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Farming Technology in the Deep Flooding Area of the Chao Phraya Delta: A Case Study in Ayutthaya

Shigeharu TANABE*

I Introduction

This paper aims to examine the major characteristics of farming technology of rice cultivation in the deep flooding area stretching on the west bank of the Chao Phraya delta, by investigating the data obtained in a specified village in Ayutthaya province.[1] A vast flat delta area subject to long and deep flooding in the rainy season extends from the bank of the Chao Phraya to the Suphanburi river to the west, and from the Phraya Banlü canal to the Phakhai region along the Nọi river to the north. This deep flooding belt corresponds to the retarding basin in the hydrographical classification of the delta.[2]

Uncertainty of monsoon precipitation at the beginning of the rainy season and prolonged deep inundation are peculiar conditions relevant to rice cultivation in this area. The difficulties posed by these gigantic and uncontrollable physical environment, despite the recent improvement of water control by the government, have not yet been fully overcome. The peasant farmers, in order to adapt to such rather unfavourable environment, have traditionally developed a peculiar kind of farming technology. That is the broadcast-sowing method together with a suitable choice of indigenous late varieties including the so-called 'floating rice' (*Khao khün nam*). The sophisticated water control which has been widely developed and maintained by peasant cooperative efforts in the intermontane basins of northern Thailand, cannot be observed in this area. However, the

* 田辺繁治, Department of Geography, School of Oriental and African Studies, University of London, England

1) The field work on which the paper is based was undertaken in 1974–75 with further short visits in 1977, 1978, 1979. Grateful acknowledgement must be extended to Mr. John Sargent, Reader in Geography and Dr. Andrew G. W. Turton, Lecturer in Social Anthropology, School of Oriental and African Studies, University of London, for making many helpful comments and corrections on an earlier draft. My acknowledgement must be also to Professor Yoshikazu Takaya and Professor Yoshihiro Kaida, the Center for Southeast Asian Studies, Kyoto University, for providing many useful ideas and information relevant to this paper. My thanks are due to the Japan Foundation for sponsoring the research in London.

2) For the classification based on the hydrographical conditions of the delta, see Kaida's detailed analysis [Kaida 1973: 403–413; Kaida 1974: 512–524]. The relationship between topographical condition and rice-growing in this delta is discussed in Takaya's pioneer work [Takaya 1971: 375–379].

broadcast-sowing cultivation as a traditional farming technology is highly efficient and rationally adapted to the existing physical environment. Meanwhile, the early season cultivation, by the transplanting method of newly improved varieties introduced in recent years, requires heavy investment of both capital and labour. The new technology together with power devices and industrial inputs has had a considerable effect on the traditional farming system. However, a series of inter-linked technological decisions which has appeared in the course of farming operations still shows strong characteristics of a peasant economy. It can be considered that Ayutthaya's farming technology has been basically developed within a peasant economy, though it has survived for many decades despite the penetration of the rice market economy.

The purpose of this paper is to examine these characteristics of the traditional farming technology as applied in a selected village of this delta region. The settlement referred to hereafter as 'Ayutthaya village,' is in fact Village No. 9 (*mu kao*) of Tambon Bang Nomkho, an administrative unit which consists of ten villages along the Khanomčhin canal and the Nọi river, in the Sena district of Ayutthaya province. The village stretches along the canal in a discontinuous linear type of settlement, and is about 6 km from the town of Ban Phaen where the district office of Amphoe Sena is located. The villagers have easy access, by both water and road traffic, to Ban Phaen, Čhao Čhet and Sikuk, all of which are local rice trading centres along the Čhao Čhet—Bang Yihon canal and the Nọi rivers (Figure 1).[3]

Although the northern part of Tambon Bang Nomkho close to the Nọi channel has a long history dating back to the Ayutthaya period (1350–1767 A.D.), Ayutthaya village was established as a result of relatively new reclamation. The pioneering settlement, precursor of the present village, is believed to have been just established at the earliest with the encroachments of clearing along the Khanomčhin canal at the close of nineteenth century.[4] In the 1890s, gradual but steady migration into the village began, as a result of the search for new frontiers of rice cultivation.[5] Some migrants came from the north,

3) A huge number of rice cargo boats, sail down the Čhao Čhet—Bang Yihon canal and the Nọi river from Suphanburi and Phakhai regions, and often stop over at a row of rice mills at those centres for the purpose of selling or trans-shipment. Most of these cargoes are sold to the rice mills directly and are later transported to Bangkok by the larger boats through the Nọi and Chao Phraya main channel. For rice trading and its market practices in Ayutthaya province, see [Pricha 1971: 171–213].

4) The rapid development of rice cultivation in this area is referred to in Phraya Boranratchathanin's contemporary description [Boranratchathanin 1962: 11–12].

5) Most peasants claimed their ownership to the cleared land, while some of them were tenants renting riceland from landlords who also operated at the beginning of the pioneering days. It should be noticed that some tenants cultivated *na luang* or royal riceland under the ownership of the King. A detailed discussion of the *na luang* and the process of reclamation in this area is given in [Tanabe 1978: 72–82].

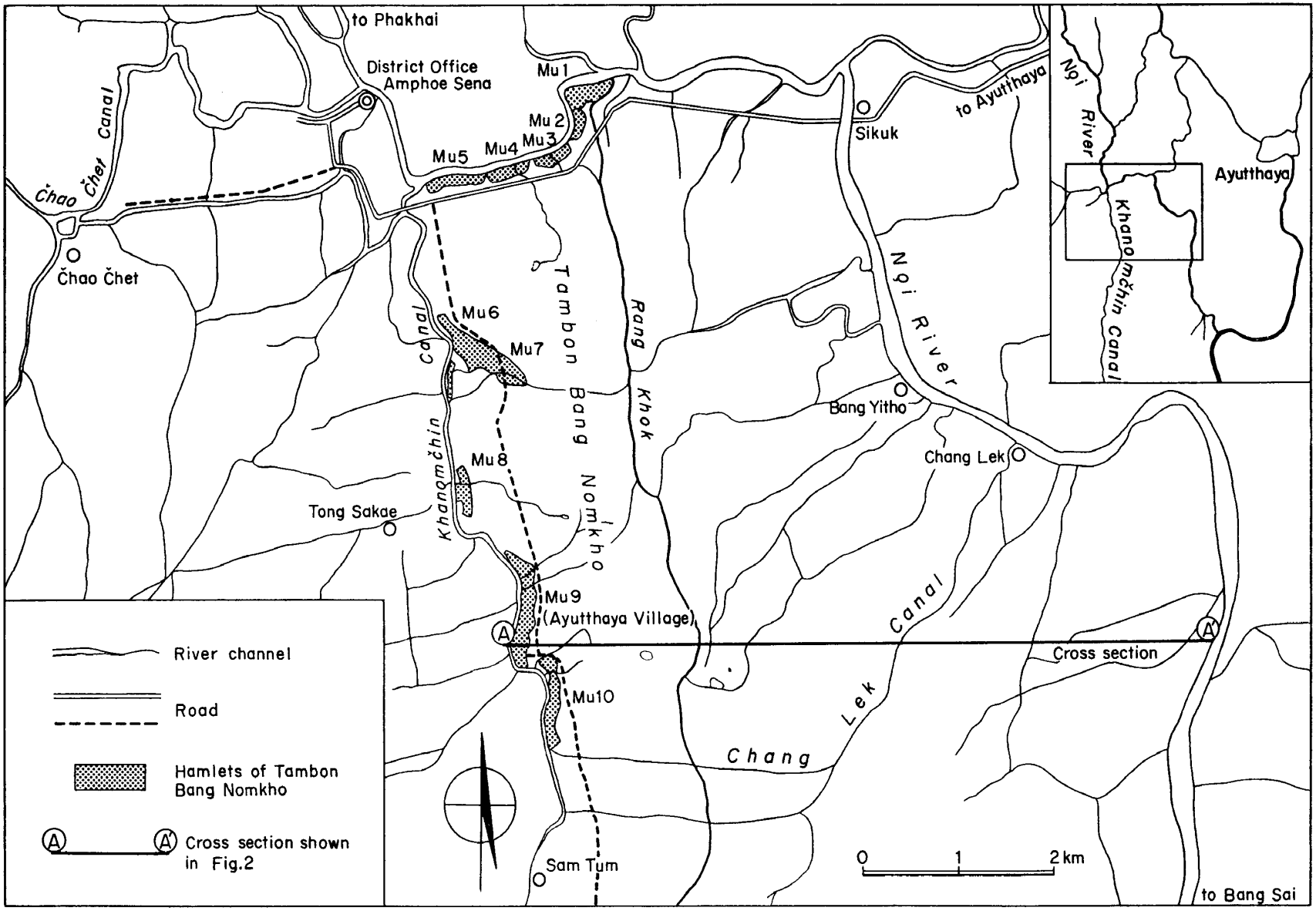


Fig. 1 Ayutthaya Village

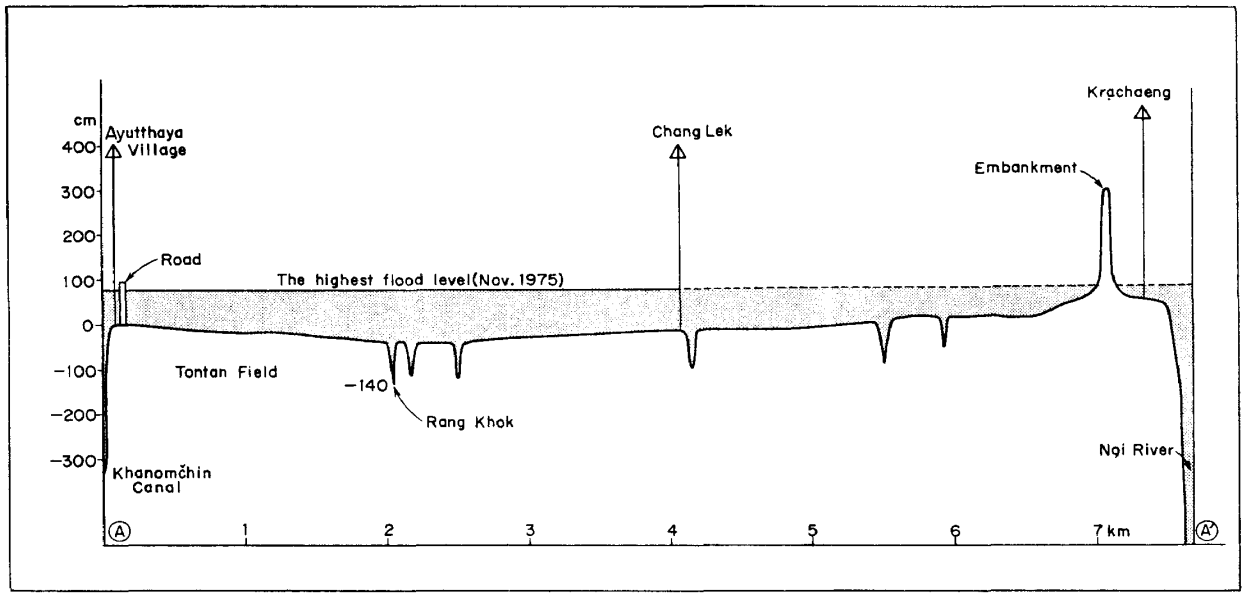


Fig. 2 Profile of the Cross Section Ⓐ–Ⓐ'

and from centres such as Ban Phaen, Čhao Čhet and Sikuk as well as the northern part of the Khanomčhin canal. The claiming of ricelands by peasants came to an end at least by the 1920s, and tenancy has steadily increased up to the present.

The Tambon Bang Nomkho contains 573 households and a population of 3538. In 1975, Ayutthaya village was the largest of the ten villages, with 83 households and a population of 378. The households of Ayutthaya village consisted of 67 farming households including 21 households of rural labourers who are almost landless and work mainly as hired labourers on farms and in other jobs, and 16 non-farming households. There are 48 households engaged in rice cultivation mainly inside the village area.[6] The main rice field, called the Tontan field, extends from the canal to the Rang Khok, a narrow and crooked drainage water course in a depression. The annual flooding from the canal into the Tontan field normally begins in late August. Owing to the heavy rainfall in the following months, flood water overflows the relatively low natural levees on which settlements are found, into the field, and the highest floods can raise the water level to over 1.5 m from ground level. The inundation continues until mid-December and gradually subsides in harvesting time (Figure 2).

In the following section of this paper, the water conditions, which represent the most crucial factors in the technology of rice cultivation, will be analyzed in relation to the development of water

6) The 44 households including 6 landlord-operators, 7 owner-operators, 13 part-owners and 18 tenants were subject of the detailed survey relating farming technology; there were also 4 households of rural labourers who cultivated small areas less than 5 rai (1 rai= 0.16 ha). The total amount of operated area was 1233.00 rai (197.28 ha) consisting of 719.75 rai of area owned and 513.25 rai of area rented in.

control under government projects. This will be followed by the section dealing with land-use patterns and farming practices of both traditional broadcast-sowing and newly introduced transplanting methods. The paper will subsequently examine the material culture of farming, and decision-making, the two elements of which farming technology essentially consists.

II The Development of Water Control

1. Inundation and Rice Cultivation

Water control in rice cultivation in Ayutthaya village is different from those techniques in use in the intermontane basins where people can get a relatively stable water supply to the fields by means of the traditional gravity irrigation works. In Ayutthaya village, seasonal rice cultivation is predominant and its broadcast-sowing method is essentially dependent on local rainfall on the fields at the early stage of cultivation in the latter half of April and May. Subsequently, it is affected more or less, by the inundation caused by annual flooding during the extended period of rice-growing from July onwards. Therefore, in the first place, rice cultivation is strictly determined by the localized rainfall pattern during land preparation and sowing. If the rainfall is insufficient or comes too late at this crucial period of sowing, cultivation is impossible, or late sowing can result in young plants being drowned by the sudden torrential rainfall and the first rise of inundation water. At the same time, cultivation has to rely upon the inundation which used to be unstable due to the localized heavy rainfall and occasional spilled water throughout the latter half, the reproductive growth period. The inundation occurs on a vast scale, being caused by drained water from an enormous catchment area upstream. In the absence of authority powerful enough to organize and carry out large-scale hydraulic works, control of inundation by the villagers would be altogether impracticable[7] [Wijeyewardene 1973: 89–110; Ishii 1978: 18–19, 26]. In hydrographic terms, the ricelands of the village on the east bank of the Khanomčhin canal are situated in the southern part of a huge retarding basin extending from Phakhai to the Phraya Banlü canal along the Nọi channel. The retarding basin, having an average elevation of ca. 2 m above mean sea level, is subject to deep and long flooding by the drained water from the Old Delta upstream [Kaida 1974: 512–513]. The most marshy depression can be seen

7) In the premodern period, the government concern was generally focused on the development of communications through the construction of large-scale canals [Tanabe 1977: 64–67]. However, during periods of stable political control, the government maintained a certain level of interest in hydraulic works for water control of ricelands. According to a source dated 1843, construction works were carried out to shut canal sluices in order to protect the rice fields from incipient flooding in the areas close to the Khanomčhin canal, by officials of the Ministry of Agriculture (*krom na*) and the governor of Krung Kao (Ayutthaya) [Krom Sinlapakọn 1969: 17–18; Tanabe 1978: 31–32].

around the Lat Chado swamp area west of Phakhai, where cultivation has suffered much loss in the past hundred years from extraordinary flooding.[8] The inundation prevails all over the area of the retarding basin and can last for a period of more than 30 weeks, which roughly corresponds to the entire growing period of broadcast-sown season rice [Kaida 1973: 405]. Under ordinary circumstances, the highest level of inundation attains 1.5–2 m on the fields in October and subsequently subsides November, and towards December. This prolonged stay of inundation water may be partially due to the slight elevation along the Phraya Banlü canal running transverse to the Chao Phraya and the Suphanburi main channels.[9] The inundated water, after remaining for a considerable period, flows down into the main part of the West Bank project area over the Phraya Banlü canal southward, from which more favourable and stable water conditions for rice cultivation may be observed. The Čhao Čhet-Bang Yihon project area in which the Khanomčhin canal area is included, falls within the northern part of the West Bank project scheme, and is subject to water control carried out by the Royal Irrigation Department (RID). Nevertheless, hydrographical conditions here seem to be much similar to the depressions around the Phakhai area.

Under such circumstances, peasants of the village who have traditionally adopted the cultivation of floating rice as their only feasible crop, developed no sophisticated water control system comparable to that of the intermontane basins. Nevertheless, there have been some attempts to alter the condition of the land. During the pioneering days of the settlement, a small tertiary canal was dredged so as to lead inundation water into the fields. This was the Tontan canal, which, with a length of about 2 km, linked the Khanomčhin canal with the Rang Khok drainage channel to the east. Although the precise year of excavation is not clear, it is said that the work was done at the beginning of this century, by the co-operative labour of peasants who worked plots in the Tontan field, the main field of the village stretching along the east bank. After its completion, though the tertiary canal served the purposes of irrigation and drainage to some extent, no other public works to improve water control were undertaken by the villagers. Water control works to facilitate rice-growing, which include irrigation, drainage and flood control, were not accomplished until the government decided to initiate and carry out a project under the RID.

8) Prince Damrong gives a brief account suggesting the presence of traditional early season cultivation before the deep flooding season around this swamp at the close of the nineteenth century [Damrong 1972: 3]. However, the cultivation of so-called 'floating rice' has been predominant in this area [Sukit 1969: 3].

9) According to personal communications with Professors Takaya and Kaida. Also see [Takaya 1969: 25–26; Takaya 1971: 391–392].

2. Water Control under the Government Projects

On the west bank of the Chao Phraya several trunk canals transverse to the Suphanburi river were already in existence at the end of the nineteenth century, when the Ministry of Agriculture dredged the Khanomčhin canal under the leadership of Phraya Kasetraksa to provide easy access to the uncultivated wilderness [Tanabe 1978: 78]. Those include, for example, the Čhao Čhet-Bang Yihon canal and Phraya Banlü canal in the area concerned. Although these canals led to an improvement in water transport between the two major channels, and to some extent stimulated the expansion of ricelands along them, at the same time, they often caused obstruction to drainage in the depressions [van der Heide 1903: 25]. Van der Heide, a Dutch irrigation expert from Netherlands East Indies refers to such conditions in this area in his report in 1903 as follows:

> "Moreover the dykes of excavated earth along the *klongs* [canals] add no small part to the natural obstructions against drainage and so at the time the water in the rivers and in the *klongs* is rising to the highest level and rainfall is still heavy, the very lowest parts often become flooded for some time as deep as 2 m and more. In these conditions only *na müang* paddy [floating rice] can be cultivated." [van der Heide 1903: 47].

The river and canal systems, thus described, and the expansion of riceland in the Khanomčhin canal area are shown in Figure 3. As far as the Tontan fields are concerned, the wilderness had almost disappeared by 1906, except in the area southward along the Rang Khok. Although most of the areas westward from the Khanomčhin were still left uncultivated in that period, they too were transformed into ricelands by the 1920s.

In 1903, van der Heide drew up a highly ambitious master plan for a water control scheme covering the whole of the Chao Phraya delta. Three years later, he proposed a smaller and more moderately designed project scheme on the west bank [van der Heide 1906]. According to his official report, submitted by the Minister to the throne, the proposed West Bank scheme was part of a greater project which aimed to expand ricelands up to 500,000 rai on the west bank of the Chao Phraya. This was to be achieved by water control with two main feeding canals; one from the Khanomčhin to the Maenam Qm canal north of Bangkok, and another from Bang Yihon to the Mahasawat canal along the east bank of the Suphanburi river (Figure 4). The former, with a total length of 48 km, was to be excavated from the site of Wat Manwichai of Ayutthaya village, then called Wat Prachanman, linking with the existing Khanomčhin canal. Locks and head regulators, one of which was to be installed at the mouth of the Khanomčhin channel, would perform the function of controlling inundation and would secure a stable supply of irrigation water to the fields. And during

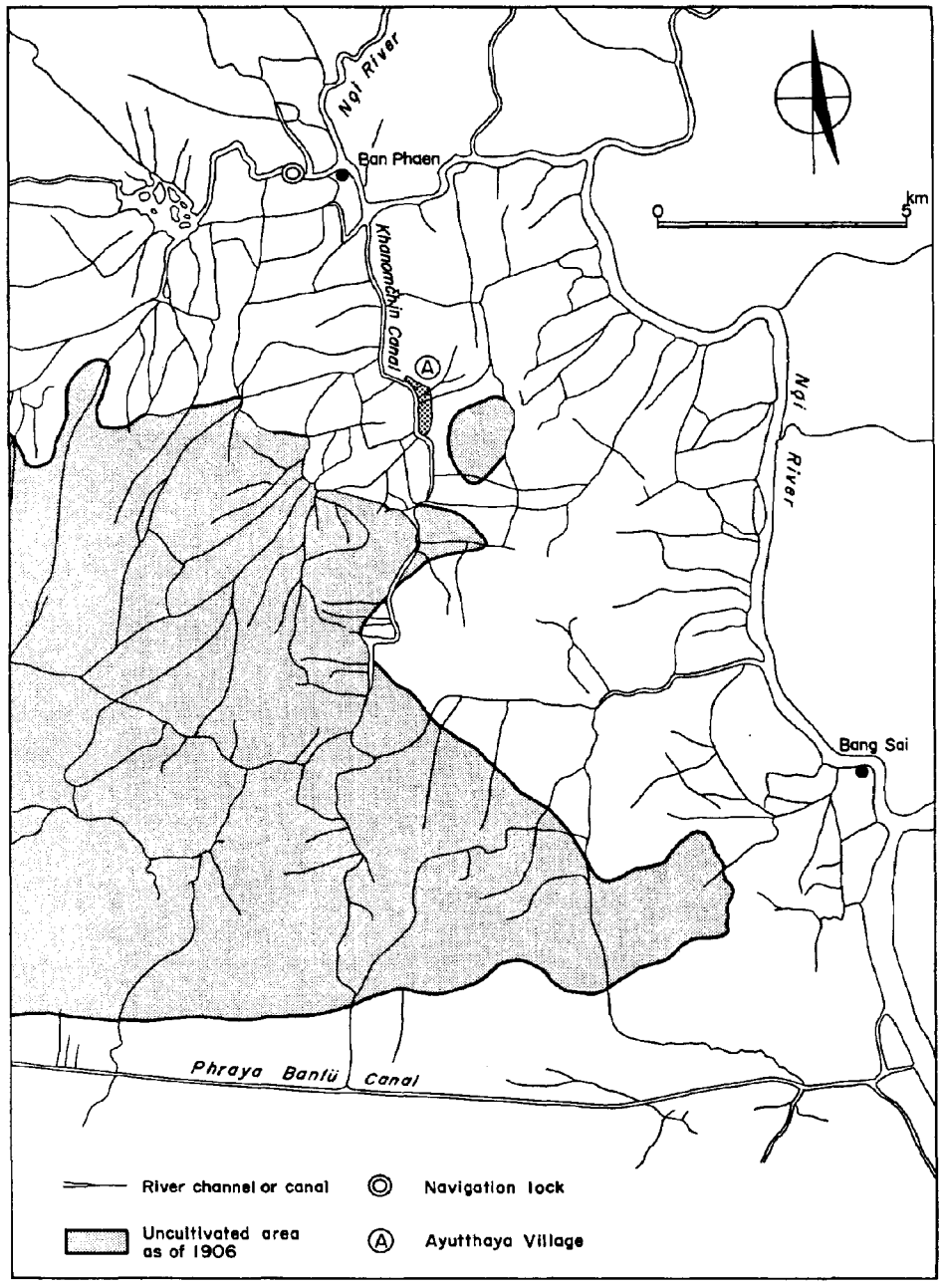


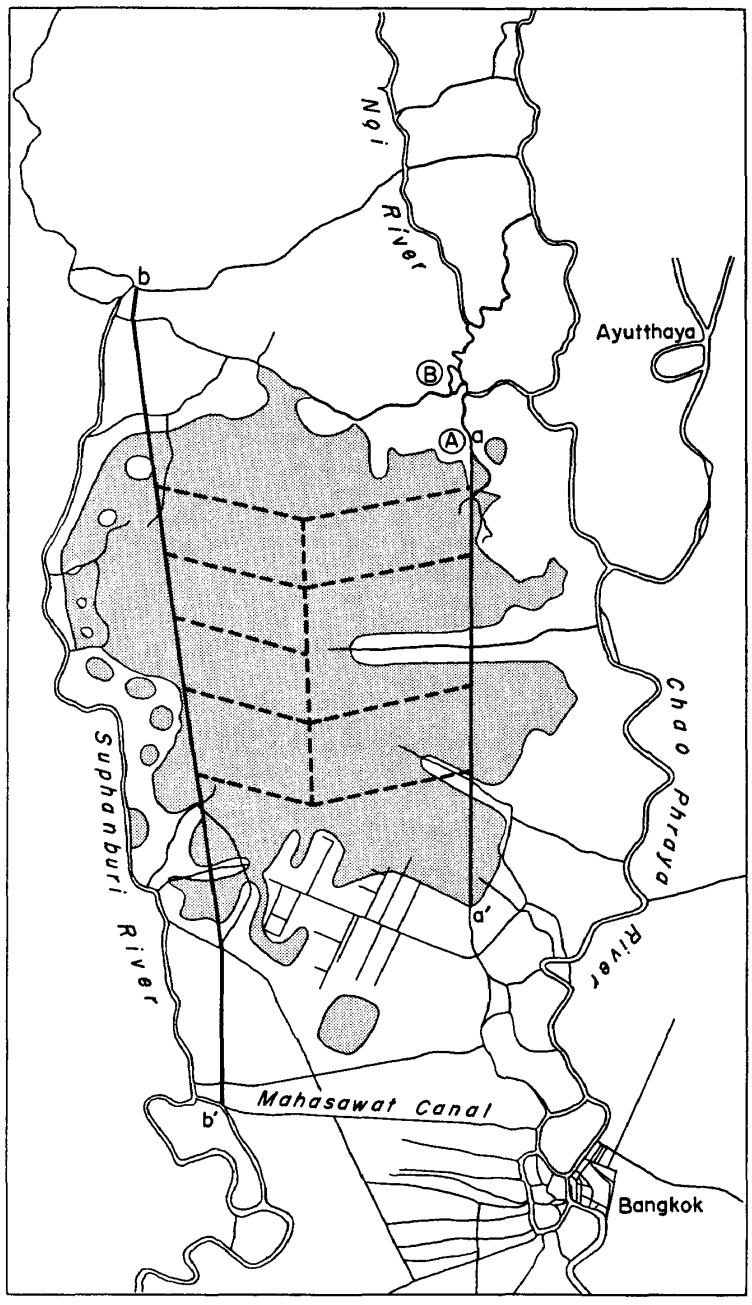
Fig. 3 Water Control within the Khanomčhin Canal Area as of 1916

the flooding season,

"although the flooding on the fields along the Sikuk river [the Nǫi river] goes as deep as about 1.5 m, the depth of inundation along the newly excavated canal will be kept within limits of 0.40 to 1.20 m." [van der Heide 1906]

It was intended that this magnificent scheme for water control on the west bank thus proposed would be completed, and in operation to the full capacity required, within eight years. The total cost of the scheme was estimated at about 3 million baht,[10] and if compared

10) In this period, £ 1 was approximately equivalent to 17 baht [van der Heide 1903: 115].



a —— a' : Proposed alignment of the West Bank main canal

b —— b' : Proposed alignment of the Suphan main canal

– – – – : Proposed alignment of branch canals

▭ : Uncultivated regions concerned

Ⓐ : Ayutthaya Village

Ⓑ : Ban Phaen

From: van der Heide. 1906 (2449). Raingan khut khlǫng fang tawantok maenam čhao phraya. K.S. 9.2/48. Archives of the Ministry of Agriculture in the Fifth Reign. Bangkok: The National Archives.

Fig. 4 The Proposed General Plan of the West Bank Scheme

with the total expenditure of about 57 million baht required for his proposed Greater Chao Phraya project, would cost only five per cent of the latter [van der Heide 1903: 125]. Nevertheless, the government decided to postpone the West Bank project as well as the larger water control scheme, and instead opted for the less expensive "reduced capacity project" in 1906 [Thailand 1915a: Vol. 3, p. 19]. The main reasons for the postponement seems to be the question of how to populate the area, even if conditions were suitable for clearance as a result of the proposed water control, as well as the heavy expenditure required to complete the project [Thailand 1915a: Vol. 3, p. 19; Thailand 1915b: 1–4; Small 1973: 4]. In any case, the water conditions in Ayutthaya village could not be improved to any extent for a long time, because the projects concerning the west bank had fallen into neglect. After van der Heide's resignation from the Department of Canals (*krom khlǫng*) in 1909, a series of smaller schemes such as the Suphan and Pasak projects together with the improvement of the existing trunk canals was carried out from 1913 onwards under the recommendation of

a British irrigation team headed by Sir Thomas Ward. In the area concerned, some locks were installed to facilitate navigation, and dredging was carried out in the Čhao Čhet - Bang Yihon canal in this period [Thailand, 1915a: Vol. 3, p. 31; Boranratchathanin, 1962: 11]. However, the government paid little regard to the improvement of water conditions in the Khanomčhin canal area until the establishment of the West Bank project in 1939 [Thailand 1927: 3–7].

More than three decades passed before van der Heide's proposal for the West Bank project was revived. Initially, this plan aimed to supplement the natural drainage system with newly excavated canals such as the San canal which runs parallel with the Khanomčhin canal to the west. These canals, it was hoped, would reduce the high levels of inundation caused by occasional heavy rainfall and by spillage of excess water. At the same time, as a result of the expansion of ricelands into the wilderness, a more stable water supply began to be required for the early period of cultivation when the local rainfall is still unreliable. In order to make use of the water in the canals to meet such demand, some regulators and sluices were constructed for the conservation of irrigation water. In addition to these works, embankment and reinforcement of the natural levees along the Chao Phraya, Nọi and Suphanburi rivers were undertaken as flood prevention measures. Thus water control in the project can be characterized by water conservation with flood protection to secure water for the early period of cultivation [Sukit 1969: 1–2]. Although these improvements and constructions slowly continued even after World War II, the water supply during the first half of the cultivation season was still inadequate and unreliable. Sufficient water could not be given to the areas through the upstream channels such as the Nọi and Suphanburi rivers until the completion of the Chao Phraya diversion dam at Chainat.[11]

The Chao Phraya diversion dam, which had been expected to occupy a key position in the Greater Chao Phraya scheme covering the delta region since van der Heide's proposal in 1903, was at last completed in 1960, and began to supply water through the Nọi channel to the West Bank tracts from 1961. Feeding the tracts with water at 105 cubic meter per second, it contributes to some extent to the supply of water during the early stage of cultivation. At the same time, two big feeder canals were newly excavated in the 1960s: the Phokhọi - Bang Yihon canal from the Suphanburi river to Bang Yihon and the Phakhai - Čhao Čhet canal from the Nọi river to Čhao Čhet. These feeder canals, although principally intended to prevent flooding further downstream by dispersing the excessive water from the two main rivers, provided a relatively ample supply of water in

11) FAO Mission for Siam and some official reports of the Ministry of Agriculture well describe the water conditions of the area before completion of the Chainat dam [FAO 1948: 58–59; Thailand 1950: 46–50; Thailand 1957: 146].

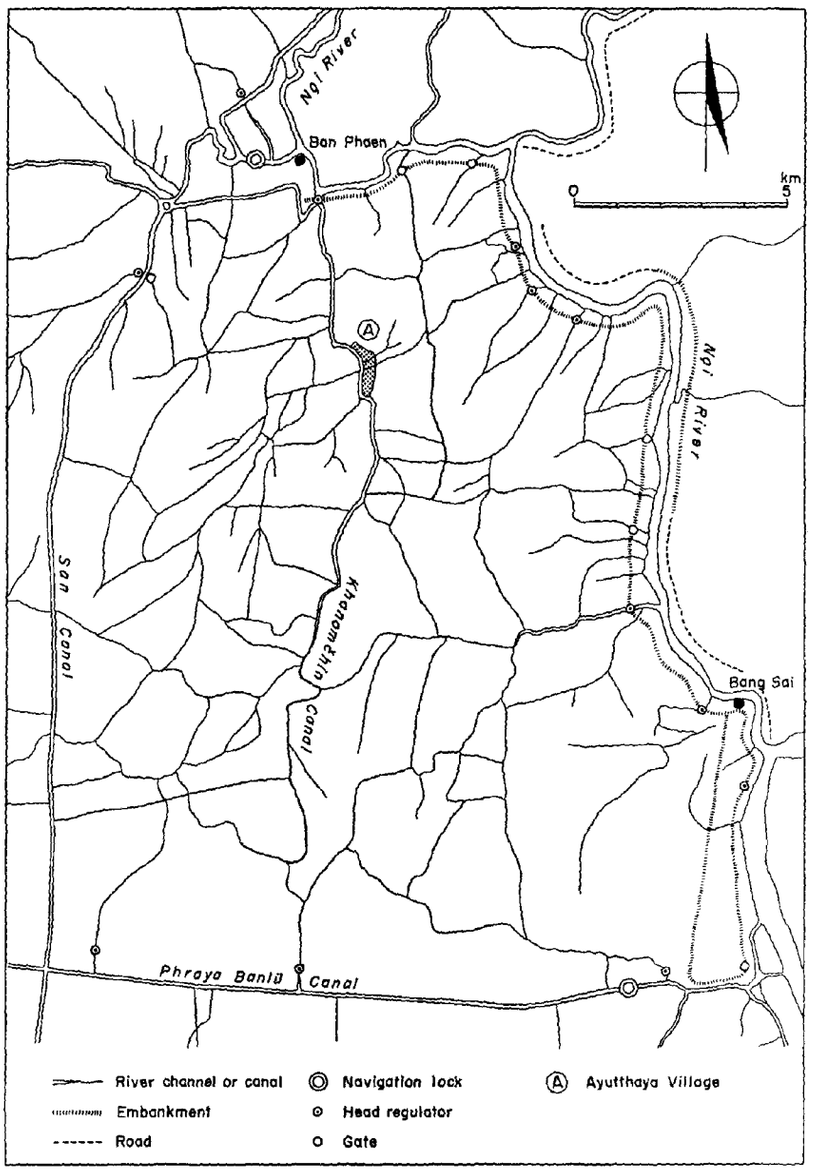


Fig. 5 Water Control within the Khanomčhin Canal Area as of 1969

the dry season as well as in the rainy season [Kaida 1974: 520–521].

In addition to the feeder canals, numerous lateral and tertiary canals constructed since the 1960s up to the present, have provided fairly favourable conditions for transition from the traditional broadcast-sowing method to the transplanting method. In the extensive areas relatively close to the canals, in fact, a remarkable transformation of cropping patterns has taken place since the late 1960s [Sukit 1969: 6–7]. The early season cultivation which is in practice an application of the newly developed non-photosensitive varieties,

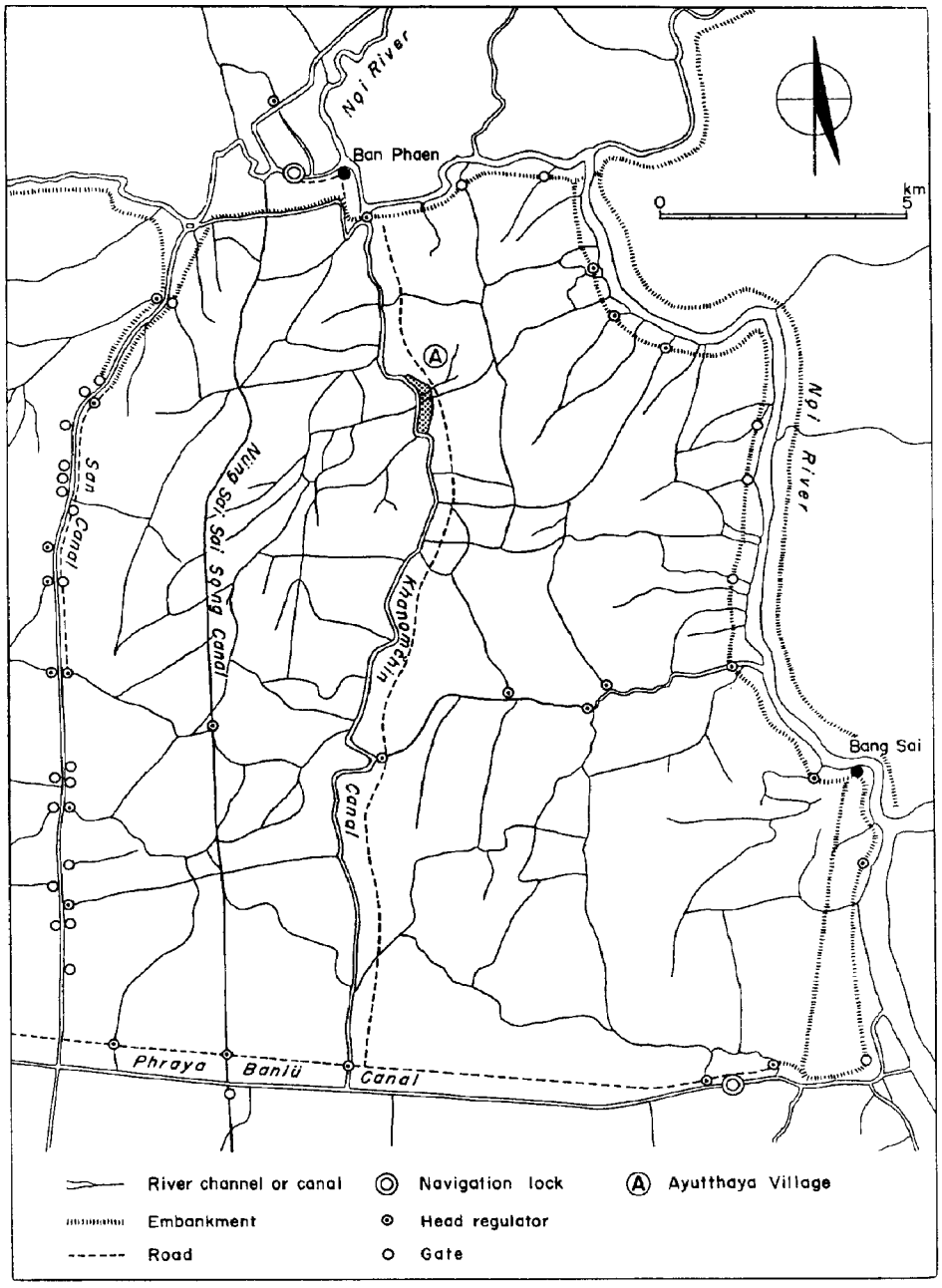


Fig. 6 Water Control within the Khanomčhin Canal Area as of 1977

such as the RD series, to the first half of the main season cropping, starts in April or May and is harvested in August or September by the time deep inundation occurs.[12] Double cropping has also been partially introduced, particularly in the area close to the canals where the water is available even in the dry season.

These remarkable developments, caused by the recent improvement of water control have taken place, however, in the southern parts of the West

12) The recent transformation of cropping pattern chiefly caused by the wide-use of low lift pumps as well as by the implementation of water works [Kaida 1974: 523–524].

Bank tracts downward from the Phraya Banlü canal. Most areas in the northern parts of the tracts in which Ayutthaya village is situated still continue under the traditional broadcast-sowing cultivation adapting to the deep inundation. Despite the implementation of water control which is certainly progressing as shown in the Figure 6, the deep inundation and its relatively early occurrence does not yet allow transplanting cultivation around Ayutthaya village. As far as the Tontan field on the east bank of the Khanomčhin canal is concerned, the water conditions still make it impossible to adopt the extensive cultivation of transplanted rice. The field is too deep to adopt early season cultivation, and has an insufficient water supply to commence dry season cultivation. The attempt to drain the excess water through the Nọi river in order to encourage early cultivation can cause the unexpected flooding of the Chao Phraya main channel further downstream near the Bangkok metropolitan region [Thailand 1978: 3]. Therefore, broadcast-sowing cultivation depending on rainfall is still necessarily practised in the village. And the introduction of early season cultivation by the transplanting method is strictly limited to the area immediately adjacent to the Khanomčhin canal.

Under such circumstances the RID has recently made efforts to enable stricter water control in the subdivided areas in the northern part of the West Bank tracts [Thailand 1978: 1–2]. The area surrounded by the Čhao Čhet-Bang Yihon canal, the Phraya Banlü canal, the Suphanburi, and the Nọi river became a subdivision named the Čhao Čhet - Bang Yihon project (*khrongkan songnam lae bamrungraksa čhao čhet bang yihon*). In order to keep the project area under more effective control, embankments together with roads have been constructed along the main rivers and canals surrounding the area. Newly excavated canals and numerous natural water courses are connected with the outer channels by the head regulators installed across the embankments. The project area is again subdivided into three zones, demarcated by major feeder canals. Each zone is surrounded by embankments or dikes of excavated earth along the canals together with a number of regulators as in Zone No. 1 shown in Figure 6. Through such construction works in progress, water conditions around the village will be more stabilized, and as a consequence, transplanting culture conducive to an improvement of the environment might emerge under a new cropping pattern in the traditional broadcast-sowing culture region.

3. Operation and Maintenance of Water Control in the Village

The water control scheme thus developed is directly operated and maintained by the RID. The State Irrigation Schemes such as the Čhao Čhet-Bang Yihon project, different from the rather small People's Irrigation Schemes constructed and maintained by the water

users concerned, are managed under the complete control of the RID through its bureaucratic organization. Under huge and complicated water control systems such as the Greater Chao Phraya scheme, water allocation into even a lateral canal is taken into account within the total plan of water distribution. Because the water conditions in one project area are systematically affected by those in other areas, localized water control would be impossible. Therefore a highly centralized management system has been adopted throughout the area covered by the Greater Chao Phraya scheme. On the other hand, where operation and maintenance of the facilities is concerned, the peasants' participation as water users is still minimal by and large. In some areas in the Old Delta upstream where the water supply has always been sufficient and stable and dry-season cropping is being operated, the peasants have developed fairly good maintenance of lateral canals and farm channels [Small 1974: 694; Kaida 1978: 231]. However, it is widely observed that the peasants' co-operation as well as their participation is generally lacking in the maintenance of the facilities in most of the project areas in the delta [Small 1974: 692].

In the case of Ayutthaya village, the operation of water control is organized outside the village. The Khanomčhin canal, the indispensable main channel for irrigation and drainage in the Tontan field, is regulated by the two head regulators installed at both ends of the canal. The operation of both regulators is under the control of the two zone-men or *nai truat chonprathan luang* under the order of the Čhao Čhet - Bang Yihon project office at Singhanat, the mouth of the Phraya Banlü canal. The zone-man, an official for the smaller unit of operation appointed by the RID, has as his main duties: to control the amount of water in the canal through the head regulator, to report water level and other data to the office, and to supervise the maintenance of the canal.[13] The zone-man who is engaged in the actual operation of water control, is also expected to keep in close contact with the peasants and to collect cropping data in the area concerned. However, the relationship between the zone-men and the villagers is not so well-established and the latter recognize them only as officials who administer the operation of canals and no more. In the areas where more efficient water control is achieved by the construction of lateral canals and ditch-and-dike networks, ditch riders or *nai truat na* are appointed in the smallest irrigation units to coordinate co-operative activities and transmit peasants' requests for irrigation to the zone-man.[14]

13) Since the canals are fully utilized in daily communication, maintenance of water traffic is one of the main duties of the zone-man.

14) Even though in the sufficiently improved areas, peasants' inadequate behaviour and lack of co-operation often cause damage to field ditches and lateral canals. Frutchey points out such maintenance problems in her survey of the Sam Chuk project area in Suphanburi province. In the area, some farmers allow buffaloes to walk and wallow in ditches while other farmers plant rice in them [Frutchey 1969: 103, 152].

But the area along the Khanom-čhin canal has not yet improved sufficiently to have a ditch rider which would be necessary in a sophisticated water control area. In the Tontan field the deep and prolonged inundation has still not been overcome despite the fact that inundation has been stabilized to some extent through the recent improvements. At any rate, the villagers appear to have neither satisfaction with the present water conditions nor any incentive to participate in the maintenance of water control. It may even be said that, at the moment, they are rather indifferent to the official management of water control.

The village does not contain a single peasant organization relating to the maintenance of canals and other water control facilities. Nor is there anyone who individually joins such organizations outside the village. Apart from the earlier example of small canal dredging during their pioneering days, co-operation in water control has been rare among the villagers. In the delta region, by contrast with the northern intermontane basins, an indigenous co-operative organization of water control has hardly been developed at all.[15] Nevertheless, since the late 1960s, the RID has been making efforts to establish and foster the Water Users' Association or *samakhom phu chai nam chonprathan* among the peasants involved in state irrigation projects throughout the country. It aims to achieve an appropriate water allocation in the users' plots through co-operative maintenance of facilities, and to encourage the most suitable cropping patterns to adapt to the improved water conditions [Metha 1978; Vanpen 1978: 11–15]. However, such attemps to create co-operative organization among the peasants have not been very successful in the deep inundation regions. For the moment, no Water Users' Association has been established in Amphoe Sena or Amphoe Phakhai [Ayutthaya 1970: 20].[16]

Thus the water control projects undertaken by the government have operated and are maintained almost without the peasants' involvement at least in the case of Ayutthaya village. At the present stage of the Čhao Čhet - Bang Yihon project which cannot bring about a satisfactory solution to the deep inundation problem, the villagers have little incentive to participate in water control. However, when as a result of improvements lateral canals are provided, the villagers will have no alternative but to organize co-operative activities. In a few plots immediately flanking the canal some villagers are able to cultivate the early season rice owing to the stabilized water level in the canal over the past few years. However, this is not a result of the improvement of the terminal

15) For a discussion of inadequate social practices and the indifference of peasant farmers towards maintenance of irrigation system in this delta, see [Small 1974: 691–694].

16) Referring to an example in Bang Pahan district, Ayutthaya province, Amyot indicates that the association does not play an important role at the level of individual farmers [Amyot 1976: 80–81].

network of water allocation. The villagers can only just get sufficient feeding water for transplanting from the Khanomčhin canal by using the motorized water wheel (*rahat*) or pump (*thǫ sup nam, thǫ phayanak*). Due to the lack of lateral canals and a terminal network of allocation, the expansion of early season cultivation has to be confined within very narrow limits.

Be that as it may, the environment of the delta seems so gigantic and uncontrollable to the peasants that effective water control is assumed to be unattainable. Any necessary large-scale improvements will not be undertaken unless the government launches, constructs and manages them. It can be considered that villagers in such environments tend to dissociate themselves from water control systems which require large-scale hydraulic engineering. On the other hand, they have made much endeavour to adapt to the uncontrollable environments with the aid of farming technology.

III Farming Technology in Ayutthaya Village

1. Land-use Pattern

The resources of Ayutthaya village have been almost completely devoted to the monoculture of non-glutinous rice, mainly to secure subsistence needs for home consumption, though some surplus has been sold on the market. In the Tontan field, under the deep inundation conditions, only rice can be successfully raised for consumption and as a commodity. The original vegetation of the Tontan field and the slightly elevated levee along the Khanomčhin canal has almost completely disappeared, as a result of the expansion of ricelands. On this large flat field only a few trunks of *sakae (Combretum)* and *makham* (Tamarind tree; *Tamarindus indica*) are left standing to give working farmers shelter from the intense sunshine. The soil of the field is dark heavy clay which is widely found in topographically low places throughout the Chao Phraya delta, and classified as Gray-black Soil in the Thai Soil Map. Like all clay soils formed under alternating seasons of saturation and intense drying, this soil is characterized by deep surface cracking [Pendleton 1962: 66]. During a considerable period of the year it is saturated with ground water, while its surface becomes solid with cracks after inundation and subsides in the dry season. The solid surface makes buffalo ploughing almost impossible unless the first rain provides adequate moisture. During the rainy season, however, it is said that inundated water from upstream deposits silt and clay, bring plant material and other nutrients in addition to inert leached material [Grist 1975: 30].[17]

With the homogeneous soil condition, the Tontan field exhibits a uniform surface which slopes very gently westward from the natural levee on which the

17) The inundation water which brings nutrients is locally called *nam daeng* (red-coloured water). According to the peasants' explanation the flow of *nam daeng* was reduced due to conservation of water in each water control project area after completion of the Chainat dam.

settlement is established towards the back swamp up to the Rang Khok. Under careful inspection, however, minute differences in relief can be observed throughout the field and even within a single plot.[18] The size of many plots cultivated using the broadcast-sowing method is quite large, varying in area from 5 to 20 rai (0.8–3.2 ha), and their ground level is often uneven. Therefore in the same plot at the beginning of the rainy season, some portions contain stagnant water, while others are dry. Subsequently, of course, the whole area is submerged with rising inundation. Each plot is surrounded and sometimes subdivided by low and coarse dikes less than 25 cm high, which are not designed to conserve water, but instead merely demarcate the boundaries of ownership. The only exception is a small area of transplanting plots along the Khanomčhin canal, which have been evenly levelled and equipped with high dikes for intensive transplanting cultivation. By contrast with villages in the intermontane basins, and despite continuous cultivation for decades, the peasant farmers of the village seem to have been unable to improve the physical conditions of the land.

Under such land conditions together with annual inundation, the land assets of villagers have been traditionally concentrated on the monoculture of non-glutinous rice. There has been little possibility of developing cultivation of crops other than main season rice, lasting around 9 months from May to January. Contrasting with intermontane basins where the main season rice is primarily regarded as a subsistence crop, the peasant farmers of the village usually sell a fair amount of their harvest, though they basically retain enough rice for the subsistence requirements of the household. Under the strong penetration of money economy, for most peasant farmers any surplus rice must be sold to purchase other commodities for consumption. Furthermore, there are even some well-to-do households which sell the whole of their rice output and purchase milled rice in the market for daily consumption. In the virtual absence of cash crops suitable for the land and hydrographical conditions, the land-use pattern is strongly inclined to the monoculture of main season rice.

In 1974–75, the total area cultivated by the 48 households of the village amounted to 1,233 rai. Some 44 households, operating 1,223 rai, were surveyed in relation to land-use and other farming details as shown in Table 1. Among these 44, the average cultivated area per household amounted to 27.80 rai, varying between 8 and 60 rai. There is a strong preference for main season cropping on all available areas, in which more than 90 per cent was planted with broadcast-sowing rice and the rest with transplanting rice. With only one exception, all farming households covered by the survey adopted broadcast-sowing cultivation with dry-sowing and/or wet-

18) Transplanted plots must be level in order to conserve flood water.

Table 1 Land-use Pattern in Ayutthaya Village (1974—5)

Cropping pattern	Period of cultivation	Number of households	Area planted rai (%)	Area harvested rai	Area harvested % of area planted
I. Main season cropping					
Broadcast-sown rice					
samruai (dryland sowing)	May-Jan.	43	1,045.75 (85.5)	1,018.75	97.4
phǫloei (wetland sowing)	May-Jan.	9	60.00 (4.9)	60.00	100.0
Transplanted rice					
(Early season cultivation)	Mar.-Sept.	14	117.25 (9.6)	117.25	100.0
Total		66	1,223.00 (100.0)	1,196.00	
II. Off-season cropping					
Transplanted rice					
(Off-season cultivation)	Feb.-Jul.	1	8.00 (0.7)	8.00	100.0
Green gram	Apr.-Jul.	9	38.75 (3.2)	17.50	45.2
Total		10	46.75 (3.9)	25.50	

sowing methods. Transplanting cultivation was additionally practised by only 14 households. The newly introduced transplanting cultivation which occupies a relatively small portion of the operated area in each household is oriented more towards the market than is the case with traditional broadcast-sowing cultivation.

Despite the recent improvement of water control, crop failures mainly caused by drought and flood have occurred, especially in the fields which are broadcast-sown. In 1974, shortage of rainfall meant that around 2.5 per cent of main season rice was damaged by drought after sowing in the broadcast-sown fields. Depending almost entirely on rainfall, without any supply water from the canal, the broadcast-sown fields are constantly vulnerable to water shortage, especially during the early stages of cultivation. Crop failure caused by excessive inundation at the ripening or young plant stages is relatively rare in the Tontan field. According to the statistics of annual rice cropping compiled at the Sena District Office, broadcast-sown rice has been damaged almost every three years, though loss by damage of this kind throughout the district has not exceeded three per cent of the total planted areas.[19] It would seem that in recent years crop failure on this scale has not seriously threaten the peasants' subsistence.

On the other hand, double cropping completely orientated towards the market covered rather less than four per cent of the total operated area. In 1974—5, as far as rice cultivation was concerned, only one household could achieve double

19) Crop failure is surveyed annually in the rice production reports (*baep khao 1*, *baep khao 2*, *baep khao 3*) prepared by each village (*mu ban*) and *tambon*.

cropping after the main season cultivation. The inundation pattern is such that main season cultivation is lengthy in duration, lasting as a rule from May to January. Because of this long duration, and the subsequent shortage of water in the dry season, there has been little opportunity for double cropping. During the past few years some households have tried to grow green gram (*thua khiao*) on small portions of land near the settlement after the broadcasting fields have been harvested. However, owing to soil conditions and the uncertainty of rainfall in the growing season the expected yields have not been obtained. Thus the possibility of further development of cash crops in the period after harvesting the main season rice is practically precluded by the physical conditions. Apart from the double cropping of rice, cultivation of vegetables and fruit trees for home consumption is also limited. Attempts have been made to plant vegetables in scanty kitchen gardens, but owing to deep inundation, yields have been low, except for some aquatic plants such as *phak bung (Ipomoea)*. Although villagers fish and harvest some vegetables from the canal banks and fields, the quantity of food so obtained is small, and most villagers have to purchase various kinds of garden produce and animal foods in the market.[20] Moreover, a number of landless rural labourers, amounting to 21 households or 31 per cent of the 67 farming households, have to purchase rice for their daily consumption.

The Agricultural cycle of the village relevant to land-use and inundation pattern is shown in Figure 7. The main season cultivation of the village traditionally begins with the arrival of the first rainfall in May soon after the *wan songkran* or the traditional New Year's Day, and lasts until January or at the latest mid-February when the harvests are ready for sale or storing in the granary. The traditional broadcast-sowing cultivation uses the indigenous late varieties with a long maturation period of 180–250 days, which corresponds almost perfectly with the inundation pattern. Growing in accordance with the rising inundation level from mid-July, they normally survive at the highest water level in November and can be harvested between December and January. The drainage of flood water is accelerated by opening the sluice at the regulator on the 10th December in order to facilitate the harvesting tasks. Although broadcast-sowing cultivation has to depend on uncertain weather at its

20) Poultry and hog raising are also practised but on a very small scale. Apart from rice as the essential source of calories and protein, fresh water fish represents a major contribution to Ayutthaya's diet. Every villager attempts to fish throughout year, but purchases a small amount of fresh, dried and fermented fish during the busy work season and the latter part of the dry season. Some important fermented fish foods are still made at home on a self-sufficient basis; *kapi* (shrimp paste) is made by 35, *pla ra* (fermented fish) by 28, *nam pla* (fish sauce) by 26 households in the 67 farming households. Ayutthaya's diet pattern is not so different from that of Bang Chan in the 1950s [Hauck *et al.* 1958: 17–19; Sharp *et al.* 1953: 185–201, 263–274; Kamol 1955: 22–23, 53–55].

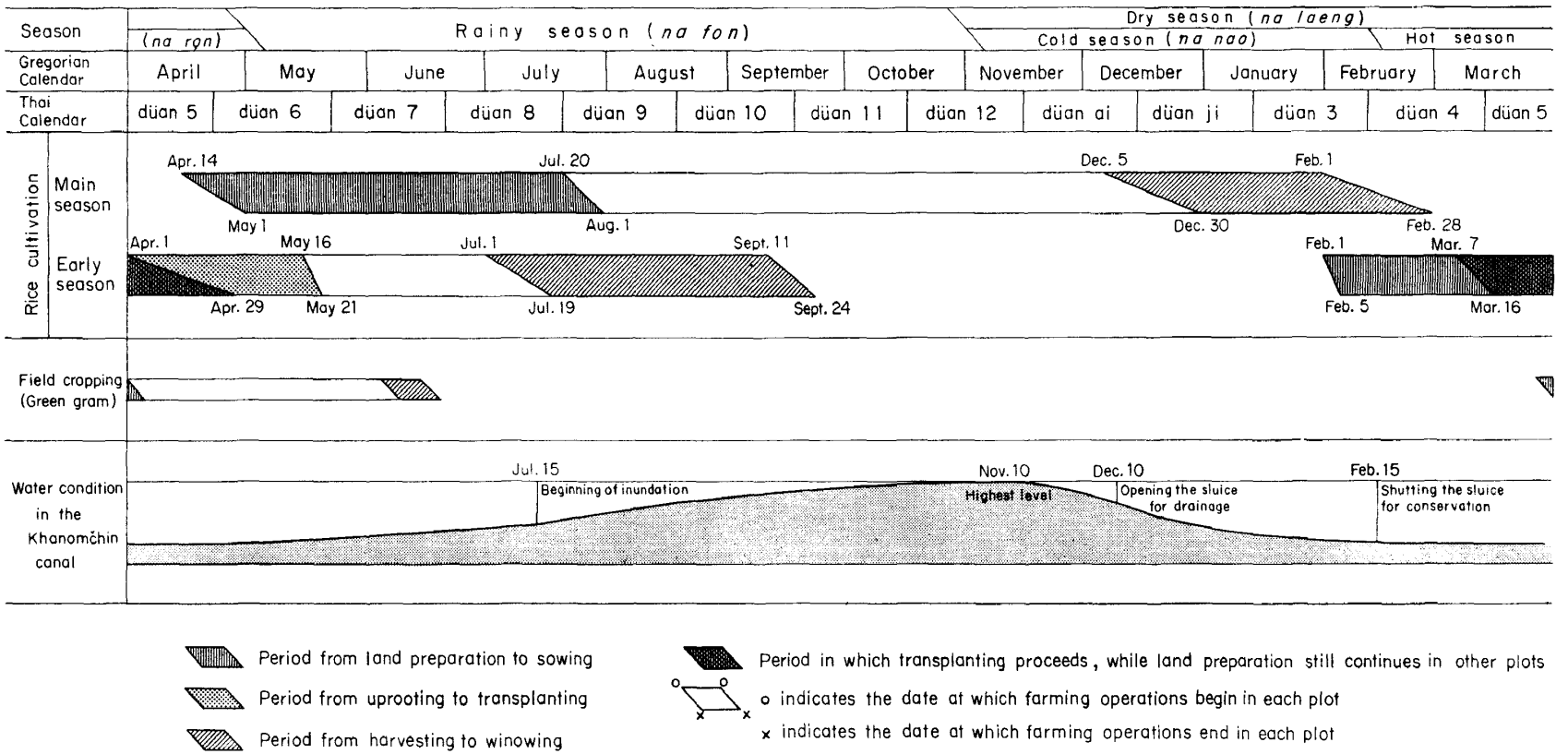


Fig. 7 The Cropping Calendar in Ayutthaya Village

beginning, it is rationally adapted to the existing physical conditions as a whole.

On the other hand, the transplanting cultivation of main season rice has been practised since 1970 when water control was improved. This newly adopted cropping was made possible through introduction of the improved non-photosensitive varieties which were primarily developed as high-yielding varieties with high fertilizer response for double cropping in the dry season.[21] Having non-photoperiod sensitivity and a short maturation period they allow the peasant farmers to commence cultivation from the latter half of the dry season and to harvest before the high inundation comes. Thus the new varieties are accepted not for double cropping after the traditional main season cultivation, but for the early season cropping outside the period of the deep inundation. Because the water level rises after harvesting, subsequent sowing of broadcast rice is practically impossible. The early season cropping with transplanting method commencing in February and March inevitably results in the demand for adequate irrigation for the nursery and the transplanted field. Owing to deficiency of water supply in this season together with the lack of appropriate arrangements for a water allocation network, this kind of cultivation can be only practised in limited plots to which the operators are able to lift water directly from the Khanomčhin canal. Thus the accessibility of plots to the canal is the decisive condition for transplanting cultivation. The operators of the plots have to lift water into the fields by employing the *rahat* with a desel motor or power pump installed on the bank of the canal. In addition to irrigation, the application of industrial inputs such as fertilizer and herbicides, and sometimes pesticides, is also essential in the transplanted fields.

In the cultivation of broadcast-sown rice, little attempt is made to look after the plants before harvesting, apart from some weeding. In the transplanted fields, by contrast, a high input of labour is an essential requirement at every stage of the cycle of cultivation. Because of heavy expenditure on producing costs, and because of the high labour input, the harvest from the transplanted fields is assigned entirely to the market, subsistence rice being obtained from broadcast-sown fields. The peasant farmers of the village cultivate some transplanted rice on the basis of water obtained by power devices. But without the security of enough yields in the broadcast-sown fields from which they obtain their subsistence rice, they are reluctant to alter their traditional cropping pattern.

21) According to Fukui's survey in 1972, the new varieties were being adopted not because of their high-yield potentials, but for their short-period, non-photoperiod-sensitive character [Fukui 1978: 259–262]. In Don Chedi, Suphanburi province, one of the first areas in which those varieties were introduced, farmers engaged in rainfed cultivation did not view the modern varieties as higher yielding than the traditional varieties in 1972 [Jerachone *et al.* 1975: 249–251].

Thus, although farmers have traditionally assigned some of their harvests to the market, it can be said that the land-use pattern of the village need to ensure an adequate output of subsistence rice in the broadcast-sown fields.

2. Broadcast-sowing Cultivation in the Main Season

The long-established traditional method of cultivation is simple and primitive and needs no sophisticated equipment. Nevertheless, it is highly efficient and rationally adapted to the existing physical environment. Broadcasting cultivation is characterised by the extensive cultivation of native late varieties, including the so-called 'floating rice', under prolonged deep inundation. Since it has been traditionally practised for many centuries, broadcast-sowing culture displays a rich and varied terminology. According to the traditional classification of riceland in central Thailand, there are two major categories: *na suan*, or literally garden rice field, and *na müang*, or local rice field. These terms sometimes indicate the rice produced in those ricelands respectively.[22] The *na suan* field was normally cultivated by transplanting method under the favourable water conditions, and the *na suan* rice was believed to be of better quality and especially suitable for export [Suvaphan 1927: 2–3]. The *na müang* field was cultivated exclusively by the broadcast-sowing method in low-lying areas subject to prolonged deep flooding. Having a shorter grain and being inferior in quality, *na müang* rice is likely to have been assigned to domestic consumption, though a great many people actually prefer it to *na suan* rice [Suvaphan 1927: 6]. This classification of riceland and its paddy, however, has recently fallen into disuse. The old terminology has been commonly replaced by more appropriate terms: *na dam* or transplanting field and *na wan* or broadcast-sown field, both of which are directly suggestive of the respective farming methods. The villagers also often speak of *na fang loi* in favourable terms to indicate their broadcast-sown fields, as distinguished from *na dam* practised in the small portion along the Khanomčhin canal. The *na fang lǫi* which may literally means the field of 'floating rice', originally derived from the legal term of riceland taxation in the pre-modern period. As many historical materials suggest, *na fang lǫi* was newly exploited riceland on which the riceland tax (*kha na*) was levied only when the area was cultivated during the year, while *na khu kho*, the first grade riceland under continuous cultivation was subject to payment for the entire

22) *Na müang* is also called *na thung*. Some western sources refer to this classification [Child 1892: 145–146; Graham 1924: Vol. 2, pp. 8–9]. For the traditional classification of riceland and farming technology, the following works are essential [Phichitprichakǫn 1921: 1–22; Suvaphan 1927; Wongsanupraphat 1941: 285–315; Anuman 1965: 129–194]. M.R.W. Suvaphan's brief but informative work was originally published in English, while Anuman's ethnographical study, first published in 1948 was translated into English by William J. Gedney in 1961 [Anuman 1961: 3–59].

area whether it was operated or not.[23] This pre-modern classification is rarely used in application to the present rice-land. Only the word *na fang lǫi* is still alive to imply the traditional broadcast-sown fields of the village, though it has no longer legal implications, but just means *na wan* as distinguished from *na dam*.

In the village context three terms: *na müang*, *na fang lǫi* and *na wan* can be thus recognized as signifying broadcast-sown fields among peasant farmers, though the use of *na müang* is currently disappearing.[24] Despite the fact that these terms imply different ways in which the broadcast-sown fields differ from the transplanted fields, at present they uniformly indicate the broadcast-sown field itself, in which the traditional technology has survived under the almost immutable conditions of the delta. Broadcast-sowing cultivation does not only indicate here a direct sowing method without transplanting of seedlings, but a consistent system of farming technology in which the techniques operated in various stages of cultivation are closely related to each other. It is a series of continuous operations from selection of varieties up to the final stage of production, which has been indigenously developed under conditions of deep inundation. Therefore, its farming technology should be described according to each step of farming operations.

Varieties All varieties raised in the broadcast-sown fields are without exception indigenous photosensitive varieties. As widely seen throughout Thailand, peasant farmers customarily classify them into three categories: *khao phan nak* (late variety), *khao phan klang* (medium-term variety) and *khao phan bao* (early variety) according to maturation period. This classification, though being a local one, seems to be effective in indicating the water conditions in the fields on which suitable varieties may be sown. The late varieties are normally selected for the plots with the deepest inundation water, while the medium-term and the early varieties, though selected to a small degree, may be grown in some slightly elevated fields where the water level is not so deep. Nine broadcast-sowing varieties sown in the village during 1974–75 cropping season are

23) Until the mid-nineteenth century, the *na khu kho* with high and constant yield had only spread to the Old Delta of the upper reaches of the Chao Phraya including Ayutthaya, Angthǫng, Lopburi, and Suphanburi which were under the relatively effective control of the central government. While the *na fang lǫi*, which relied mainly on rainfall and inundation, seems to have been distributed in the newly reclaimed areas all over the delta. The legal application of this classification had been maintained up to the beginning of this century. See the decrees promulgated in 1864 and 1905 [Phrachǫmklao 1968: 162–168; Sathian 1951: 163–167]. Robert Lingat's comprehensive work and Prince Damrong's comment are also useful [Lingat 1940: 32–33; Damrong 1923: 1–7].

24) Another term frequently used is *na pi* or main season rice field in opposition to *na prang* which currently means off-season rice field in general. The *na prang*, however, seems originally to have indicated the traditional early season cultivation. Graham suggests that such a traditional off-season cultivation, though called *khao na trang*, practised at the beginning of this century [Graham 1924: Vol. 2, p. 9].

Table 2 Rice Varieties in Ayutthaya Village (1974—5)

Traditional classification			Name of variety	Harvesting date*	Approximate maturation period
khao fang lǫi khao na müang	*khao khün nam* (floating rice)	Late variety	*khao pin kaeo*	Jan. 25—Feb. 5	230—250
			khao phuang nak	Jan. 5—Jan. 20	210—230
			khao sam luang	Jan. 1—Jan. 15	210—220
		Medium-term variety	*khao phuang klang*	Dec. 20—Dec. 31	190—200
	khao mai khün nam *khao kiao kan nam* (non-floating rice)	Early variety	*khao phuang bao*	Dec. 10—Dec. 25	170—180
			khao kami	Dec. 10—Dec. 20	170—180
			khao khao ta haeng	Dec. 10—Dec. 20	170—180
			khao hǫ met lek	Dec. 10—Dec. 20	170—180
			khao luang čhaek	Dec. 10—Dec. 20	170—180
Improved variety			RDI (*kǫ khǫ nüng*)	Jul. 1—Sept. 11	120
			C4-63 (*si si*)	Aug. 10—Sept. 5	120

* According to the harvesting of the 1974—5 cropping season

shown in Table 2 with their harvesting date and approximate maturation period. The three late varieties with maturation period of between 210 and 250 days are predominantly adopted in most of the plots in the Tontan field. The cultivation of the medium-term and early varieties which take between 170 and 200 days to reach maturity, tends to be confined to a few plots. However, those maturation periods are not precisely fixed and only indicate roughly the duration of growth. Every villager must always be aware of the approximate harvesting period of each variety, and the important point about this classification is that it is based on a fixed date of ripening. Regardless of a considerably wide range of sowing period owing to the uncertainty surrounding the onset of the monsoon rainfall, the date of harvest of these varieties can be forecasted accurately [Grist 1975: 83–84].

Thus the peasant classification of varieties fully reflects the ripening period; the late variety harvesting between January 1 and February 5, the medium-term variety between December 20 and 31, and the early variety between December 10 and 31. The range of harvesting period of each variety must chiefly depend on socio-economic conditions such as the feasibility of mobilising a labour force during the period. Nevertheless, it can be considered that the harvesting period is strongly associated with the conditions of inundation. Most late and medium-term varieties ripen when the flood water is subsiding, and can be harvested from late December onward after the water has almost drained. On the other hand, the peasant farmers must harvest the early varieties before the flood water is completely drained, though they are planted in rather elevated areas.

With respect to characteristics of the growth habit of varieties, the peasant farmers usually further classify them into

two groups: floating rice (*khao khün nam*) and non-floating rice (*khao mai khün nam*).[25] Three late varieties and one medium-term variety are here identified as *khao khün nam*, while other early varieties are *khao mai khün nam*. As referred to in much of the agronomical literature, 'floating rice' grows, at the internodes of the plant, to keep pace with the rising inundation, and its stem may attain a length of up to five or six meters in order to keep the tip of the plant above water [Ramiah and Ramaswamy 1941: 1–8; Grist 1975: 80, 110, 140–141]. Growing in a rather zigzag fashion under the water and with its tip and some leaves crawling on the surface, the striking habit of *khao khün nam* is often expressed as *fang lǫi* or floating stalk. The growth rate of internodes attains about 5 cm, and sometimes 10 cm per day is recorded [van der Heide 1903: 47; Grist 1975: 141; Kaida 1978: 241]. According to the peasant farmers' observation of the plant, *khao khün nam* must have at least four leaves including the uppermost leaf, or *bai tat hang plathu* (leaf of halved *thu* fish tail) which always remains above the rising level of the flood water.[26] On the other hand, *khao mai khün nam* cannot survive, for its panicle is submerged in extremely deep areas. These non-floating varieties are also called *khao kiao kan nam,* or rice harvesting in the water, because they must be harvested in the still inundated fields, even using boats, before flooding subsides. At any rate, the late and medium-term varieties with the characteristics of 'floating rice' are predominantly selected in most of plots throughout the Tontan field.

Two Types of Land Preparation and Sowing In Ayutthaya village, the broadcast-sowing method can be placed in two categories according to land preparation and sowing which are closely related to the water condition in the plots during the beginning of the rainy season. In dried field plots, the dry sowing method (*samruai*) is employed while in puddled field plots where water is able to come in, the wet sowing method (*phǫloei*) is seen.[27] The *samruai* method is usually practised by sowing the ungerminated seed in the plots where soil is adequately moisturized during preliminary ploughing and sowing. The area adopting this method is quite large, amounting to 85 per cent of the total cultivated area (Table 1). Although the *phǫloei* fields

25) *khao lǫi, khao fang lǫi,* and *khao khün nam* all mean, in a vague sense, 'floating rice' grown in extremely deep flooding areas [Wongsanupraphat 1941: 295]. However, the former two may include varieties without a floating habit, according to the region.

26) The panicle emerges from the sheath of *bai tat hang plathu,* which is commonly called 'flag leaf' [Grist 1975: 70; Matsuo 1961: 149]. According to Anuman the rice in panicle formation is thus called *khao klat hang plathu* (rice plant with *thu* fish tail) in Ayutthaya province [Anuman 1965: 154].

27) Both broadcast-sowing methods are widely practised in deltaic environments of Southeast Asian countries [Grist 1975: 141–143]. Like the wet sowing method, locally called *nam tom* in Singburi province, these methods are called by differing names according to the region [Tanabe 1978: 6]. Wongsanupraphat gives a detailed description of these two methods as practised during the fifth reign (1868–1910A.D.) [Wongsanupraphat 1941: 294–301].

are that for broadcast-sown, their appearance resembles paddy fields cultivated by the transplanting method. This is because the germinated seeds are sown in puddled plots resembling the nursery bed of the transplanting method. In many cases, because *phǫloei* plots are in low-lying swampy land, the plots are in a flooded condition during land preparation in April and May. The plots in which the *phǫloei* method is employed occupy only five per cent of the total area. Figure 8 is a cross-section from the Khanomčhin canal to the Rang Khok, showing the relationship between the distribution of the two types of cultivation and the local relief. From a portion of elevated levee along the canal, the terrain gradually slopes downwards towards the Rang Khok with some depressed pockets. Apart from the transplanting fields stretching no more than 200 m far from the bank, the *samruai* field is predominant throughout the entire area. Without exception, however, the *phǫloei* fields lie scattered in depressions where the level of ground water is relatively high and where puddles can be seen in the early and late rainy season. In many cases, a kind of reed, *kok samriam (Cyperus digitatus)* grows in such depressions.[28] Depressions provide good bathing places for buffaloes during the period of water shortage, and during the period of flooding in the rainy season, function as drainage channels.[29] The depth of water in November is around 100 cm on the *samruai* fields, while it attains 150 cm in some depressions of the *phǫloei* field.

For the *samruai* method the first rains are awaited, and ploughing is traditionally done by water buffaloes. Buffaloes have provided the motive power for a long period, but since the late 1960s farm machines have increasingly been in use while ploughing with buffaloes is now disappearing. As shown in Table 3, though power devices such as tractor and power tiller are widely used in land preparation, buffalo ploughing was practised by a considerable number of households in 1974–75 cropping season. In buffalo ploughing of the *samruai* field the traditional task of land preparation is divided into three parts: the rough-ploughing (*thai da*), cross-ploughing (*thai prae*) before sowing, and the cover-ploughing (*thai klop*) to cover the sown seeds with soil [Anuman 1965: 143–150]. The rough-ploughing is done so as to throw up the soil in ridges, and weeds which are turned

28) According to the peasant's classification two typical kinds of reed seem to be simple indicators of water condition; *kok samriam* or *kok rangka,* a perennial weed can be seen only in the depressions where the level of ground water is high throughout year, while *kok hua daeng* or *kok klom* (*Cyperus tegetiformis*), an annual weed may emerge anywhere simultaneously with the growing of rice.

29) Some natural drainage channels called *lamrang satharana* (public water course) are currently preserved as the property of the state. In former times these channels would often function as buffer boundaries between villages. The Rang Khok is such a channel and its depressions containing stagnant water even in the dry season are made use for buffalo bathing, and are called *aeng khwai* or buffalo puddles.

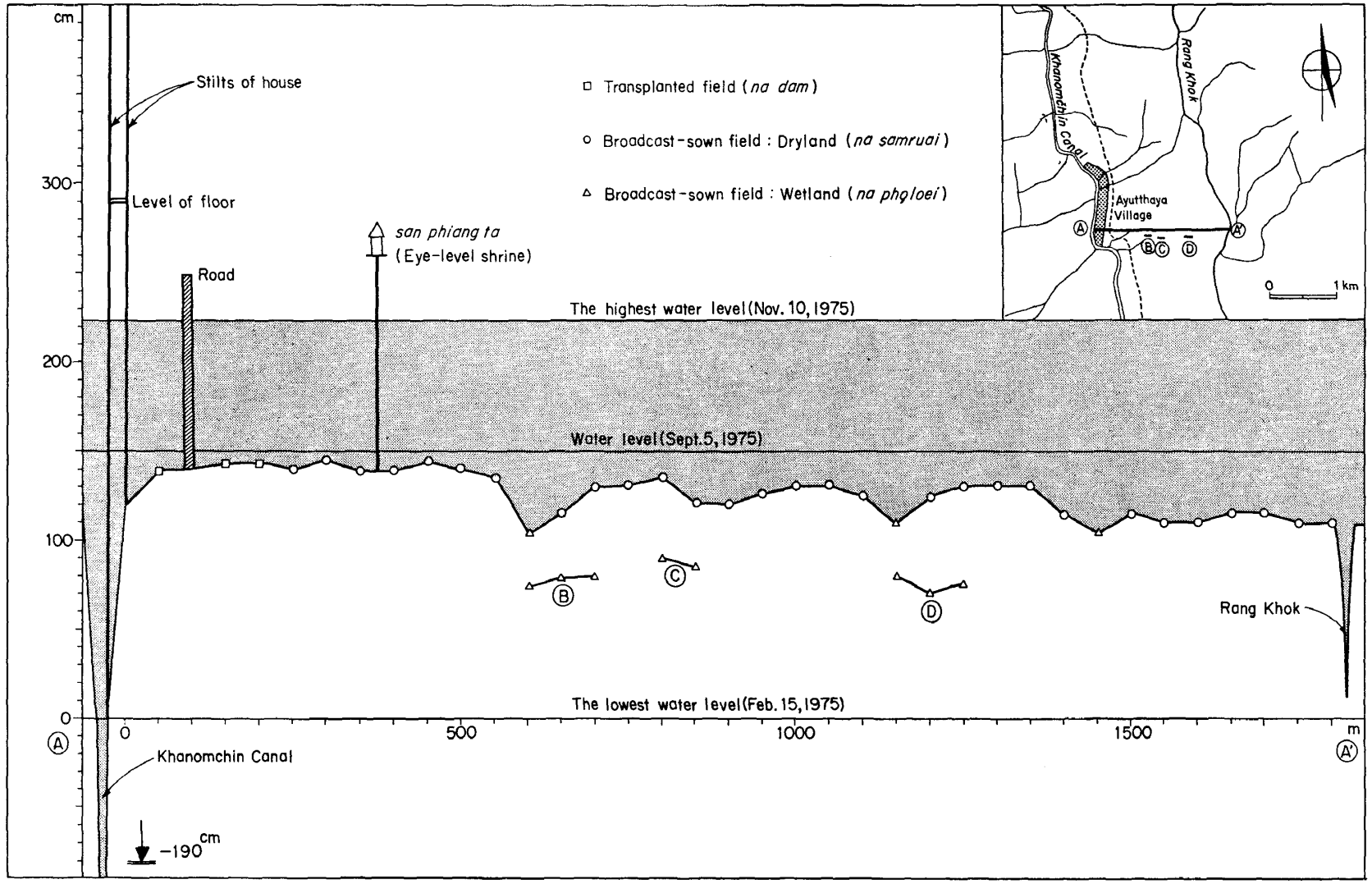


Fig. 8 Local Relief and Type of Cultivation in the Tontan Field

Table 3 Methods of Land Preparation in Ayutthaya Village (1974—5)

Type of cultivation		Rough-ploughing Cross-ploughing	Cover-ploughing	Harrowing Levelling	Number of households
Broadcast-sowing method	*samruai* (Dryland Sowing)	Buffalo	Buffalo		13
		Tractor	Buffalo		13
		Tractor	Power tiller		1
		Power tiller	Buffalo		2
		Power tiller	Power tiller		14
	phǫloei (Wetland sowing)	Buffalo		Buffalo	4
		Power tiller		Power tiller	5
Transplanting method		Buffalo		Buffalo	5
		Power tiller		Buffalo	2
		Power tiller		Power tiller	8
Total					67

over are allowed to rot and fertilize the soil. After rough-ploughing the plots are left alone for many days, and are then cross-ploughed in order to turn the ridges over again. The main purpose of both ploughings is to simultaneously weed and loosen up the soil. The moisturized plots are normally ploughed to an average depth of 4 *niu* (10 cm). A peasant farmer drives a buffalo round to the left and can plough approximately one rai per day.[30]

While the cross-ploughing is proceeding, a peasant farmer has to be ready for sowing. Although when seeds are sown, the surface of the soil may be moisturized to some extent, puddling is not suitable for the *samruai* sowing. Ungerminated seeds kept since the previous harvest are put in a woven bamboo basket (*krabung*), which is hung from the farmer's waist by strings. A peasant farmer walking forward throws up a handful of seed in the air. The average rate of seeding is two *thang* (40 *l*) or about 20 kg per rai; it is twice of the transplanting method and equivalent to 125 kg/ha.[31] Immediately after sowing or at least within a few days, cover-ploughing is performed to turn the seeds under. Some peasant farmers harrow the sown plots in substitution for cover-ploughing.

In addition to the traditional buffalo ploughing, tractors and power tillers are now widely used, especially in rough-ploughing and cross-ploughing. However, cover-ploughing after sowing is usually done by buffalo or power tiller, even though a tractor may have been used previously in preparing the land for sowing in the same plots. A tractor would be too heavy to do such a delicate task after sowing. As none of the vil-

30) Harrowing or *khrat* which is commonly observed in this delta, is seldom practised in the *samruai* fields of the village [Anuman 1965: 151; Kamol 1955: 99].

31) For the rate of seeding in dryland sowing, 85 kg/ha in Bangladesh and 112 kg/ha in central India are reported [Grist 1975: 141–142].

lagers owns a tractor, mechanized ploughing is done by a tractor hired from adjacent villages in Amphoe Sena and even from remote areas such as Amphoe Bang Pain to the Southeast. In terms of wages, ploughing by a hired tractor cost 30–35 baht per rai in 1975. In addition to large tractors smaller power tillers are coming into wide use, and are owned by several households. These power tillers are in general popularly called *khwai lek* (iron water buffalo), and are divided into two types: *rot thai mü*, or two-wheeled tiller pushed by hand and the medium-size four wheeled tiller called *rot thai nang khap*. Large tractors are employed only when extensive areas of *samruai* field have to be prepared before sowing. The smaller devices, by contrast, can be utilized at every stage of land preparation and even in the puddled plots of *phǫloei* broadcast-sowing method and transplanting method. At any rate, as far as farming techniques are concerned, the use of machinery in land preparation of *samruai* fields greatly helps to shorten the period of ploughing; a tractor can cultivate a one rai field in half an hour, while buffalo ploughing takes a whole day or approximately six hours working for the same area.[32] Moreover, tractor and tiller ploughing enable the peasant farmers to begin cultivation earlier than the traditional buffalo ploughing. Farmers relying on buffalo must wait for the first monsoon rainfall to soften the solid surface of the clay soil, and so make ploughing possible. Power devices, however, need not depend on unreliable rainfall, and can be used to start land preparation at any time [Amyot 1976: 117].

The land preparation of *phǫloei* wet sowing field start with ploughing in the puddled soil. In this method, because of flooding at the beginning of the rainy season, large tractors cannot be used, and buffaloes or power tillers are used instead. From plloughing through harrowing into levelling, the land preparation of the *phǫloei* method is the same as that for transplanting method. The ploughing is done several times in the plots on which the water depth is kept approximately 3–4 *niu* (7.5–10 cm).[33] This is followed by harrowing twice or three times in order to remove weeds and break down lumps of clay, so as to obtain a fine mud three or four days before sowing. On the day of sowing, after water is drained off by scooping baskets (*chong long*) or power pumps, the plots are harrowed until level. After this, the surface is finally smoothed with a log of 1.5–2.0 m long and some small ditches are made in order to facilitate drainage. Three days before sowing, seeds are soaked overnight in water contained within an earthen jar (*ong*) and are then transferred to a woven bamboo basket (*krabung*) or roud bamboo crate (*kheng*) covered with straw, and kept in a cool

32) In Bang Chan a power tiller could plough 5 to 10 rai per day [Hanks 1972: 126].

33) Since the deeper water restrains weeds from growing, cross-ploughing is often omitted in plots with water of more than 5 *niu* (12.5 cm) deep.

place for two days. After being sprinkled with water twice a day, the seeds sprout with a primary root of about one centimetre and are then ready for broadcast-sowing. The germinated seeds carried in a *krabung* are sown on the prepared fine mud with the sower moving carefully backwards. The average rate of seeding is two *thang*, the same rate as under the *samruai* method.[34] As in the case of the nursery bed, the water level in the *phǫloei* fields must be carefully controlled. In particular, for about ten days immediately after sowing, the water should be kept off the *phǫloei* fields. When the water level rises because of rain, the farmers must hasten to drain out the water. After the plants take root, their survival in flood water is assured. Thus land preparation of the *phǫloei* method is quite similar to that of transplanting the nursery bed. With respect to water control the *phǫloei* fields may be well regulated with relatively high dikes. Continuous efforts are made to ensure drainage for a certain period after sowing. Subsequently, however, the plots are left alone to be exposed to the encroaching inundation from August onward.

The *samruai* and *phǫloei* are the typical broadcast-sowing methods in Ayutthaya village. But there can be seen, though within a very limited area, another method called *piakniao* which is a hybrid of the two.[35] In a large plot where there are high and dry portions existing together with a swampy portion, ploughing and harrowing but not water controls are possible. So after rough-ploughing and cross-ploughing are done as in the case with the *samruai* method, ungerminated seeds being sown and carefully covered under the soil by harrowing. The *piakniao* method is not necessarily applied to fixed plots in every year, because the condition of puddled areas changes from year to year, due to unstable precipitation at the beginning of the rainy season.

After-cultivation After sowing, though the water may be regulated in the *phǫloei* plots for several days, the typical broadcast-sown field is left basically as it is apart from some weeding. During the ploughing and harrowing, some weeds are turned over and left to rot, while others are removed manually. After sowing, certain kinds of shrub emerge to accompany the growing rice, i.e. *seng* (genus *Corchorus*), *sano (Sesbania)*, *phak bung (Ipomoea)*, *kok hua daeng (Cyperus tegetiformis)* and *kok samriam (Cyperus digitatus)*.[36] Removal of those weeds and grasses is carried out a few weeks after sowing when the plants have rooted strongly. Peasant farmers pull out and

34) In other countries the rate of seeding in wetland sowing is normally higher than in dryland sowing; 112 kg/ha in Bangladesh and 150 kg/ha in the Philippines are reported [Grist 1975: 141–143].

35) For the *piakniao* method practised in Singburi province, see [Tanabe 1979: 6]. Apart from these methods, Wongsanupraphat refers to a peculiar method of broadcast-sowing called *na nam sai*, in which germinated seeds are sown in the extremely deep flooded plots [Wongsanupraphat 1941: 299–300].

36) Although weeding of *phak bung* is difficult, it is perhaps one of the most popular vegetables for Ayutthaya's diet [Grist 1975: 280].

remove them, and at the same time make careful observation of the young rice plants. If they discover sparsely growing and thinly planted portions of the plot, they transplant young plants from densely growing areas.[37] Although hand weeding is still practised from a few weeks after sowing up to mid-August, herbicides introduced about 1970, are now widely applied in both broadcast-sowing and transplanting fields. In 1975, herbicides were used by 36 households or 82 per cent of the 44 operating households of the village. Peasant farmers can purchase herbicides from the Ban Phaen Agricultural Co-operative (*sahakǫn kankaset ban phaen*) or from grocers at Ban Phaen, and can easily apply them to the fields with a sprayer. Application of herbicides is normally made immediately after the young plants take root in July, and seems to lighten the task of hand-weeding to a certain degree. In addition to herbicides, pesticides have recently come into common use in the broadcast-sowing fields. Especially popular are pesticides to control land crabs (*pu na*) which inflict serious damage on young plants [Grist 1975: 335–336].[38] Although farmers cultivating transplanting fields are familiar with the application of fertilizers, the use of fertilizer has not been observed in either *samruai* or *phǫloei* broadcast-sowing fields. As widely seen in the Chao Phraya delta, application of fertilizers is in fact impossible in broadcast-sowing fields subject to deep flooding. The recent widespread use of industrial outputs such as herbicides and pesticides very probably began in 1970 or 1971, together with the introduction of improved plant varieties for early season cultivation. Aside from those tasks mentioned above, no after-cultivation can be done until harvesting time when the flood water subsides in early December.

Harvesting By harvesting time, in December, January and early February, most of the rice stalks exhibit lodging [Grist 1975: 160]. In the 1974–75 cropping season, harvesting continued from 5 December up to early February. Although the sluice at the mouth of the Khanomčhin canal is usually opened to facilitate drainage of the Tontan field, water still remains in many plots until the end of December. Thus, some early varieties of non-floating rice, or so-called *khao kiao kan nam*, which ripen in December must be harvested in the water, using boats for hauling harvested stalks. This is subsequently followed by harvesting of medium-term and late varieties of floating rice or *khao khün nam* in the almost dry fields. The stalks are cut off at an extremely high point about one *sǫk* (50 cm) from the ear in a scooping motion with a deep curved sickle

37) In Bang Chan's transplanted field, such proper replacement of young seedlings are is practised [Kamol 1955: 102].

38) Rats (*nu na*) are another terrible pest prevailing in the Tontan field. The damage caused by rats has been increasing in recent years, though some are caught for food. See Amyot's survey in other parts of Ayutthaya province [Amyot 1976: 123].

39) The deep curved sickle used in the delta is quite different from the Lannathai sickle found in the northern intermontane basins [Watabe 1964: 37; Tanabe 1976: 722–723].

peculiar to the delta area.[39] It is said that such short stalks can easily be carried on a pole (*khan lao*). In floating varieties with a strongly pronounced shattering habit, even a light touch with the ground will cause the grains to fall. As far as the harvesting technique is concerned, there is no basic difference between the *samruai* and *phǫloei* methods.

In the course of broadcast-sowing cultivation, the peak labour requirement is in harvesting, which has to be done rapidly within a limited period. This is in contrast to the transplanting method, where there is another labour peak at transplanting time. In order to meet the intensive labour demand in the harvesting of a relatively large area, many households must depend on labour exchange or *ao raeng*, and on hired labour, to supplement the domestic labour supply. Although the traditional reciprocal labour exchange was widely practised in the past, it seems to have almost disappeared, and at a rather earlier period than elsewhere in the delta, having been mostly replaced by hired labour in the late 1950s.[40] In the village, harvesting by hired labour from outside has also been popular for many decades. Until the late 1960s, most hired labourers were peasants from the North East region or *khon isan* who moved in successive waves to obtain temporary harvesting employment in the villages of the delta region. After the late 1960s, hired labourers from some provinces of the central region replaced labourers from elsewhere, some of them arriving even in the mid-1960s.[41] Hired labourers of this kind work at harvesting the Tontan field, after they have finished harvesting in their own villages, and stay at a temporary field hat (*kratǫp*). Harvesting work is done not by time work based on a daily wage payment but by piece-work for the area to be harvested, the rate being normally contracted with the head of the hired labourers. In 1975, the rate of wage varied from 15 to 20 baht per *ngan* (0.25 rai), or equivalent to 60 and 80 baht per rai respectively, and skilled peasants can normally harvest two *ngan* in a day.

Drying and Bundling The harvested stalks of broadcast-sown paddy are usually left on the ground to dry out in the sun for two or three days. Where the ground is still wet, the stalks are carefully laid on the lodged stubs to dry. In the case of *khao kiao kan nam* harvested in the water, the cut stalks have to be hauled by boat to dry ground in the farm compound. Harvested and dried in the sun, paddy stalks are bundled with dried leaves of *kha* (*Imperata arundinacea*) in the plot where stalks are left to dry. Bundling work (*hǫp khao*) is usually done by the domestic labour of the operating household, but a few households use hired labour at the rate of 30 to 40 baht per 100 bundles.

40) For traditional labour exchage practised in Bang Chan, see [Kamol 1955: 111–114].

41) These provinces are Singburi and Chainat in the upper delta, Saraburi, Lopburi and Prachinburi in the eastern marginal area of the delta, and Nakhǫn Sawan, Phichit and Phitsanulok further to the north.

Hauling The bundled sheaves are set over carrying poles (*khan lao*) and brought out by male farmers from the plots to the roadside, and then taken to the threshing floor by traditional buffalo cart (*lǫ lüan*) or by farm machines such as a small cart attached to a power tiller. Hauling work is basically done by the farmer and his family using their own vehicle, but some households depend on hired vehicles.

Preparation of Threshing Floor As the entire labour force of the household is continuously involved in a series of tasks after harvesting starts, the preparation of a threshing floor (*lan nuat*) should be completed before harvesting. A piece of ground which has been selected for use as a threshing floor is made clean and soaked with water for a night to soften its surface. It is then trampled over by buffaloes for two hours or run over by power tiller, and levelled using a hoe (*chǫp thak*) and wooden scraper (*khatha*) to smooth the surface. Subsequently the floor is left to dry until the evening when it is again soaked with water. Finally, after repeating this process for two or three days, buffalo manure is mixed with water and spread on the floor to fill up the surface completely. Thus a piece of ground which may be rugged or cracked can be improved and made suitable for threshing.

Threshing The sheaves are loosened and spread around in a large circle on the threshing floor using a straw hook (*khan chai*). This work is called *tok khao*. In the traditional method, a pole is usually set in the centre of the floor to which several buffaloes are tied and threshing is done by the trampling of these animals over the sheaves. In former days, exchange of buffaloes (*khǫ raeng khwai*) for threshing was customarily performed in the same way as labour exchange in harvesting, but it has now almost disappeared. At present in place of buffalo threshing, rented power tillers are increasingly used to run over the stalks and thresh out the grain. In 1975 about half of the operating households used a hired power tiller for threshing and its rental fee was 30 baht per 100 bundles. While the tiller or buffaloes work over them, the stalks are raised and turned over by using a straw hook, until the threshing is completed. The grains finally are gathered up using a wooden scraper.

Winnowing After threshing is completed, a winnowing machine (*khrüang si fat*), run either by hand or power, is used to separate the chaff from the grain. Winnowing work is done at the threshing floor usually by the members of the household. After the chaff and other undesirable parts have been removed, the work is finally done and the grain is stored in granary, or prepared for marketing.

The above description of the farming cycle shows that the broadcast-sowing method is strongly dependent on the existing physical environment of which rainfall and inundation are the most decisive factors. Application of the broadcast-sowing method together with suitable selection of indigenous varieties has been

the only feasible way to overcome uncertainty of weather at the beginning of cultivation and prolonged flooding to a considerable depth. In particular adoption of *khao khün nam* which has a growth habit astonishingly well adapted to deep flooding, has enabled the peasant farmers to operate rice agriculture in such a difficult environment. Compared with the transplanting method, the broadcast-sowing method is relatively less labour intensive, especially in the first half of growing period: from land preparation to after-cultivation. In addition, co-operation among peasant farmers in the course of farming operations seems to have been rather scarce except for labour exchange and the exchange of buffaloes. The intensive labour requirement comes only in the harvesting period. As the traditional labour exchange arrangement has almost disappeared, hired labour is the only external resource of labour supply used to supplement the domestic labour force. The broadcast-sowing culture in Ayutthaya today could not survive without such hired labour coming from the outer region of the delta. During the past ten years much of the labour has become mechanized with tractors and power tillers. At the same time, introduction of the early season cultivation has caused a growing dependence on industrial inputs.

3. Transplanting Cultivation in the Early Season

Early season cultivation of transplanted rice was first introduced in the Tontan field in 1970, following the steady progress of water control in the West Bank tracts southwards from the Phraya Banlü canal. In the Tontan field, however, it has not expanded so rapidly, and in 1975 was practised on only 117.25 rai or about 10 per cent of the total operated area, by 14 households. As far as transplanting technology is concerned, it has been widely practised using native varieties in the area wherever feeding water is available at the beginning of the cultivation. But in the case of Ayutthaya village peasant farmers have not been familiar with transplanting cultivation of main season rice to any degree since the pioneering stage many years ago. They have been broadcast-sowing cultivators in the deep inundating area for a century, though acquiring a sufficient knowledge of the transplanting method from neighbours along the Nọi river and the Phraya Banlü canal. For the broadcast-sowing cultivators the land naturally watered at the beginning of the rainy season has been simply used as wet-sowing *phọloei* field without any improvement to the plots. Under such circumstances, transplanting technology of the newly developed varieties was introduced, accompanied by the necessary industrial inputs for cultivation. The non-photosensitive varieties for transplanting seem to provide a distinctive cropping pattern, which begins at the end of the dry season and lasts up to August. This is the early season cultivation recently developed in the plots close to the canal.

Varieties In the transplanted plots

close to the canal, non-glutinous varieties RD1 or C4-63, developed as non-photosensitive varieties, are used for early season cultivation. The RD1 is one of the improved varieties released by the Rice Department of the Thai government in 1969, while C4-63 was developed in the College of Agriculture, University of the Phillipines, in 1968 and subsequently became popular in many Southeast Asian countries.[42] Both varieties have a quite short maturation period of about 120 days. These varieties differ from the indigenous ones in that the plant heights are very much lower, being only 90–100 cm, and are locally called low rice or *khao tia*. The yield per rai is considerably higher than those of indigenous varieties and usually attains 40 to 50 *thang*. However, cultivation of these varieties normally requires strict water control in each plot and the application of chemical fertilizer, herbicides and pesticides, as well as transplanting of seedlings, are essential.

Land Preparation In contrast to broadcast-sown plots, transplanted plots must be surrounded by well maintained dikes about 30 cm in height to conserve and control the water. Before land preparation begins the plot is watered by *rahat* or a power pump installed on the bank of the Khanomčhin canal. Subsequently the plot is covered with water for two or three days, after which ploughing is carried out using buffaloes or power tillers. Rough-ploughing and cross-ploughing are repeated and finally harrowing is done to break down lumps of clay and remove weeds, followed by levelling the fine mud immediately before transplanting. The water depth should then be kept at 4 *niu* (10 cm) for transplanting.

Nursery Bed The land chosen as a nursery bed (*plaeng kla*) is usually close to the canal from which feeding water can be lifted. Land preparation of the nursery bed begins earlier than in the main plots, and is carried out in the same way. After levelling is completed some shallow ditches are scratched out on the surface for irrigation and drainage as with the case of the *phǫloei* field. The water is then drained off from the nursery bed. The germinated seeds, prepared in advance as in the *phǫloei* method, are carefully broadcast over the bed. On average one *thang* (20 litres or 10 kg) of seed is needed for one rai of the eventual transplanted area, equivalent to only a half of the rate of sowing required in the broadcast-sowing method. Until the seedlings attain a length of 6 to 7 cm, or a week after sowing, the nursery bed must be kept wet, and therefore strict water control is essential. The soil of the nursery bed is thereafter maintained with appropriate moisture, using devices to water when the necessity arises until the time of transplanting. Some 35 or 40 days later, by which time the seedlings are about 40 to 50 cm high, the water is completely drained and the seedlings are left for two days before

42) RD5 released in 1973 is said to be more suitable for deep inundation, but it had not yet been adopted in 1975.

uprooting.[43] Until the time of uprooting and transplanting comes, every stage of the farming operation is performed mostly by the domestic labour force.

Uprooting and Transplanting When the peasant farmers transplant seedlings between late April and mid-May, rainfall is still insufficient, and there is no alternative but to rely entirely on irrigation water lifted from the canal into the transplanting plots. *Rahat* and power pump must be fully at work and intensive labour is essential at this stage. Bunches of seedlings are grasped and pulled out by the handful, roots being strongly smacked against the heel and washed in water to rid them of mud. Two or three handfuls of seedlings are arranged into a bundle, and the top of the leaves is cut off on an arranging board (*paen wang khao kla*) stuck into the nursery bed. Seedling bundles are then immediately hauled by carrying pole to the main plots. Subsequently transplanting (*dam na*) takes place in the main plot in which the water depth may be kept 4 to 5 *niu* (10 to 12.5 cm). A peasant farmer takes three or four seedlings from a bunch held in the left hand, and inserts them quickly into the mud. Although the interval between stands may be kept about 25 cm, seedlings are planted at random without any rule with the peasant farmer moving backwards.

For the uprooting and transplanting tasks peasant farmers depend primarily upon hired labour. By contrast with harvesting in broadcast-sown fields, hired hands are mostly supplied from inside the village, and outsiders are seldom seen in these operations. Hired labourers are not paid on a daily basis but enter contracts to render labour on a piecework basis called *čhang mao*. Uprooting pays at the rate of 20 baht per 100 bundles; it is possible to do 200 bundles per day. Transplanting pays 20 baht per *ngan* (0.25 rai) and 2 *ngan* can be done in a day. In uprooting and transplanting tasks, there are even cases where the owning household contributes no labour and contracted hired labour has thus taken a new importantce.

After cultivation After transplanting, the rainfall pattern in May is normally still uncertain, so that water control is a matter of very grave concern to the peasant farmers. Until the new plants take roots the water should be retained at a depth of about 5 *niu* (12.5 cm) for a week or ten days to control the growth of weeds.[44] Power devices continuously lift water into the plots in order to keep them wet up to the tillering stage. Thereafter, from June onwards, rainfall and inundation may provide sufficient water. Thus in the transplanted fields, irrigation devices must be appropriately worked from the land preparation in the dry season up to the tillering stage in June and July when the monsoon rainfall becomes stabilized.

43) Some nursery beds, however, are inevitably flooded, because of the volum of water delivered to the main plots.

44) Another purpose of such water regulation is to help water absorption of the young seedlings [Matsuo 1961: 165].

The application of chemical fertilizers is widely seen and is regarded as necessary and effective for the successful cultivation of improved varieties. In many cases about 15 to 27 kg per rai of ammonium phosphate (18–22–0) is applied at tillering stage, 7 to 10 days after transplanting.[45] In five households split application of fertilizer is practised at tillering, and at the time of panicle formation. In recent years herbicides and pesticides have also come into widespread use and their application to the fields is much the same as in the broadcast-sown fields.

Harvesting and Other Operations In the transplanted fields when the paddy has been fully ripened the water is drained as much as possible for convenience of harvesting. Complete drainage is sometimes impossible, because in August the water level in the adjacent area is already rising. As the improved varieties have short stalks, when the paddy is cut at one *sǫk* (50 cm) from the ear, about 40 to 50 cm of stubs are left on the ground. The required labour force is largely supplied from within the village, as in the case in uprooting and transplanting. The piecework wage for harvesting in August is about 15 baht per *ngan*, which is somewhat lower than in broadcast-sown fields in the dry season. This is because during the season, hired hands who have finished their own work in the broadcast-sown fields, are easier to obtain within the village.

45) One bag containing 40 kg cost 215–250 baht in 1975.

After harvesting all necessary operations are carried in the same way as in the main season cultivation. The transplanting cultivation may be finished at the latest by the beginning of September, and thereafter no more crops are planted under the increasing water depth, until the next dry season.[46] With the improved varieties, the early season cultivation is thus designed to be completely finished within the first half of the rainy season. The plot for transplanting cultivation is entirely devoted to such newly introduced rice growing, and therefore it is not associated with the traditional cropping pattern, the only exception being the case of double cropping. For most peasant farmers, the early season cultivation is practised as a substitute for traditional cultivation. Although the transplanting method certainly provides higher yields, the application of the method involves a heavier labour requirement and greater use of industrial inputs throughout the process of cultivation. It may be assumed that the wider application of the transplanting technology, though rather limited at present, will come with further improvement in water control. This will considerably affect the socio-economic condition of the village.

46) It should, however, be noticed that some peasant farmers can harvest another small quantity of ratoon paddy (*khao luk rang*) in the same plots. After the first harvesting, the ratoon crop grows up among the remaining stubble and ripens under the relatively favourable water conditions in higher plots close to the natural levees. About 40 or 45 days after the first harvesting, the remaining stubble give a ratoon yield one-seventh to one-fifth that of the first crop.

4. Farming Equipment

The traditional farming implements used in the village have not changed for many decades since the earliest pioneering age. Most of the items are quite similar to those which have been commonly used throughout the Chao Phraya delta region for many centuries. It is unlikely that any modification or change has been made to any of these implements. Throughout the history of the village, farming tools have not been improved or radically changed, except for the recent introduction of power devices. Therefore, the farming technology depending on such traditional implements has continuously survived until recent years.

Farming technology consists essentially of land preparation by a wooden plough with an iron blade drawn by a water buffalo and various operations which involve much manual labour with rather simple tools.[47] Table 4 shows the essential items of farming equipment which are needed in broadcast-sowing and transplanting cultivation and which are mostly owned by farm operating households. The newly introduced and expensive power devices are also shown in the table. Most of the items of essential equipment listed here were possessed by five households surveyed, while the prices are those given by one of them in 1975. The figures for prices in Bang Chan, which is also located in the delta some twenty miles northeast of Bangkok, are derived from Kamol's survey in 1948 [Kamol 1955: 95–96]. The possession of a complete set of these tools is not absolutely essential for cultivating the land. Many young households cannot afford to purchase expensive equipment such as winnowing machines, and hauling facilities. But they can make use of them by borrowing from relatives and neighbours, and might expect eventually to get them in the future. Especially among relatives, even power devices are subject to free renting. In addition to traditional tools, sprayers for herbicides application and power devices have begun to be prevalent since early 1970s. In particular, the power *rahat* or power pump is essential to operate transplanting early season cultivation.

Most traditional tools are made of wood or bamboo, though some of them are made from metal. Many kinds of relatively simple tool are made in the village by peasants themselves, but metal goods are almost all purchased at the marketplace in the district town of Ban Phaen. It is said that until twenty years ago some kinds of metal goods used to be bought from pedlars and traders plying along the Khanomčhin canal. For example, knives brought by traders

47) Ploughs drawn by two buffaloes are not used in the Tontan field. The typical plough (*thai*) consists of a rod (*khan*) and curved handle in which a ploughshare is embeded with an iron coulter. This type of plough is customarily called *thai hua mu* (pig's head plough), because the ploughshare is designed like a pig's head. It seems to be much influenced by the Indian plough, and is different from the triangular type of plough which is popular in the intermontane basins of northern Thailand [Hopfen 1960: 53–54; Watabe 1967: 65; Tanabe 1976: 717–718].

Table 4 Farming Equipment in Ayutthaya Village (1975)

I. Traditional equipment arranged by farming operation

Name of tool (in Thai)	Main material*	Supply**	Price Ayutthaya 1975	Price Bang Chan*** 1948
1) **Land preparation**				
Plough (*khan thai*)	m, w	t	150	80
Yoke including harness (*takhok*)	w	v	0	12
Harrow (*khrat*)	w, b	v, t	50	30
Hoe (*chǫp thak*)	m, w	t	20	14
Iron rake (*khrat*)	m, w	t	20	5
Siamese spade (*siam*)	m, w	t	8	3
Soil-carrying basket (*bung ki*)	b	v, t	6	
2) **Water control**				
Water scooping basket (*chong long*)	b, w	v	0	
3) **Sowing**				
Carrying basket (*krabung*)	b	v	0	15
Earthen jar (*ong*)	e	t, p	150	
4) **Transplanting**				
Seedling arranging boad (*paeng wang khao kla*)	w	v	0	
5) **After-cultivation**				
Field knife (*mit*)	m, w	t	20	19
Big curved knife with long handle (*liam*)	m, w	t	20	
6) **Harvesting**				
Large sickle (*khiao na müang*)	m	t	26	24
Small sickle (*khiao nok thung*)	m	t	26	
7) **Hauling**				
Carrying pole (*khan lao*)	b	t	6	
Buffalo cart (*lǫ lüan*)	m, w	v	1,200	
Boat (*rüa phae* or *rüa mat*)	w	t	1,150	386—1,400
8) **Threshing**				
Straw hook (*khan chai*)	m, w	t	20	21
Bamboo rake (*khlat mü süa*)	b, w	v	0	
Wooden scraper (*khatha*)	w	v	0	
9) **Winnowing**				
Bamboo winnow (*kradong*)	b	v	0	
Winnowing machine (*khrüang si fat*)	m, w	t	700	498
Woven bamboo mat (*ramphaen*)	b	t	25	
Bamboo broom (*maikwat tǫk*)	b	v	0	
Coconut broom (*maikwat kam maphrao*)	w	v	0	
10) **Storing and measuring**				
Woven bamboo basket for storing seeds (*phǫm*)	b	v	0	
Measuring bin (*thang tuang khao*)	m, w	t	60	

II. Newly introduced equipment

Name of device (in Thai)	Range of price in 1975
Four wheeled power tiller (*rot thai nang khap*)	34,500—45,000
Two wheeled power tiller (*rot thai mü*)	4,500— 6,500
Power *rahat* (*rahat tit khrüang*)	3,750— 4,200
Power pump (*thọ sup nam*)	5,700— 6,200
Sprayer (*khrüang chit ya*)	80— 350

* m: metal; w: wood; b: bamboo; e: earthenware
** t : town=Ban Phaen; p: peddlers; v: village
*** from Kamol Odd Janlekha. 1955. *A Study of the Economy of a Rice Growing Village in Central Thailand.* Bangkok: The Ministry of Agriculture, 95–96.

from Nakhọn Luang in Ayutthaya province were once famous for their quality among the peasants throughout the delta region. However, those traders supplying specific equipment have almost disappeared with a few exceptions such as suppliers of earthenwares from Pakkret further downstream of the Chao Phraya main channel.[48] The decline of such trade has apparently been caused by the rapid development of retail shops in Ban Phaen to which transport facilities have much been improved in recent years. Be that as it may, although the supply of metal goods and other industrial products emanates entirely from the marketplace of the town, the villagers are still considerably self-sufficient in wooden and bamboo tools.

The traditional items of equipment are, in general, not very expensive. Although prices in 1975 have certainly risen compared with Bang Chan twenty-seven years ago, the peasant farmers can still afford to buy most of them. Among these items hauling devices and winnowing machines have usually been high-priced equipment. By contrast with the intermontane basins, the boat has been an inevitable hauling and transport facility in the flat delta, even though road traffic has recently improved to a certain degree. Every household has to possess at least one boat not only for cultivation but also for non-agricultural purposes and to maintain daily life in an aquatic environment. As the usage of boats has developed, at least seven different types of boat can be distinguished in the village. On the other hand, the buffalo cart or *lọ lüan* pulled by a water buffalo is peculiar to the deep flooding area where road traffic has not yet developed.[49] It was still made in the village by a few peasants and sold to others until a few years ago. Most operating households possess one

48) A good example of such traditional trade in Northeast Thailand is given by Anuman [Anuman 1965: 135].

49) This unsophisticated vehicle must be a variant of traditional sled (*lüan*) which could be easily driven on the lodging stubble to haul the harvests from broadcasted fields. The *kwian* pulled by either water buffaloes or oxen, which is popular elsewhere in the country is seldom seen in the deep flooding areas.

Table 5 Ownership of Expensive Devices and Draught Animals by Land Tenure Category (1974—5)

Land tenure category	Number of households (%)	Land preparation			Irrigation		Hauling	
		Buffalo	Four wheeled tiller	Two wheeled tiller	*Rahat*	Pump	Buffalo cart	Boat*
Landlord	2 (3)							2
Landlord-operator	6 (9)	8				1	4	12 (3)
Owner-operator	7 (11)	13	1	1	1	2	7	21 (2)
Part-owner	13 (19)	26	1	2	1	5	12	37 (6)
Tenant	18 (27)	23			2		6	39 (4)
Rural labourer	21 (31)	3						30
Total	67 (100)	73	2	3	4	8	29	141(15)

* The figure in parenthesis indicates the number of boat with engine attached.

of these carts for hauling harvests in the Tontan field, though in recent years some peasants have begun to hire a cart attached to a power tiller for this purpose. The winnowing machine, together with the manually operated *rahat*, is one of the popular farming machines which has been in favour among peasants in this delta since relatively early days.[50] Before the introduction of the hand-winnowing machine in the early 1950s, the peasant farmer would toss his paddy using a wooden spatula, so that cleaned grain fell on the mat and husk and chaff were carried away by the wind. The grains placed on a woven bamboo winnow (*kradong*) were again shaken and tossed many times to be cleaned. This simple winnowing method has almost disappeared in line with the increasingly widespread use of winnowing machines in the late 1960s. Today, hand-winnowing machines, also powerdriven ones are sold in the marketplace at Ban Phaen.

As indicated in the previous sections, the traditional farming technology is rapidly changing through the recent mechanization of farming tools, and the improvement of water conditions. Table 5 shows the possession of these power devices, draught animals and hauling devices by land tenure category. Buffalo cart and boat, the traditional hauling and transport facilities, are possessed by most of households, even though they are relatively expensive. It should be noted in particular, that on average two boats are possessed by a household regardless of land tenure status. By contrast, expensive power tillers and irrigation devices had been purchased in recent years by owner-operators and part-owners who have a comparatively larger operated area. At present, these well-to-do households are the only ones wealthy enough to possess the new devices needed to operate successfully both broadcast-sown and transplanted plots.

50) The hand or foot driven *rahat*, which was commonly used in transplanted fields before the introduction of power driven ones, was not found in the village.

As a result of the strong tendency towards farm mechanization, the water buffalo which has been a typical draught animal in the delta, will shortly disappear. Even though buffaloes were still owned by every farm operating household in 1975, they are apparently being replaced by the hired tractor and power tiller both in land preparation and threshing. Some water buffaloes are no longer employed and are kept only because the peasant farmers dislike the slaughtering of these animals. It can be considered that the traditional plough agriculture, which in the past has relied on water buffaloes and simple equipment, now faces a rapid change. As far as farming tools are concerned, this change is brought about by the introduction of power devices in land preparation and irrigation, the two most crucial steps in the rice-growing operation.

5. Knowledge and Decision

In Ayutthaya village, farming technology seems highly dependent on nature and on the physical environment, which exert a deep influence on success of production. Ayutthaya's technology shows a far greater dependence on the physical environment than the technology of the intermontane basins, especially as regards the traditional broadcast-sowing culture. However, throughout the course of farming operations the peasant farmers in striving towards success in cultivation make careful decisions facing a range of choices in the midst of considerable uncertainty. Throughout the farming process, it is necessary to make a number of decisions based on empirical knowledge. Necessary knowledge of farming technology is basically acquired and accumulated individually by continuous participation in farming from childhood onwards. Children over about ten years, or even younger, contribute considerably to farming operations, helping adult workers. In particular, they usually join in weeding with their parents, and some of the daily supervision of buffaloes, including grazing, has been customarily regarded as the children's main task [Kamol 1955: 103]. Thus, children can acquire sufficient knowledge, working and playing side by side with their parents, by the time they begin to cultivate their own plots as adults. As primary education hardly touches upon farming technology, villagers' knowledge of agriculture seems to be formed entirely on the basis of their own personal experience.

Information about farming is informally conveyed through daily conversation among peasant farmers. In particular, daily communications relevant to farming are extremely frequent among relatives, who live close to each other, often as independent households in the parent compound. Although such information is not systematic, fragments interpolated in the daily conversation are concerned with a wide range of farming matters including the weather, water conditions, growing conditions of the crop, pests, and the price of paddy.

This casual accumulation of information is the major and the most practical basis upon which farming decisions are made. Apart from information gathered within the village, every villager is able to obtain information easily from outside the village; they have easy access to the Ban Phaen marketplace via both road and canal, and radio has already come into common use. Rice traders (*phọkha rapsü khao*) come aboard rice cargo boats (*rüa krachaeng, rüa thọ*) to buy the harvest directly from peasant farmers, and transport rice for sale to rice millers operating along the Nọi river at Ban Phaen, Sikuk and Čhao Čhet. These rice traders coming from both inside and outside the village, provide information about rice marketing to some extent. Most peasant farmers have individually established mutual trust and friendship with such a rice trader over the years [Amyot 1976: 159–166]. It seems, however, that rice traders are rather less interested in transferring detailed knowledge relevant to farming technology to the peasant farmers.[51]

In addition to the informal and individual acquisition of information, the district office to some extent provides administrative guidance to peasant farmers concerning agricultural technology. An agricultural officer or *kaset amphoe* undertakes the task and *kamnan,* or head of *tambon* conveys his suggestion to the villagers in the administrative unit of *tambon.* In 1975 a one-day course concerning the control of rats was given according to the instructions indicated by the agricultural officer. In general, however, official suggestions offered by the district office as well as those of irrigation zone-men have little pronounced effect upon the peasants' behaviour in farming.

Another source of information for decision-making may be agricultural rituals.[52] In the course of farming operations the most significant rituals are those particularly concerned with the rice soul or *khwan khao* which is also called *mae phosop* or Rice Goddess. *Khwan khao* is believed to be something like a soul giving life to the rice, which transmigrates from the seed to the plant. It is always present within the rice whether in field or granary. In order to detain it safely in the rice, seed and plant must be carefully treated, so that a series of *khwan khao* rituals is performed throughout rice-growing.

The first ceremony called *raek na khwan* is held in the plot where broadcast-sowing starts.[53] Before sowing, a *san phiang ta* is erected for the guardian spirit of the plot or *čhao thi čhao thung.* The *san*

51) See Ammar's excellent work for a relevant discussion of the role of middlemen in agricultural marketing [Ammar 1977: 11–15].

52) As stressed by Ford and Moerman, technology is an analytic category that views behaviour as solutions to problems. In this sense, agricultural ritual is a patterned behaviour and indigenous idea to overcome the uncertainty of rice cultivation [Ford 1942: 555–557; Moerman 1968: 26].

53) The first ploughing ritual or *raek na* commonly practised in other parts of the delta is not found in the village [Anuman 1965: 136–137].

phiang ta, literally, eye level shrine, consists of a roughly made bamboo altar attached to a single wooden pole and adjusted to the adult's eye level (Figure 8). After making an offering of joss sticks and flowers to the spirit, a handful seeds of *khwan khao* which have been reverently kept in the granary since the last harvesting, is mixed with the seeds in the basket. These seeds are at first sown around the *san phiang ta*, asking *mae phosop* or *khwan khao*, for a fruitful year's harvest, and subsequently broadcast-sowing starts in other parts.

The second ritual associated with *khwan khao* is called *tham khwan khao* or invocation of *khwan khao*, which is performed on the day of the full moon of the twelfth lunar month, i.e. on the day of the *lǫi krathǫng* ceremony. Although the ritual is usually held on an auspicious day during the period of panicle formation in October, in Ayutthaya village it takes place on the day of one of the most popular ceremonies in November, when heading has taken place. In the afternoon of the day, a magic pentacle figure made of six bamboo strips called *khaleo*, fixed on a bamboo pole with a red flag on its top, is set up at a corner of the cultivating plot.[54] *Khaleo* is apparently a symbolic fence protecting *khwan khao* from evil spirits and animals. Offerings including some fruits, sweets, and areca nuts (*mak*) are placed in a small bamboo basket and hung up on the *khaleo*. Subsequently peasant farmers chant an incantation to invoke *khwan khao*, while sprinkling Thai perfumes (*namop*) and powder on the plants, and combing the leaves with a comb used for dressing the Rice Goddess. This highly personified ritual is performed at the crucial period of rice-growing between panicle formation and heading, while praying to the *khwan khao* to bring ample harvests.

The third ritual called *raek khao*, or beginning of harvesting, takes place at the onset of harvesting. With just a few words to the spirit of the plot, not to *khwan khao*, the peasants harvest three bunches of stalks, and thereafter harvesting can proceed. When harvesting and hauling of stalks to the threshing floor have been almost completed the fourth ritual of *rap khwan khao* or inviting the *khwan khao* can be seen. With auspicious chanting the peasants make offerings to *khwan khao* in the harvested plot, including two kinds of sweets called *khanom tom daeng* and *khanom tom khao*, a bunch of *namwa* banana, a boiled egg and a lump of boiled rice (*khao pak mǫ*). They then glean grain and stalks left in the harvest plot, and put them in a white garment. While chanting an incantation to invite *khwan khao* they make a straw figure called *tua khwan khao* or *tua mae phosop* from those panicles with grain. This straw figure of the Rice Goddess is dressed in red, yellow and green coloured clothes. The *khwan khao* thus present in the straw figure is conveyed to a corner

54) The magic pentacle figure is called by differing names such as *chaleo* and *thaleo* according to the region [Anuman 1965: 154–155].

of the threshing floor with other gleaned grain. These symbols of *khwan khao* are set there together with offerings similar to those left at the ritual place in the plot. After staying at the threshing floor during threshing and winnowing, the figure in which *khwan khao* resides is stored together with the cleaned new paddy in the granary until the next sowing. The transmigration of *khwan khao* is thus accomplished by this ritual.

It should be noted that these four rituals are all performed at the crucial growing phases of rice cultivation, namely: sowing, panicle formation and heading, harvesting and the end of farming operations. The first and third rituals are clearly associated with the spirit of the land, while the first, second and fourth rituals are symbolic activities representing *khwan khao* or the life of rice itself. The unusual time and space created by these rituals seems to enable the peasant farmers to confirm their confidence in farming operations. It is significant that these agricultural rites in Ayutthaya are primarily performed by each household. The symbolic behaviour in these rites is directed towards the land spirit and *khwan khao* of the individual farm. In Ayutthaya village few agricultural rituals are collectively performed either in groups or by the entire village community.[55] In the intermontane basins a series of rituals associated with the land spirit and *khwan khao* can be widely seen in a quite similar way. In addition to those rituals individually performed in each operating household, some collective agricultural rites are performed; for example the rite of the spirit of irrigation dam (*phi fai*) involves all the members of the irrigation control group, and some rain-making ceremonies are still practised [Tanabe 1976: 760–764]. Be that as it may, most of the agricultural rituals which have survived in Ayutthaya village are strongly suggestive of individual family farming.

With the available resources, knowledge and information, the peasant farmers must first attempt to make some major decisions before commencing cultivation at the beginning of the farming year. The most important of these are decisions about the method and timing of cultivation in the plot, which may determine the agricultural cycle itself throughout the year. As already described in the earlier section, selection of method is almost completely dependent on topography and water conditions, and is especially influenced by access to the canal for the transplanting method of early season cultivation. For the operation of transplanting method, moreover, an expensive device for irrigation, and intensive input of hired labour, must both be secured. Under present conditions of water supply, the possibility of switching of cropping to early season cultivation is thus restricted to a few well-to-do households who have

55) The only exception is a rain-making rite called *hae nang maeo* (parade of female cat) which fell into disuse about thirty years ago. For the *hae nang maeo* rite in central Thailand, see [Anuman 1972: 57–68; Anuman 1954: 39–40; Demaine 1978: 50–51].

preserved land assets or who can rent in operating plots close to the canal. Although early season cultivation overcomes the problem of when to start rice-growing in the midst of environmental uncertainties, decisions about timing are still crucial in both broadcast-sowing methods. Even though peasant farmers start ploughing whenever a power device is available, the decisions concerning the timing of sowing are still of crucial significance due to the instability of monsoon precipitation. After the disappearance of the rain-making rite many decades ago, the recent wide-spread diffusion of radio may enable every peasant to hear weather forecasts. In fact, however, weather forecasts are not entirely reliable, because of the highly localized precipitation pattern at the beginning of the rainy season.[56]

Another major decision has to be made concerning the selection of the seed variety to be sown on the plot concerned. As shown in the earlier section, the selection is made primarily depending on the water conditions of the plot. At the same time, apart from adaptability to ecological conditions, the market price for selling, and the eating quality for consumption may also be important considerations in the selection. Ayutthaya's farming has traditionally been oriented towards markets, so that most peasant farmers dispose of a fair amount of their produce, reserving enough quantity for home consumption. In general, the broadcasting varieties used in the village are not of particularly high quality in the market. However, the villagers know well that in order to secure stable yields under the deep flooding, they have no alternative but to select those varieties. On the other hand, the cooking and eating quality of those broadcasting varieties is said to be fairly satisfactory for their daily consumption.[57] Therefore, there has traditionally been a strong preference for indigenous broadcasting culture both for selling and consumption. Under such variables concerning exchange and use, decisions are made for seed selection which may determine the entire process of farming technology. Ayutthaya's peasants usually choose at least two suitable varieties among a relatively narrow selection, even in a plot which seems to be homogeneous in physical condition. Thus the decisions are dominated by consideration of the principle of safety-first. Although the decisions in method and seed selection are only a first step, villagers take great care to minimize

56) On the contrary, traditional almanacs and calendars arranged by lunar month are still regarded as fairly useful and reliable sources among peasant farmers. The older generations sometimes make use of old manuals to select auspicious days before commencing ritual and farming operations. See Phonlathep's manual on rice-growing and its rituals [Phonlathep 1924: 22–30].

57) In the village, 34 households or 77 per cent of the 44 operating households consume their own home-grown rice. However, in some cases in Ayutthaya province, peasant farmers even dispose of their whole harvest, on the market, because the quality of the product of their the broadcasted fields is inferior for consumption [Amyot 1976: 160].

risks at every stage of the farming operation.[58]

Compared with villages in the intermontane basins, which are still characterized by a backward, subsistence farming, Ayutthaya village has been highly influenced by market economy throughout its history.[59] Whether broadcast-sowing or transplanting culture, Ayutthaya's farming is deeply involved in rice marketing practices. The traditional farming technology, particularly the broadcast-sowing culture, which represents that of subsistence economy in material culture and decision-making, has survived under penetration of market economy without any remarkable changes up to the present. The recent introduction of early season cultivation accompanied by heavy requirement of capital and labour has increasingly affected the traditional technology. Nevertheless, a series of technological decisions of the peasant farmers keeps alive a strong tendency to revert to a peasant economy. The broadcast-sowing culture which is quite rationally adapted to the natural environment, may well continue to exist as the major source of the peasant economy, unless the present water conditions are drastically improved.

58) The peasant's principle of minimizing risks has been observed in other areas of Thailand [Moerman 1968: 68–69; Hanks 1972: 48; Scott 1976: 15–26; SOAS 1978: 35–36].

59) It can be considered, following Myint, that Ayutthaya's peasants are apparently in 'the second phase of the money economy', in contrast to those in the intermontane basins [Myint 1973: 35–38].

Bibliography

I. Sources in Thai Language

Anuman Rajadhon, Phya (Yong Sathiankoset). 1965 (2508). Chiwit khọng chao na [The Life of the Farmer]. In *Prapheni bettalet: nangsu chut prapheni thai khọng sathiankoset.* Lem 4 [Various Traditions: Sathiankoset's Collected Writings on Thai Tradition. Vol. 4], Bangkok: Samnakphim Samakhom Sangkhomsat haeng Prathet Thai.

————. 1972 (2515). *Chiwit chao thai samai kọn lae kansüksa rüang prapheni thai* [The Old Life of the Thai People and a Study of Thai Tradition]. Bangkok: Samnakphim Khlangwitthaya.

Ayutthaya, Čhangwat Phra Nakhọn Si. 1970 (2513). *Raignan pračham pi phọ sọ 2513* [Administrative Report, B. E. 2513]. Ayutthaya : Thithamkan Kaset Čhangwat Phra Nakhọn Si Ayutthaya.

Boranratchathanin, Phraya. 1962 (2505). *Raya thang sadet praphat lam maenam nọi lae lam maenam yai monthon krung kao lae monthon nakhọn sawan* [Account of the Royal Trip on the Nọi River and the Chao Phraya River in Monthon Krung Kao and Monthon Nakhọn Sawan]. Bangkok: Cremation volume of Nang Phun Arayakun.

Damrong Rachanuphap, Krom Phraya. 1923 (2466). *Tamnan phasi akọn bangyang kap khamathibai khọng phračhao boromawongthoe krom phra damrong rachanuphap* [A History of Some Taxes and Prince Damrong's Explanation]. Bangkok: Cremation volume of Mọmčhaojing Satchan.

————. 1972 (2515). *Čhotmaihet raya thang senabodi krasuang mahatthai sadet truat ratchakan huamüang nai rọ sọ 117, 119* [Records of Prince Damrong, Minister of Interior in his Inspection of Provinces in 1898/9 and 1900/1]. Bangkok: Felicitation volume to Phra Thepsumethi on his sixtieth birthday.

Krom Sinlapakọn, ed. 1969 (2512). Rüang kiaokap krung kao, tọnthi 1 [Concerning Krung Kao, Part 1]. In *Prachum phongsawadan* [Collected Historical Sources]. Bangkok: Ọngkankha khọng Khrusapha.

Lingat, Robert. 1940 (2483). *Prawatthisat kotmai thai kotmai thidin* [A History of Thai Law: A History of Land Law]. Bangkok: Thammasat University.

Metha Hongrangkun. 1978 (2521). Botbat khọng samakhom phu chai nam chonprathan

tọ kansongsoem kankaset thi chai nam phüa kankaset [The Role of the Water Users' Association in the Development of Irrigation Agriculture]. In *Raingan kan samana kanchainam phüa kankaset* [Proceedings of the Seminar on the Water Use in Agriculture]. Chainat: Samnaknggan Kaset Phak Klang.

Phichitprichakọn, Krom Luang. 1921 (2464). Rüang tham na [Rice Cultivation]. In *Latthi thamniam tang tang, phak thi 3* [Various Customs, Part 3]. Bangkok: Cremation volume of Khunjing Lamo Nọranetbanchakit.

Phonlathep, Čhao Phraya. 1924 (2467). *Tamra pluk maiphon kap tamra pluk khao khọng boran* [The Old Manuals of Fruit Cultivation and Rice-Growing]. Bangkok: Commemorative volume of the Royal Ceremony of First Ploughing.

Phračhọmklao Čhaoyuhua (Mongkut). 1968 (2511). *Prachum prakat ratchakan thi si* [Collected Proclamations of the Fourth Reign]. Vol. 2. Bangkok: Cremation volume of Phramaha Phothiwongsachan Inthachotthera.

Pricha Khuwinphan. 1971 (2514). Kankha khao nai ayutthaya [Rice Market Network in Ayutthaya]. In *Raingan büang ton kanwichai čhangwat phra nakhọn si ayutthaya* [Preliminary Report of the Research in Ayutthaya Province]. Bangkok: Social Science Research Institute, Chulalongkorn University.

Sathian Laiyalak, ed. 1951 (2494). Prakat kae withi lae phikat kep ngoen kha na rọ sọ 124 [Proclamation on the Revision of the Collection Method and the Rates of Riceland Tax, 1905]. In *Prachum kotmai pračham sok* [Collected Laws Arranged Chronologically] Vol. 20. Bangkok: Nitiwet.

Sukit Wisuan. 1969 (2512). *Khet khrongkan chonprathan fang tawantok khọng maenam čhao phraya* [The West Bank Water Control Project Area]. Bangkok: Royal Irrigation Department. (Mimeographed)

Suvaphan Sanitwongse, M. R. W. 1927 (2470). *Rüang khao khọng prathet sayam* [The Rice of Siam]. Bangkok: Cremation volume of M. R. W. Suvaphan Sanitwongse na Ayutthaya.

Thailand, Royal Irrigation Department. 1978 (2521). *Prawat lae khọmun railaiat khrongkan song nam lae bamrung raksa čhao čhet bang yihon* [A History and Data of the Čhao Čhet — Bang Yihon Irrigation Project]. Bangkok: Royal Irrigation Department. (Mimeographed)

van der Heide, Homan. 1906 (2449). Raingan khut khlọng fang tawantok maenam čhao phraya [Report on the Canal Excavation Project on the West Bank of the Chao Phraya River]. K. S. 9.2/48. Archives of the Ministry of Agriculture, in the Fifth Reign. Bangkok: The National Archives.

Vanpen Surarerks. 1978 (2521). Kan ruamklum khọng kasetrakọn nai khet chonprathan khọng sangkhom chonnabot phak nüa [Co-operation of Farmers in Irrigation Area of Northern Rural Society]. In *Raingan kan samana kan suan ruam khọng prachachon nai kanphatthana chonnabot* [Proceedings of the Seminar on people's Co-operation in Rural Development]. Bangkok: Samnaknggan Khanakammakan Phatthana Setthakit lae Sangkhom haeng Chat. (Mimeographed)

Wongsanupraphat, Čhao Phraya. 1941 (2484). *Rüang prawat krasuang kasettrathikan* [A History of the Ministry of Agriculture]. Bangkok: Cremation volume of Nai Phonek Čhao Phraya Wongsanupraphat.

II. Sources in Other Languages

Ammar Siamwalla. 1977. Farmers and Middlemen: Aspects of Agricultural Marketing in Thailand. *Social Science Review* 2: 1–36.

Amyot, Jacques. 1976. *Village Ayutthaya: Social and Economic Conditions of a Rural Population in Central Thailand.* Social Research Institute, Chulalongkorn University.

Anuman, Rajadhon, Phya. 1954. Amusements during Songkran Festival. *Journal of the Siam Society* 42: 39–43.

———. 1961. *Life and Ritual in Old Siam, Three Studies of Thai Life and Customs.* Translated by William J. Gedney. New Haven: HRAF Press.

Child, Jacob, T. 1892. *The Pearl of Asia, Reminiscences of the Court of a Supreme Monarch or Five Years in Siam.* Chicago: Henneberry.

Demaine, Harvey. 1978. Magic and Management: Methods of Ensuring Water Supplies for Agriculture in South East Asia. In *Nature and Man in South East Asia,* edited by Phillip A. Stott. School of Oriental and African Studies, pp. 49–67.

FAO Mission to Siam. 1948. *Report of the FAO Mission for Siam.* Washington: Food and Agriculture Organization of the United Nations.

Ford, Clellan S. 1942. Culture and Human Behavior. *Scientific Monthly* 55: 546–557.

Frutchey, Rose H. 1969. Socio-Economic Obser-

vation Study of Existing Irrigation Projects in Thailand. US Bureau of Reclamation, US Department of the Interior and US Operations Mission to Thailand. (Mimeographed)

Fukui, Hayao. 1978. Paddy Production Technology: Present and Future. In *Thailand: A Rice-Growing Society,* edited by Yoneo Ishii, pp. 246–271. Honolulu: The University Press of Hawaii.

Graham, W. A. 1924. *Siam.* Vol. 2. London: Alexander Moring.

Grist, D. H. 1975. *Rice.* Fifth Edition. London: Longman.

Hanks, Lucien M. 1972. *Rice and Man: Agricultural Ecology in Southeast Asia.* Chicago: Aldine, Atherton.

Hauck, Hazel M.; Rajatasilpin, A.; Indrasud, S.; Campbell, M. B.; and Thorangkul, D. 1958. *Food Habits and Nutrient Intakes in a Siamese Rice Village: Studies in Bang Chan, 1952–54.* Southeast Asia Program Data Paper No. 29. Cornell University.

Hopfen, H. J. 1960. *Farm Implements for Arid and Tropical Regions.* Rome: Food and Agriculture Organization of the United Nations.

Ishii, Yoneo. 1978. History and Rice-Growing. In *Thailand: A Rice-Growing Society,* edited by Yoneo Ishii, pp. 15–39. Honolulu: The University Press of Hawaii.

Jerachone Sriswasdilek; Kamphol Adulavidhaya; and Somporn Isvilanonda. 1975. Don Chedi, Suphan Buri. In *Changes in Rice Farming in Selected Areas of Asia,* edited by International Rice Research Institute. Laguna: The International Rice Research Institute.

Kaida, Yoshihiro. 1973. A Subdivision of the Chao Phraya Delta in Thailand Based on Hydrographical Conditions: Water Conditions in Deltaic Rice Fields (I). *Southeast Asian Studies.* Kyoto: The Center for Southeast Asian Studies. 11(3): 403–413.

———. 1974. Pioneer Settlements and Water Control Development on the West Bank of the Lower Chao Phraya Delta: Water Conditions in the Deltaic Lowland Rice Fields (II). *Southeast Asian Studies.* Kyoto: The Center for Southeast Asian Studies. 11(4): 512–524.

———. 1978. Irrigation and Drainage: Present and Future. In *Thailand: A Rice-Growing Society,* edited by Yoneo Ishii, pp. 205–245. Honolulu: The University Press of Hawaii.

Kamol Odd Janlekha. 1955. *A Study of the Economy of a Rice Growing Village in Central Thailand.* Bangkok: The Ministry of Agriculture.

Matsuo, Takane. 1961. *Rice and Rice Cultivation in Japan.* Tokyo: The Institute of Asian Economic Affairs.

Moerman, Michael. 1968. *Agricultural Change and Peasant Choice in a Thai Village.* Berkeley and Los Angeles: University of California Press.

Myint, Hla. 1973. *The Economics of the Developing Countries.* Fourth Edition. London: Hutchinson.

Pendleton, Robert L. 1962. *Thailand: Aspects of Landscape and Life.* New York: Duell, Sloan and Pearce.

Ramiah, K. and Ramaswamy, K. 1941. Floating Habit in Some Varieties of Rice Known as Deep-Water Rices. *Indian Journal of Agricultural Science* 11: 1–8.

Scott, James C. 1976. *The Moral Economy of the Peasant: Rebellion and Subsistence in Southeast Asia.* New Haven and London: Yale University Press.

Sharp, Lauriston; Hauck, Hazel M.; Kamol Janlekha; and Textor, Robert B. 1953. *Siamese Rice Village: A Preliminary Study of Bang Chan, 1948–1949.* Bangkok: Cornell Research Center.

Small, Leslie E. 1973. Historical Development of the Greater Chao Phya Water Control Project: An Economic Perspective. *Journal of the Siam Society* 61 (1): 1–24.

———. 1974. Water Control and Development in the Central Plain of Thailand. *Southeast Asia, An International Quarterly.* Southern Illinois University. 3 (2): 679–697.

SOAS Lam Pao Project Team. 1978. *Land-Use and Socio-Economic Changes under the Impact of Irrigation in the Lam Pao Project Area in Thailand.* School of Oriental and African Studies.

Suvaphan Sanitwongse, M. R. W. 1927. The Rice of Siam. In *Rüang khao khǫng prathet sayam,* pp. 1–9.

Takaya, Yoshikazu. 1969. Topographical Control over the Agriculture in the Mae Nam Delta. *Japan Agricultural Research Quarterly* 4(4): 24–27.

———. 1971. Physiography of Rice Land in the Chao Phraya Basin of Thailand. *Southeast Asian Studies.* Kyoto: The Center for Southeast Asian Studies. 9(3): 375–397.

Tanabe, Shigeharu. 1976. The Irrigation System

in Nọng Paman, A Lannathai Village in Northern Thailand. (In Japanese) *Bulletin of the National Museum of Ethnology* 1 (4): 671–777.

———. 1977. Historical Geography of the Canal System in the Chao Phraya River Delta from the Ayutthaya Period to the Fourth Reign of the Ratanakosin Dynasty. *Journal of the Siam Society* 65 (2): 23–72.

———. 1978. Land Reclamation in the Chao Phraya Delta. In *Thailand: A Rice-Growing Society,* edited by Yoneo Ishii, pp. 40–82. Honolulu: The University Press of Hawaii.

———. 1979. Rice-Growing Technology and Land Tenure in the Chao Phraya Delta: A Case Study in Phakthan, Singburi Province. In *Comparative Study of Paddy-Growing Communities in Southeast Asia and Japan,* edited by Masuo Kuchiba, pp. 1–39. Kyoto: Ryukoku University. (Mimeographed)

Thailand, Royal Irrigation Department. 1915a. *Project Estimate for Works of Irrigation, Drainage and Navigation to Develop the Plain of Central Siam.* Vol. 3. Bangkok: Ministry of Lands and Agriculture.

———. 1915b. Report on a Scheme for the Irrigation of so much of the Valley of the Menam Chao Phraya as may be Possible for a Capital Outlay of One and Three Quarters Million Sterling. Bangkok: Ministry of Lands and Agriculture. (Mimeographed)

———. 1927. *Administration Report of the Royal Irrigation Department of Siam, for the Period 2457–2468 B.E. (1914/5–1925/6).* Bangkok: Ministry of Lands and Agriculture.

Thailand, Ministry of Agriculture. 1950. *Thailand and Her Agricultural Problems.* Bangkok: Ministry of Agriculture.

———. 1957. *Agriculture in Thailand.* Bangkok: Ministry of Agriculture.

van der Heide, J. Homan. 1903. *General Report on Irrigation and Drainage in the Lower Menam Valley.* Bangkok: Ministry of Agriculture.

Watabe, Tadayo. 1964. Farming Technology of Wet Rice Cultivation in Thailand. (In Japanese) *Southeast Asian Studies.* Kyoto: The Center for Southeast Asian Studies. 2 (1): 25–42.

———. 1967. *Glutinous Rice in Northern Thailand.* Kyoto: The Center for Southeast Asian Studies.

Wijeyewardene, Gehan. 1973. Hydraulic Society in Contemporary Thailand ? In *Studies of Contemporary Thailand,* edited by Robert Ho and E. C. Chapman. Research School of Pacific Studies, Australian National University.