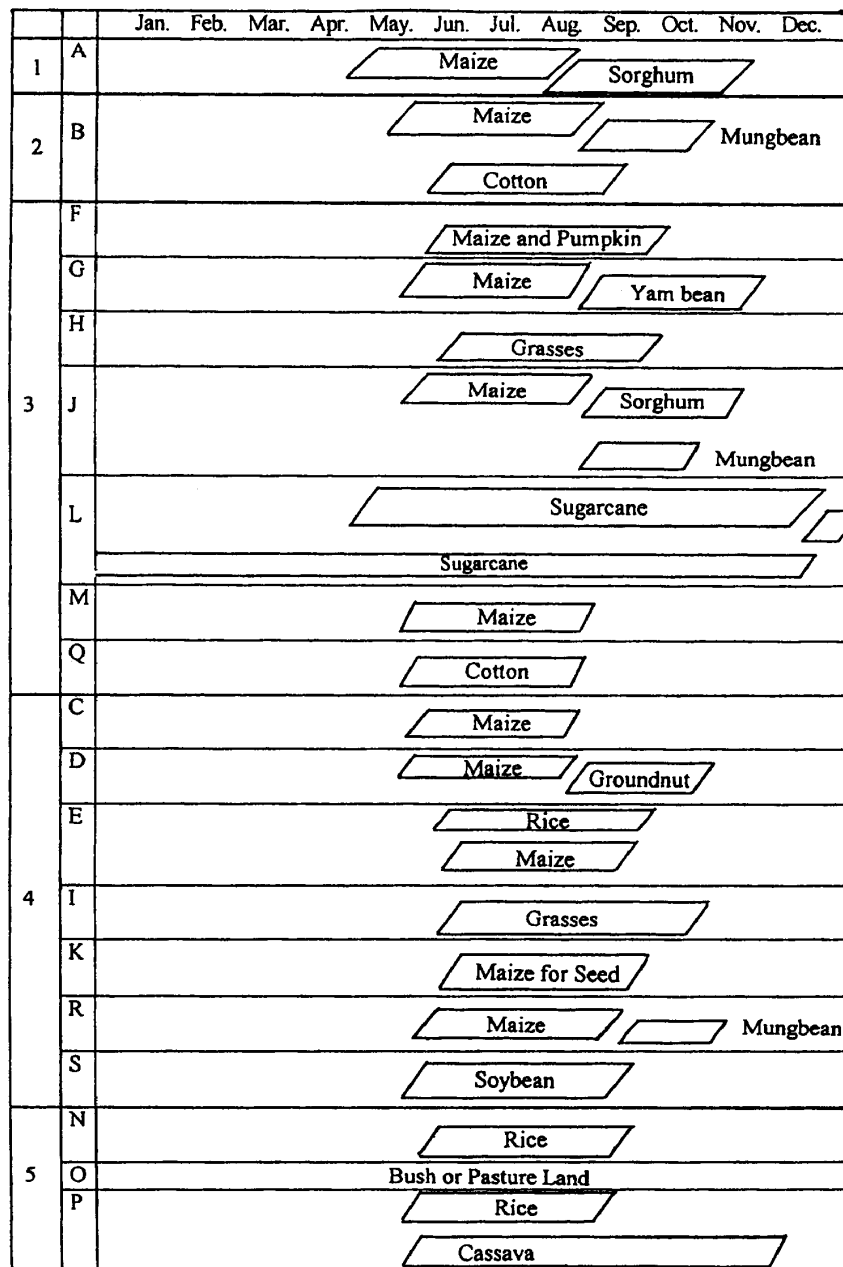


Fig. 7 Rain/Soil Units and the Main Cropping Patterns in 1992

is further divided according to the soil fertility into Units 3, 4 and 5.

Unit 3 occupies central PN and the soils are good. Here, the patterns F, G, H, J, L, M, and Q were observed in 1992. Before the mid-1980s, however, a popular pattern was maize followed by sorghum or legumes. The choice of second crop depended on the rainfall each year: the choice was wide in years of early onset of rain, while, in the years of late onset, the choice was either a drought-tolerant crops, i.e. sorghum, or a crop of short growth period, i.e., mungbean. In worse years, there was no second crop after maize. Even in the years of early onset, maize frequently suffered from drought. Though the soils are as good as those in Unit 1, the two-crop-a-year system was very

vulnerable.

This appears to have prompted many farmers in this unit in the late 1980s to abandon maize-growing entirely and initiate completely new ventures such as dairy cow farming, chicken farming and sugarcane cultivation. Though these ventures needed substantial funding, they were similarly managed by small-holders, with the assistance of various financial institutions.

Both rainfall and soils are poor in Unit 4, where the cropping patterns C, D, E, I, K, R, and S were common. Here, it is very difficult to grow two crops of any kind in a single rainy season. The general trend is, therefore, single cropping of a high value crop including seeds, cotton and fruit trees like mango. Recently, the contract production of seed maize and soybean is increasing.

The soils are sandy, poorly drained and very low in CEC in Unit 5. This is where the old villages are located. The depressions are planted to rice, and the surrounding higher land to cassava (Pattern N, O, or P). The conditions are so harsh that there was no significant change in the cropping pattern for a long period.

The above analyses are based on the cropping patterns in 1992. The cropping patterns, however, vary from one year to another according to various factors that also vary annually. Such factors are not limited to rainfall and include market prices of the outputs as well as inputs (materials and labor). A case of two farmers who reacted in different ways to rainfall in a particular year illustrates the year-to-year variability.

Two farmers living near PN District Office normally grow maize as the first and sorghum as the second crop. In 1993, both sowed maize seeds on 20 May, but there was little rain later. There was no rainy pentad in PN between early June and late July of 1993 (Fig. 4). One of them gave up hope for the crop, cut down the plants with no ears on 29 July, and sowed soybeans. The other waited for recovery, but the plants did not recover, contrary to his expectation. He harvested on 26 August, earlier than usual, and got only 2.8 ton/ha. He sowed sorghum as the second crop.

V Changes of Maize Cultivation Methods

In the early years after reclamation, the cropping pattern of the area was rather simple, with maize as the principal crop. The same crop is still dominant today, though the pattern is much more diversified. The continued dominance of maize does not mean that there has been no technological progress in its cultivation. On the contrary, there has been significant progress and productivity has improved accordingly.

Maize Cultivation Just after Reclamation

The presence of many tree stumps made it impossible to plow for a few years after reclamation. After the first monsoon rain, seeds were sown into holes made with hoes at distances of 70 cm by 70 cm. Three to five seeds were sown in a hole and they were

thinned to two to three plants per hole after germination. Intertillage was not required in the first year because there were no weeds, but it was thereafter. No care was needed between intertillage and reaping. Merchants came with a threshing machine, threshed ears in the farmer's backyard and took the grain.

Sometimes castor beans were intercropped between maize rows in the first year of cultivation after reclamation. They were sown after maize and harvested in October to December. Castor beans were exported mainly to Japan at that time [Nishigori 1992: 70-76]. This crop, however, disappeared several years later. Various reasons have been reported for the discontinuity: laboriousness of threshing using cattle or buffaloes, difficulty of tractor plowing due to the woody residues, and low profit, that is, a high unit price but low yield [*ibid.*: 72]. Legumes like groundnuts and mungbeans replaced castor beans.

Present Maize Cultivation Methods

After the first rain, big tractors plow once coarsely with three disks and harrow once or twice with seven disks. Seeds are sown with machines set on small tractors. The same small tractors are used for intertillage two weeks to one month after sowing. Chemical fertilizers are applied at the time of sowing, intertillage and/or flowering. Organic manure, if used, is applied before plowing. Neither fungicide nor insecticide is used for maize. Harvesting is done manually three to four months after sowing. Machines thresh ears and the produce is sold as grain.

When sorghum is cultivated after maize, big tractors with three disks plow-in the residues of maize, and seeds are broadcast at the same time. Sorghum is harvested after about four months. No chemical fertilizers or other such inputs are used for this crops.

Chemical Fertilizers

Some farmers have been using chemical fertilizer since the time of reclamation, but many

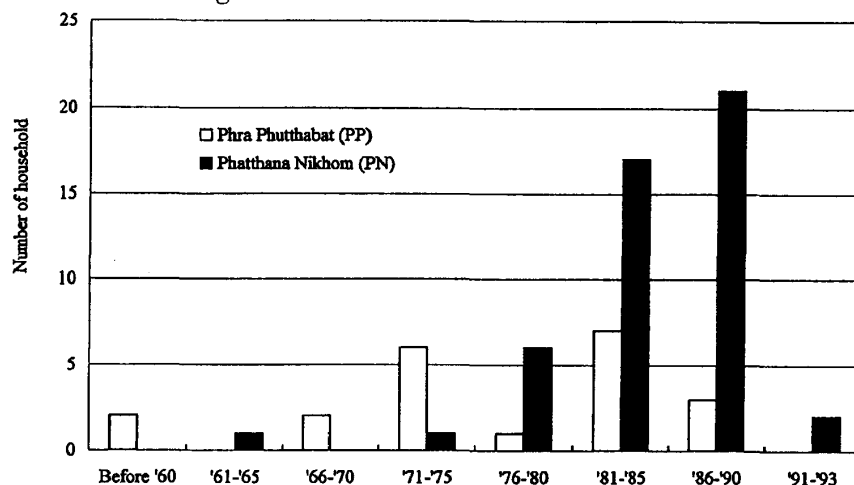


Fig. 8 Starting Time of Chemical Fertilizer Application in Phra Phutthabat and Phatthana Nikhom

started using it in PP in the 1970s and in PN in the 1980s, about 20 or 30 years after reclamation (Fig. 8). When asked, farmers replied that they did so because of the decline of soil fertility. Those who have been farming in the area since the 1950s reported that the yield of maize was as high as 3 to 5 tons/ha just after the clearing and dropped to about 2 tons/ha after several years. It appears that the yield remained rather stable at that level for many years. It is unlikely that the soil fertility was exhausted after cultivation of maize for two to three decades, when farmers started to use fertilizer. They might have started using it not because they had just then noticed the decline of soil fertility, but because of changes in the supply of fertilizers in the 1970s. At that time, a regulation prohibiting import of some chemical fertilizers including ammonium sulfate was lifted. Thai Central Chemical Co. Ltd. (TCCC), the only fertilizer company in Thailand at that time, started production in 1975 [Suehiro 1988: 285]. Greater availability was another reason for the popularization of chemical fertilizer in the study area in and after the 1970s.

Regardless of what factors influenced the start of fertilizer use in the area, it is certain that farmers use it because it increases yields. Its actual effect on yields, however, is not always evident. Fig. 9 shows the yield of maize and the input of chemical fertilizer at 30 interviewed farms in 1994. As can be seen, the relation between them is not clear. This is mainly due to drought. Farmers know that the rainfall between sowing and flowering is particularly critical for the use of fertilizer to be effective.

As stated before, the use of chemical fertilizer first spread in PP District in the 1970s, and seven to eight years later in PN District. This time lag is probably related to the greater uncertainty of rainfall in the latter area. The 1980s also saw the dissemination of new drought-tolerant cultivars of maize. It appears that the more

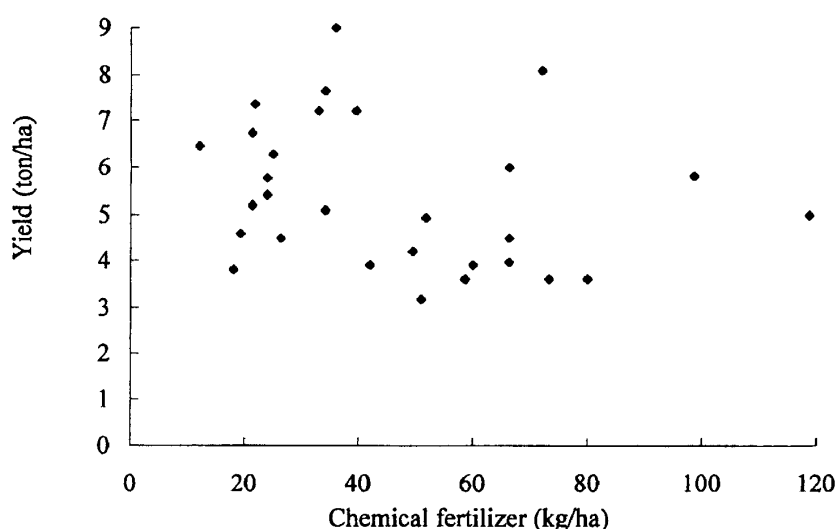


Fig. 9 Relationship between Maize Yield and the Rate of Chemical Fertilizer in 1994

Note: Chemical fertilizers contain other elements but the rate is expressed in kg N per ha.

assured harvest afforded by these cultivars induced PN farmers to follow those in PP.

At present, there is no significant difference in the application of chemical fertilizer between either the districts (the averages of 12 and 18 interviewed farms being 38.6 and 43.2 kg N/ha in PP and PN, respectively) or the areas of black and red soil (of high and low moisture-holding capacity, respectively). Further investigations are needed on the costs and benefits of fertilizer application under the condition of great year-to-year variability.

Organic Manure

Organic manure, usually chicken manure, is also now commonly used in maize cultivation. It is applied after the onset of monsoon rain and plowed in. The common rate of application is one to two truckfuls per 4-ha lot. A six-wheeled truck carries ca. 4 to 5 ton of manure. In many cases, it is applied every other year. Most farmers purchase chicken manure from poultry farms of various sizes nearby. The practice started in PP in the first half of the 1980s and in PN in the latter half.

Farmers did not feel the need to apply manure, either organic or inorganic, in the early years. Some started using organic manure when the soils lost their initial vigor. First, it was dung of domestic animals, cattle and swine, but regular use in sufficient amount was difficult. Organic manure could be bought at market but was too expensive. In the early 1980s, however, it became available much more cheaply. This is due to the rapid development of the broiler industry in the 1970s: the export of frozen chicken started in 1973 and increased dramatically after 1978, Japan being the major destination [Suehiro 1987 : 285-286]. The study area has the advantage of being relatively close to Bangkok. Here, commercial chicken-raising began in the mid-1970s [Chamnien 1975] and increased through the 1980s.⁸⁾ In particular, many farmers in Unit 3 and 4 in PN District shifted to this industry because of the chronic effects of drought on maize. They were supported by banks and agribusiness corporations.

Many farmers interviewed reported that the role of organic manure was twofold: one was to supply nutrients, as chemical fertilizer did, and the other to soften the soils. Since they believe that the continuous use of chemical fertilizer alone makes the soils hard, it is likely that the second role of organic manure became recognized more clearly after the popularization of chemical fertilizer. This might be another reason for the use of organic manure in the 1980s.⁹⁾

Changes of Cultivars

It is not clear when maize was introduced into Thailand, but it was after World War II

8) In Saraburi Province, there is the biggest broiler farm and the processing factory of the CP group, which started operation in 1989. The estimated number of broilers raised by them in Saraburi Province reached one million annually [Suehiro and Nambara 1991: 87].

9) Chicken manure is preferred to cattle manure because it leads to less growth of weeds in the

that maize production was established as an industry there [Senanarong 1974: 31; Yasuda 1978: 41-42]. The United States Operation Mission (USOM) to Thailand, which was founded in 1950, introduced Golden Flint Corn developed in Guatemala [*ibid.*: 42]. This cultivar, called "Gotemara" locally, spread rapidly and was already popular in the study area at the time of reclamation. The seeds were taken from the harvest of previous years and not uniform in shape, size and color.

A serious disease known as downy mildew began to spread in the late 1960s. The affected area was only 80 ha in Nakhon Sawan in 1968, but by 1970 it had expanded to 8,000 ha in other provinces including Saraburi and Lopburi. In 1974, 102,400 ha in 21 provinces were damaged [Senanarong 1974: 31]. A cultivar resistant to this disease was introduced from the Philippines and crossed with Thai composite cultivars, which created a downy mildew-resistant cultivar, Swan 1. Its seed production started in 1975 [JICA 1977: 71-76, 86]. Downy mildew was suppressed successfully by the dissemination of this new cultivar.

In the early 1980s, new hybrid cultivars with high yield potential and drought resistance started appearing on the market. In addition to the public institutions like universities and experimental stations, private seed companies joined in the development of new cultivars. In the late 1980s, most farmers in the area planted these new cultivars. In their dissemination to the study area, the variable rainfall and soils within the area appear to have had little influence. They spread over the whole area within a short period.

Those new high-yielding cultivars were produced and marketed by giant multinational corporations including Cargill Ltd., Continental Grains Ltd., and Pioneer Hybrid International Inc., to which CP group, the biggest agribusiness group in Thailand, joined.¹⁰⁾ Every year since the late 1980s, the individual maize farmers in the study area have had to choose an appropriate cultivar from those offered by these suppliers.

In 1992, most farmers in the area chose "CP-888," developed by the CP group. Its characteristic is that one plant bears two ears. It won a reputation for its high yield and drought resistance. The reputation was so favorable that most interviewees in the area in 1992 and 1993 praised this cultivar even though some of them had not actually cultivated it. In the following years, however, many farmers switched to another new cultivar. This reflects the facts that farmers today have a keen interest in new products and are well informed, and that the market is highly competitive. TV, radio and other media quickly propagate information not only on new cultivars but also on farm inputs such as fertilizers and other chemicals. Many demonstration plots are set up in farmers' fields by the agribusiness corporations. Sales persons visit farms one by one.¹¹⁾

fields. Cattle are raised afield while chickens are fed concentrates.

10) The CP group formed a joint seed-producing company with Dekalb Agresearch Co. Ltd. of USA in 1980, and started the production in 1984 [Suehiro and Nambara 1991: 87].

11) An example of the rapidity of farmers' response is the case of sunflower. It was first

One reason for the rapid decline in popularity of CP-888 in 1994 was the high cost of harvesting labor. As mentioned previously, this cultivar bears two ears per plant, but they are smaller and more difficult to remove from the stem than those of other cultivars, which requires greater labor for harvesting. Labor costs in the area have continued to increase since many factories have opened in the study area. They offer, on average, 80 baht per day while the farm wage was normally 100 baht per day in 1992. It is thus getting more difficult to recruit farm laborers. The greater labor requirement of CP-888 was not fully compensated by the higher yield.

Plowing

As stated before, plowing was impossible for a few years after clearing the forest because of remaining tree stumps. Yet a good harvest could be expected thanks to the high soil fertility and scarcity of weeds. After removal of the stumps, plowing and intertillage became possible and necessary. Plowing also allowed cultivation of the second crop, since timely planting immediately after the first crop became possible.

Tractors were available to farmers from the earliest years of the project. There were tractor operators, many the descendants of Chinese immigrants, who specialized in plowing on a contract basis. Some wealthy farmers owned big tractors and also engaged in contract plowing for their neighbors. Without such tractor-plowing, a farmer could not plant the second crop in the whole of his 25-*rai*-lot.

The total number of tractors in the area, however, was limited. Water buffaloes were also used. In the early years, a field was ready for sowing after only one plowing since the soils were soft and weeds few. Thereafter, a tractor plowed a field immediately prior to sowing, while with an animal it took a week to plow 25 *rai*. Later, harrowing became necessary. In many cases, it was performed with buffaloes while plowing might have been done with big tractors. Thus, farmers frequently missed the best timing for sowing, which was critical for successful cultivation. Big tractors and water buffaloes coexisted for a long period, the former for plowing and the latter for harrowing, sowing and intertillage. In the early 1970s, about two thirds of farmers in the study area raised water buffaloes as draft animals [Chamnien 1975].

Small tractors were first introduced in the late 1970s, taking over the roles played by water buffaloes. Some were also operated on a contract basis, but many were operated by small-holders themselves. The switch from animals to small tractors was gradual, and it was not until the late 1980s that the animals disappeared from the rural scene, except for paddylands and localities where the fields were too stony. Small

➤ introduced by the agricultural office of Lopburi District in 1991. This crop is tolerant to drought and thus suitable as a second crop. The acreage increased within a few years [Phra Phutthabat Field Crop Research Center 1993: 16]. In the first two years, it was incorporated mainly into Pattern J (maize-sorghum or maize-mungbean) and Pattern K (maize for seeds) in Unit 3 (good soils but poor rain). In 1993, however, it was seen in most parts of the study area.

tractors allowed timely sowing, thus alleviating the risk of drought.

Harvest

Maize ears are plucked manually from the standing plants after drying.¹²⁾ Before the early 1980s, they were plucked earlier and sun-dried in cultivator's backyard. At that time, the contamination by aflatoxin of maize for export to Japan became a serious problem. Cooperative research by Japanese and Thai scientists concluded that the contamination could be reduced by sufficient drying of the ears of the plant [JICA 1985; Yamamoto 1987]. The practice was recommended by agricultural extension personnel and quickly popularized in the study area.

In the past, labor for harvesting was provided by relatives and neighbors, and often exchanged between them, but this is no longer so. It depends more on laborers from afar, including the Northeast and paddy areas of Suphanburi and Lopburi. Some come from the old rice-growing villages within the study area such as Dilang, and a village of ethnic minority people, the Hmong.¹³⁾ Time of work and wage are often negotiated through agents who come to the area every year.

The last five years have seen increasing difficulty in procuring farm labor, especially members of the younger generation, because of the increasing job opportunities in the industrial sector. Labor shortage is felt not only at the time of harvest but throughout the season. Labor-saving technologies such as herbicides are being tested by some farmers.

Yields

As stated before, the yield was 3 to 5 ton/ha just after reclamation and dropped to about 2 ton/ha in a few years. It remained at that level until the late 1970s, when the use of chemical fertilizer became common. In the late 1960s, when forest clearing in the study area was approaching the final stage, the crop suffered from locusts.¹⁴⁾

At present, the general yield level in the study area is about 5 ton/ha. The yield of the interviewed farms in 1993 was 5.1 ton/ha. They reported that 6 to 7 ton/ha was possible given adequate rainfall. The average yield of maize of the whole country was 2.6 ton/ha in 1991 [Ministry of Agriculture and Co-operatives 1992]. The study area is thus one of the most advanced and successful areas of maize cultivation in Thailand.

12) After complete drying on the plants, cobs without husks are plucked off [Sato 1964 : 43].

13) Of 120 families in the Hmong (or Maeo) village, 80 make their living by wage labor. The shabby houses built on stilts of palm trees make a sharp contrast to those of Thai farmers in the area.

14) Bombay locust (*Nomadacris succincta* Lin.) was first noticed as early as 1960. It broke out in eastern Lopburi Province in July and August 1963, and the population reached 100 per square meter. Insecticides were used but not extensively. The continuous rain in the latter half of September, however, was effective in suppressing the insect by infestation of the parasitic *Entomophthora grylli*. It was estimated that 95% of the locusts had died by the beginning of October [Roffey 1968 : 238].

VI Discussion

The process of development of commercial cultivation of field crops in the study area can be divided into two stages: the first from the reclamation in the 1950s till around 1980, and the second thereafter.

A system of two crops in a season with maize as the first crop emerged within a few years after forest clearing. Throughout the first stage, there were great variations within the area in the cropping pattern, especially in the choice of the second crop after maize. The distribution of the various patterns was found to be closely correlated with the variable moisture conditions in the area, which were largely determined by rainfall and the soil moisture-holding capacity.

Around 1980, new technologies became widely adopted including both organic and inorganic fertilizers, high-yielding and drought-tolerant cultivars, and mechanization. The environmental conditions of the area continued to affect farming practices, but in different ways. In that part of the area where both of the rainfall and soil condition are favorable, the maize-based two-crops-a-year cropping system persisted with greatly improved productivity. In the less favorable parts, maize was replaced by other field crops or, in places, a completely new farming system involving no field crop at all. The new technologies offered the chance to free themselves from the chronic risk of drought.

Forty years have passed since reclamation began in the study area, but so far no sign of environmental deterioration has been noticed: neither soil degradation, salt accumulation, nor build-up of pest populations. Instead, the adoption of modern technologies has greatly improved the productivity of the maize-based system (maize production has increased nearly threefold yield in a decade) and helped evolve the similarly productive and drought-free farming systems.

The socio-economic circumstances of Thailand in the 1950s and following decades were also favorable for development of the commercial cultivation of field crops. In the case of maize, a stable market was one factor. The export of maize to Japan from 1959 under the Maize Agreement helped create a steady demand at the initial stage of the maize industry in Thailand [JICA 1977: 56]. Over-population of the rice-growing villages in Central Thailand on the one hand, and, on the other, the existence of vast uplands to be exploited for field crops were further socio-economic factors providing the background to success. Efficient marketing is another indispensable condition. The physical infrastructures, especially upcountry roads, of which the most significant example in the 1960s was the Friendship Highway, greatly contributed to expansion of the commercial field crops area. The intangible infrastructures for marketing the new produce benefited from the existing time-honored system for marketing of Thai rice [Kaneko 1979: 103].

One of the characteristics of the commercial production of maize and other field

crops in Thailand is that they are produced mostly by countless small-holders. While working in the field, the authors were impressed by the supplementary but essential roles played by similarly small to medium-size local enterprises involved in the maize industry. The tractor operators who plowed on a contract basis and the agents recruiting farm laborers are examples. Before the involvement of large corporations supplying modern technologies, local merchants and traders played an important role in communication and dissemination of information. Participation of the private sector, not necessarily large firms but often petty merchants and traders, contributed greatly to the commercial farming by small-holders.

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