Chapter 2
Agricultural Origins

Rice is synonymous with Thai agriculture. This results from the cultural development origins of Tai and Thai people, and the role of rice in political development, economic progress, international trade, and in the modern era, providing a large part of the fuel for `agriculture as the engine of development'.[1] However just as the Thai were not the original inhabitants of Thailand, so wet rice was not the country's first important agricultural crop. Shifting cultivation, possibly including some dry rice within a range of vegetable crops are thought to have predated the use of wild wet, and certainly, domesticated, wet rice production. While some claim that Thailand was the world's first site of plant domestication, the wet rice cultivation system originated in China. With the improvements in wet rice cultivation came animal agriculture, wealth creation, and the trappings of a sophisticated culture. While agriculture in Thailand has been more than rice, rice has been more than agriculture to Thailand, and remains critical to an understanding of modern Thai agriculture.

The context for the emergence of a Thai agriculture included prehistorical agricultural developments, the later major regional Kingdoms of Angkor and Pagan, and the long and influential contact of the South with Srivijaya Kingdom of Java, as introduced in this chapter.

From Gathering to Growing

The shift to agriculture from less labour demanding hunting and gathering was probably motivated by a desire for greater regularity and security of food supply

[1] Tribe, D.E. (1994)

under conditions of environmental change and population increase. Initially involving only a few societies with demographic advantages for further expansion and eventually domination of the foragers, agriculture became the food production norm throughout lowland Southeast Asia. Its geographical origins remain conjectural, yet some evidence of pre-historical rice cultivation suggest its early and widespread development in the region.

In the 1970s, archaeological research in Ban Chiang, northeastern Thailand claimed the earliest date of plant domestication in the world.[2] More recent finds confirm the domestication of plants before 9,700 BC and one view of the development of agriculture suggests a Thailand to China transmission.[3] Regardless of the exact place of plant domestication in the region and the direction of technology transfer, the association of cultures based on wet rice agriculture suggests wide cross regional contact in the design of domestic architecture, utensils, and crafts. The development of rice culture in Thailand is contentious and impossible at this stage to link to the historical period. One theory suggests that dry rice sown with a digging stick into the ashes of a cleared and burned forest predates the cultivation of wet rice. The theory, which is based on traditional stories in Vietnam, that rice originated in the mountains and moved to the plains, may be challenged in terms of river valley based migration patterns, and the apparent absence of relevant historic sites in the mountains. Rice seed broadcasted into receding flood water areas was labour efficient, and probably became the earliest form of wet rice domestication[4] as a simple modification of primitive husbanding of useful plants in their natural environments.

Shifting cultivation in upland and mountainous regions of Thailand long predates that of today's hill tribe groups. The extensive use of fire in forest farming provided a labour cost-effective means of introducing root and tree crops, particularly along the water courses of lowland and contiguous rising regions before the creation of irrigation fields.[5] This contrasts with a common view that tending of seed plants in the North and Northeast may have in fact predated the domestication of the root

[2] Solheim, W.G. (1970)
[3] Jumsai, Sumet. (1997)
[4] Wyatt, D.K. (1989)
[5] Pelzer K.J (1978)

and tree crops.[6] From scant information, one can only conclude that fire-based shifting cultivation, long practised in Thailand, has little apparent association with the emergence of larger rice-based populations.[7]

Ban Chiang archaeological indicators of rice domestication are subject to some doubt about the differentiation of wild and cultivated forms of rice grains found in pots, and rice husks used to fire pottery. Nevertheless, cultivation of rice in southern China near Hang Chow has been dated to approximately 5,000 BC,[8] from vegetative layers up to 50 centimetres thick containing rice leaves, straw, husks, and grain. Vegetational change over the past 10,600 years, at least in southern Thailand, includes forest destruction phases more than 4,000 years ago which may indicate human activity, as it is associated with a rise in presence of *Artocarpus* pollens which are thought to have been a shifting horticultural product grown with dryland rice.[9] However, archaeological sites with rice-based agriculture seem to be more easily found than those of equally complex societies originating from other forms of agriculture.

Legumes and chickens may have been encouraged around dwellings by about 10,000 to 20,000 years ago which was around the time of linguistic and cultural differentiation of groups which had hitherto shared a common culture for up to 30 millennia. Subsequent defining characteristics of the cultures of Southeast Asia included rice consumption, associations with swine, chickens, and cattle, and water transport through outrigger canoes. [10]

Neolithic to Iron Age

The absence of one primary agricultural development site within Asia suggests domination by peoples already familiar with the crops of rice, millet, yam, taro and perhaps even a form of sugar cane. Domestic animals, chickens, dogs, and even cattle, probably expanded from coastal civilisations. The large grain cereals of these societies facilitated regular bulk production from minor manipulation of

[6] Gorman C.F (1971)
[7] Kunstadter, P. and Chapman, E.C. (1978)
[8] Labbe′, A (1975)
[9] Maloney, B.K. (1998)
[10] Wyatt, D.K. (1989)

the natural environment until a decrease in temperatures during the early Holocene period probably caused the disappearance of wild rice from some northern environments. The hot and humid areas further south then suited domesticated rice, especially seasonally flooded and natural swamp areas. The seeking out of these natural swamps with slowly receding water regimes characterised neolithic Thai agriculture.[11]

The relative abundance of Thai prehistorical information, and claims to be the source of plant domestication results from high levels of archaeological activity. For example, plants remains found in Spirit Cave in northwest Thailand which were once believed to be domestic rice are now generally considered to be the wild rice gathered by a pre-agricultural group.[12] Hunting and gathering communities of Thailand possibly survived through to the first millennium of the current era with some contact with agricultural communities emerging from about 3,500 BC. However, the then flooded areas of the Khorat Plateau do not seem to have been peopled by hunters and gathers, and archaeological sites dating from around 3,500 BC, which include bones of domesticated animals and rice husks, were possibly early agricultural communities which had migrated south in search of naturally flooding swampy soils suited to rice cultivation. The Khorat Plateau is considered to have been largely vacant until the late fourth millennium BC when technologies and crafts similar to those evident in Chinese and Vietnamese sites occur, and which are distinct from those of other sites in Thailand. Cultural influence along coastlines is suggested although the location of the coastline through these periods remains a matter of speculation.[13]

Thus neolithic Thai agriculturists co-existed with hunters and gathers for millennia as agricultural settlements slowly expanded and proliferated through population growth and migration.[14] Migrants from China by sea as well as down river valleys is suggested through the Khok Phanom Di site between 2,000 and 1,400 BC. Khok Phanom Di, now land-locked, was once an estuary with mangroves and fresh ponds suited to rice production with the benefits of alluvial deposition to maintain fertility. The Ban Kao culture of Kanchanaburi dated at 2,000 to 500 BC

[11] Bellwood, P. (1992)
[12] Yen D.E. (1977)
[13] Sternstein, L. (1964)
[14] Shoocongdea, Rasmi (1996)

further supports the likelihood of agricultural technology at least co-originating from sea migration. Linguistic analyses have then been used to posit that agriculturists of Austro-Asian languages groups came from southern China before the arrival of the first Austronesian speakers in southern Thailand and Malaysia in the first millennium BC. The prehistoric sites of the Northeast were possibly those of Austro-Asiatic speakers who were eventually assimilated into the southward migrating Tai peoples before the thirteenth century.[15] The association of rice with migration and development of larger communities, while tenuous from the scant available information, provides a common foundation to the agricultures of the major Kingdoms which subsequently influenced what became Thailand.

Domination of Rice

The diets of these early agriculturists of Thailand seem to have included peas, beans, cucumbers and water caltrops. By the time of the introduction of animal agriculture in the form of water buffalo to assist in rice cultivation, the diet may well have included deer, rabbits, pangolin, civets, and even rhinoceros, from the surrounding forests. Fish, snails, and frogs, and a range of forest derived plants, would have supplemented a diet to which domesticated pigs, cattle, and chickens would soon be added.[16] The use of buffalo for trampling and incidental fertilising of wet rice fields probably predated their use as a draught animals and, particularly in Tai sites, it would appear that their use for ploughing was associated with wooden rather than the iron plough-shares found in Vietnamese sites of a similar era.[17]

With such new technologies in agriculture, seasonal variations in rice yields could be reduced, albeit with increased labour inputs. However, with larger population densities supportable through these systems, division of labour, and increased efficiency for its use would soon develop through the iron age allowing further increases in settlement size. Prior to the iron age, three hectares (19 rai) seems to have been a maximum area for an independent site compared to more than twenty hectares (125 rai), possibly in association with reservoirs or moats, once iron was introduced. This more managed agriculture allowed the development

[15] Zide, A. and Zide, N. (1976)
[16] Rogers, P. (1996)
[17] Bellwood, P. (1992)

of politics, social ranking systems, and military organisation. Such developments in Thailand appear to have occurred independent of those of India or China although there must have been contact and exchange of technologies. This probably explains the use of iron in implements found at the Ongbah Cave and the Ban Don Ta Phet sites in western Thailand which date from about 100 BC and overlap with a period of increased sea contact with the subcontinent of India.[18] The demand for new techniques grew with the expansion of rice agriculture.

Once introduced, rice fed foreign contact and technological development. Chickens and pigs were raised in rice-based settlements although monoculture of sugar cane, yam, banana, and coconut was not practised. Sea trade widened technological awareness and food supply which allowed more free time for development of a society. Technical innovations of puddling, ploughing and even contrived annual replenishment of alluvium, led to a reliable form of low intensity Thai agriculture by the eighth century. The agro-economic base in the most developed areas by that time appears to have been rice, fish, and coconut as the preferred major dietary components with taro, yam, sago, and vegetables as supplements in times of seasonal uncertainty. The greater potential of the wet rice cultivation system to sustain the development of a civilisation was now clear.[19] The alternatives, hunting and gathering or reliance on another staple, could not have produced this situation. Hunting and gathering relied on small groups and low population densities. The best available alternative cereal was the widely adaptable species, millet which had predated rice as a staple throughout the region; however, its shifting cultivation prohibited large population concentrations with the labour economies of wet rice.

Not only did rice contain this potential which has so dominated the Tai and Thai views of agriculture, the wet rice cultivation system itself appears to be one of the most sustainable forms of agriculture. Continuous wet rice cultivation over long periods have been demonstrated in a range of countries and civilisations as a result of its flooded production.[20] While this condition is physiologically essential for only a small period of the growth of the rice plant, it provides other

[18] Bellwood, P. (1992)
[19] Hall, K.R. (1992)
[20] Pelzer , K.J. (1945)

benefits in terms of nutrition, suppression of weeds, and creation of a stable environment while leading to minimal changes in soil structure after an area has been developed into a paddy field.[21] The roles of soil reduction and nitrogen fixing organisms in the aquatic rice growing environment contribute significantly to the sustainability of the traditional form of wet rice cultivation.[22] Modern intensive productions systems do not share all of the attributes.

Today, agriculture in Thailand remains dominated by rice visually and culturally. The world's largest rice exporter, peopled by connoisseurs of rice varieties and quality, the symbol of Thailand is rice in many ways. Technologies rely on innovative adopters whose cultures affect and are affected by such adoption; knowledge of the ethnic and cultural origins and influences relevant to early Thai agriculture are limited, yet informative in a quest for the essence of Thai agriculture.

Early Thai Agriculturists

A bountiful land would inevitably attract immigrants. Thus Thai agriculture is traced from the earliest inhabitants through subsequent migratory waves introducing new technologies, absorbing those of past and existing cultures, while mostly remaining alert to the introduction of other new ideas. Such increases in efficiency may be interpreted as means of reducing agricultural labour inputs, for in this respect, Thailand's agriculture is unique; food surpluses appear to have been, and be expected to be, easily produced. Whether this attitude is climatically determined as is popularly assumed, or relates to the bounty of the land, or to the peoples of the land, some consideration of early Thai farmers themselves is warranted.

The hunting and gathering progenitors of Southeast Asian peoples were inhabiting small, relatively permanent sites around 40,000 years ago. The design of many of their bamboo and wooden tools can still be seen in today's utensils. With stone cutting implements other tools such as blowpipes, bows and arrows, baskets, and animal and fish traps were created.[23] Hunters and gatherers evolved

[21] Matsuo, T. (1961)
[22] Tanabe, S. (1994)
[23] Wyatt, D.K. (1984)

to today's Chao Nam, Phi Tong Luang, and Samang, now all marginalised groups who prefer minimal contact with the wider Thai community. The initial displacement of the hunters and gatherers was probably by the Austronesian migration from somewhere north of Thailand down through the east Indian Archipelago bringing the forebears of the people who later became the Malays.[24]

The environmental variations of the late Pleistocene period brought minimal effective changes compared to those which impacted on the peoples of Europe of that era. As a consequence, stone flakes indicating human activity dating back 40,000 years are widespread. The oldest dated so far on the Southeast Asian mainland appears to be between 37,000 and 27,000 years old, from the Lang Rongrien site in Krabi, Thailand. The post glacial expansion of peoples in western Thailand and northern Vietnam is so far untraceable until the agriculturists of some 5,000 years ago, such as those of the Khorat Plateau. Plant remains such as almonds, legumes, betel nut, butternut kernels, bamboo, gourds, but no millet or rice, have been found in sites such as Spirit Cave in north western Thailand, indicating that the Austronesian speaking agriculturists expanded across wide areas of Southeast Asia displacing the pre-existing hunting and gathering communities of the region.[25]

These early Thai agriculturists moved by water and land to settle in various parts of Thailand and surrounding Asia. For example, the Isthmus of Kra was an important trading site by about 350 BC on the basis of high agricultural productivity and convenient topography for surplus rice production, long before the introduction of canal based irrigation systems. The trading culture of the Isthmus of Kra was part of Funan Chinese influence which extended from the Mekong River mouth to Kra along the coast. By the third century, Chinese, Persian, and Indian traders were prevalent in these sites.

The Indian origin of writing for the region is evident in accounts of the regularity of the rice surpluses.[26] Fragments of Funan records describe the inhabitants of areas now in Thailand in a manner suggestive of Austronesians, and also describes their honest nature and devotion to agriculture. Noting that… *they sow one year and harvest for three*, … records also indicate the people's involvement in ornamental

[24] Donner W. (1978)
[25] Bellwood P. (1992)
[26] Hall K.R. (1992)

engraving, silver utensil production, and trade in gold, silver, pearls, and perfumes. Later documents suggest Mon and Khmer residents elsewhere in Thailand, although the influence of Funan beyond coastal areas appears to have been minimal and their understanding of changes inland was probably limited.[27] Other Chinese records nevertheless do confirm the existence of significant cities in the Chaophraya Basin from the seventh century, particularly around Nakhon Pathom and the Golden Cradle, U-Thong.[28]

Early settlement of U-Thong, probably from the first century BC, suggests the emergence of irrigation canal engineering skills in Thailand.[29] A thirteen kilometre straight geological formation running east from U-Thong to, what would have been at that time, the head of the Gulf of Siam suggests separate development from coastal trading settlements. The ability to control water links directly to the subsequent Khmer Empire and suggests that the intervening Dvaravati cultural period of Thailand probably focused more on trade than political domination.[30]

The Dvaravati culture appears to have arisen between the sixth and ninth centuries based on Buddhism, the Mon language, and overland trade between the Gulf of Martaban and the Gulf of Siam via the Three Pagoda Pass. More a civilisation than an Empire, no capital is known to have existed although archaeological sites appear to be densest around the fringes of the central plain. Sites fan out from those around the Gulf along trade routes to Myanmar, Cambodia, Chiang Mai, towards northern Lao-PDR, and northeast towards the Khorat Plateau. Frequent finds of foreign objects provide further evidence of the trade orientation of the civilisation. Foreign ideas, tools, and innovations flowed speedily along trading routes and demand for agricultural produce stimulated the testing of new techniques for producing food surpluses.[31] Lasting until the eleventh or twelfth century, Dvaravati influence is otherwise poorly understood. Ethnically it is suggested that it was controlled by peoples of Mon[32] or Mon-Khmer origin although there appears little supporting or contrary evidence.

---

[27] Rogers P. (1996)
[28] van Beek S. (1995)
[29] van Beek S. (1995)
[30] Rogers P. (1996)
[31] Wyatt D.K. (1989)
[32] Guillon, E. (1999)

While the Dvaravati Empire is difficult to define, the production of the centre of U Thong contains evidence of its Mon origin, Indian influence, and ability to absorb diverse pre-existing cultures, migrants, and seafarers, such as from the Funan trading sites. Its culture appears to have extended beyond its governed realm, interfacing easily with the expanding Khmer culture. It was around this time that migration from southeast China and Vietnam introduced domestication of the water buffalo which displaced draught cattle and ultimately assisted expansion of rice production within the Chaophraya Delta.[33]

Meanwhile, the coastal exposure of the South continued to provide separate development options. By the sixth century a widespread network of agricultural communities existed in Pattani and Yala as much as they did in the North, Northeast, and Central Plain. The cultural differences of the South today reflect these different origins, and histories, even in some agricultural practices. However, the Central Plain has long been a focus of the region, both because of its subsequent history and its potential, which was clearly apparent to Indian Missionaries who, in the third to second century BC, named the region linking southern Myanmar, central Thailand and eastern Cambodia, Suvannabhumi, Land of Gold. Through this period the central cities of importance appear to have been Suvannbhuri, City of Gold, and U-Thong, Cradle of Gold. Upland river valleys in the west and south west leading into areas of northern Lao-PDR and southern Yunnan remained sparsely populated by the aboriginal Austronesian or Austro-Asiatic speaking groups, possibly ancestors of some of today's hill tribes. These peoples were poorly equipped to deal with the technologically superior wet rice growers.

Wet rice irrigation probably evolved to river off-takes to augment natural pondages. Ponding and canalling of water to maintain a stable rice growing environment would have been an easy development, with rice terraces evolving as an adjunct of nature's own micro-environments. In contrast to this hydraulic domination, populations closer to the sea where water was abundant and hence did not need to be conserved, or in the delta where water remained mainly uncontrollable, adapted their lives to the flux of water and its control.[34] In all

[33] Suchitta, Pornchai (1989)
[34] Jumsai, Sumet (1997)

cases, life in Thailand was increasingly dominated by water; the name *Sayam* or 'Siam' may have even contained the meaning of 'people of the river'[35] or 'water people'.

Migration has been the hallmark of the development of Thai agriculture. The earliest inhabitants provided inputs to today's Thai agriculture, notwithstanding their demise as migrating agriculturists gained influence. The initial wave of Austronesians into what is now Thailand was subsumed by the next migration of the Mon-Khmer, probably from northern India, supplemented with other tribes from Indo-China, while coastal areas were influenced by Chinese, Indian, and Arabian trade. By the time peoples of the Tai ethnic group with their own unique skills in irrigation arrived in numbers, much of the scene for future agricultural development had been set. A further migratory wave of the Tibeto-Burmans is today represented by the Lahu, Lawa, and Karen ethnic groups which began migrating before the influx of Tai people to Thailand with subsequent migration occurring into the present century.[36] Chinese immigration in the nineteenth and twentieth centuries maintained the pattern of introducing new agricultural technologies to Thai agriculture. The amalgam which is today's Thai agriculture may thus be seen as a reflection of the unity within ethnic diversity of the country and its openly assimilatory culture.

Within the first millennium, inland communities had discovered means of reliably producing rice surpluses and within centuries, organisational skills to continually increase surpluses would allow the emergence of the Khmer Empire centred at Angkor. Technologies developed through Khmer agriculture provided the next major fillip for Thai agriculture.

Khmer Agriculture

The agricultural settlements which gradually displaced hunters and gatherers grew to agricultural cities, some of which were subsumed into the emerging State-religious Empire of the Khmer. Such agro-cities required an assured rice production base, which in the case of the Khmer, relied on supplemental water

[35] van Beek S. (1995)
[36] Donner W. (1978)

management, and appropriate rice varieties. Judged by today's standards, such systems might be considered sustainable within the parameters of technical applications, and they did last for centuries before finally failing. In the event, Khmer wet rice culture proved less sustainable than the pre-Green Revolution river-basin wet rice systems of the Tai and others.

An indication of the probable distribution of prehistoric villages and patterns of agro-cities in natural floodplains of what is today Thailand are presented in Figure 2.1. Onto these, the sophisticated Khmer society grafted its culture. The flood plains, complemented with grasslands which included clusters of wooded vegetation, and the mangroves both in inland freshwater areas and along the coast, provided a genesis of agriculture in Thailand and formed the basis of its subsequent development. The original dense forests of the hills and mountains, the thorny scrub of the rain shadow areas, and hard laterite crusts, on the other hand, were of little interest to early and later agriculturists alike.

Agro-cities in the shallow and gentle floodplain areas have been found in

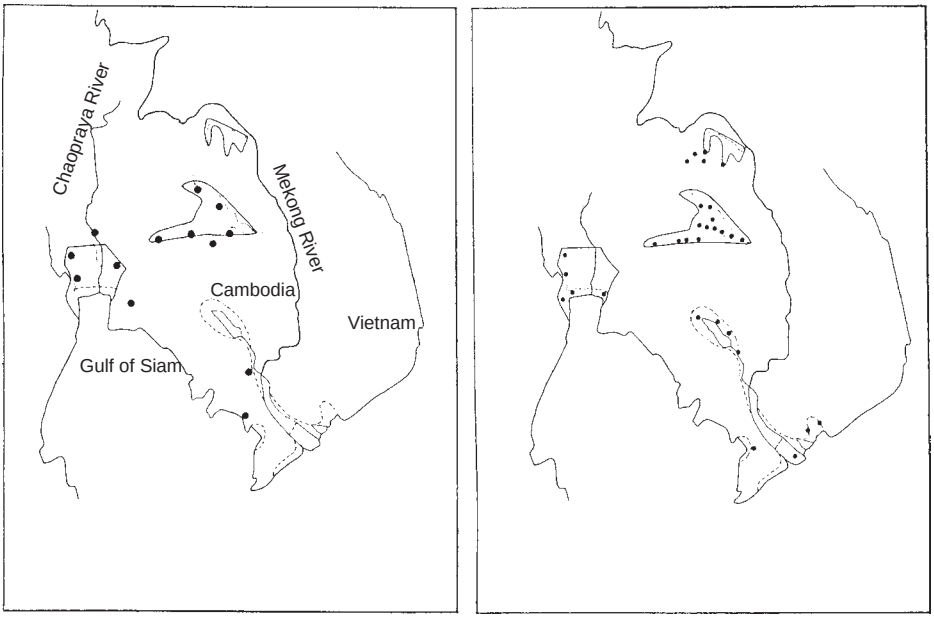

Figure 2.1 *Probable Pre-historic Village (right) and Agro-city Sites*[37]

the central plains around the delta of the Mae Klong River, an area now dominated by sugar cane on the higher ground and rice in the floodplains. The cities of Nakhon Pathom and the agro-cities of the Northeast on the Mun-Chi River floodplains were likewise located on the basis of reliable flooding areas, in contrast to river bank developments in many other areas of the world. The agro-cities apparently extended through the Mekong River delta in what is now Cambodia and Vietnam.

The transition from agricultural settlements to agro-cities[37] arose from the apparent abandonment of prehistoric villages and concentration into larger settlements, often surrounded by more than one moat with radiating canals. The agro-cities were overwhelmingly associated with the gentle flooding regimes around the boundaries of large flood plains. This significant change in settlement patterns was associated with the adoption of monocultural flooded rice production which reduced labour inputs and risk compared to that of the smaller agricultural settlements. Nevertheless, the significant individual earthworks undertaken appear to have been related to governance within each agro-city without coordination across a wide area. Many of these large settlements contained no religious edifices and hence the term 'agro-city' has been adopted to indicate this stage of agricultural development prior to the emergence of religious States.[38]

In the ninth century, the civilisation of the north western shore of the large natural overflow reservoir of the Mekong River, the Tonlesap in Cambodia, grew to dominate the areas including much of what is today Thailand. Rice fields around the edge of the Tonlesap, down into the lower reaches of the Mekong River, and into the Mun and Chaophraya basins, allowed the Khmer Empire to establish itself with rice as the primary source of growth and wealth. Earlier sites along the coast between the second and sixth centuries had been based on the China-India trade routes which had a landing point in what is now Cambodia linked to the Kra Isthmus land connection. Whether it was a natural limitation of growth of the several small trading cities, or shifts in trade which restricted the growth of the coastal cities, is rendered less relevant by the fourth century technology which allowed ships to sail at a greater distance from the coast and thus only call at major

[37] van Liere, W.J. (1989b)
[38] van Liere, W.J. (1989a)

trade centres. However, the emerging dominance of an inland over a coastal culture hailed the consolidation of an agriculturally powerful region with the effect that hinterland agricultural cultural origins have blended with coastal cultures in the modern Thai culture. Thus the centrality of rice was confirmed.

Various Khmer attempts to consolidate power were constrained until they understood the central significance of a secure rice supply. This allowed, with foreign religious influence, the development of a State-religious Empire in which temples owned land and agrarian workers contributed labour motivated by both coercion and future spiritual reward. The Empire eventually crumbled from within, as a result of, among other factors, alternating strong kings and interregnal disorder which disrupted maintenance of domestic water systems which incidentally served rice production. Policies to ensure rice surpluses were also negated. Around the same time an increase in trade and commerce may have encouraged the disillusioned Khmer to abandon the high cost and increasingly difficult to manage site of Angkor in the 1430s in favour of better sites for trading; such an alternative theory to the fall at the hands of advancing Tai military force seems consistent with the likely limited organisational capabilities of the Tai at the time.[39] The Khmer Kingdom, an antecedent to the Thai culture, supported a population in excess of one million in its Angkor capital at a time when the Norman army marched on the city of London and its population of 35,000. The agricultural system to support this major world centre required skilled engineering and agronomy.

The Angkor agricultural system was based on the natural rise of flood waters and their rapid recession in the Tonlesap, and their supplementation by a network of dams and bunds to divert or retain receding waters. No large dam technology is evident. Phnom Kulen, approximately fifty kilometres north west of Angkor was the centre of the water management network, which as the civilisation evolved was increasingly dedicated to religious and domestic water supply purposes. Control of land as well as water was essential to the development of the Empire. Landed elites donated their land and its farmers to the temple and registered these transactions for possible spiritual and probable commercial gains. Control of labour and production, including management responsibilities, seems to have been handed to temples while the donor continued to retain a percentage of the harvest.

[39] Taylor, K.W. (1992)

Donations also included domestic stock such as cattle, buffalo and goats, tree crops such as coconuts, fruit, areca nuts, and other agriculturally related items such as threshing floors and clothing. Concentration of economic power in the temple consolidated political development, which in turn was reflected in agricultural legislation, for example, a tenth century edict concerning negligent grazing of buffalo in proximity to rice fields. The King, difficult to separate from the temple, retained the right of ownership of all unused and unallocated land and could also influence ownership rights in all areas. The Thai system was to retain these elements centuries later.

Thus the temple was the central agricultural institution. As a source of investment it was the agricultural bank. It had the capital and land, and increasingly became the repository of technical information for agriculture itself, albeit with a cosmological emphasis. The temple managed agricultural labour, including war captives, through promises of spiritual rewards as they opened unpopulated lands donated to the temple. The water management system required large infrastructure to control receding floodwaters, and for canals to supplement irrigation, and thereby proscribed small private agricultural producers, who would have in any case been inconsistent with the evolving political system.

By the twelfth century, the Empire was producing around 38,000 tonnes of hulled rice each year[40] for the Pra Khan temple complex from a system with no formalised bureaucracy but simply a temple-King assignment of land rights balanced with spiritual and subsistence rewards to the poor. The King, as the largest land owner and the temple as the owner of labour led to easy accommodation of the God-King system compatible with the adopted Indian religions of Angkor.[41] Inscriptions from the ninth to thirteenth centuries proclaimed the King as both creator and director of public works which irrigated some five million hectares (31 million rai),[42] incidental to providing water for domestic and religious purposes. The water system has been termed 'theocratic hydraulics' as many water sources were, latterly at least, of symbolic or religious importance rather than having been designed for a central irrigation purpose. Through this period, Angkor was known through the region for its 55 million rice fields.

[40] Hall, K.R. (1992)
[41] Hall, K.R. (1992)
[42] van Liere, W.J. (1980)

The Khmer selected sites for high labour efficiency in the simple rice water management system. The sites themselves suggest use of rice varieties with relatively low water requirements and probably modest yields. Ranking reliability of production over maximising yields reflect the limitation of the water management systems, and the State's emphasis on stability of production, an approach which flowed into Thai agriculture and politics. As the Khmer Empire waned, Sukhothai, one of its outposts, was progressively dominated by Tai whose own irrigation technologies had been integrated with those of the Khmer. However, infrastructure developed for agriculture is now difficult to discern from other purposes.

The Sukhothai and Sisatchanalai sites in northern Thailand include a 100 kilometre long earthwork extending as far as Kamphaengphet which was probably a flood-controlling barrage. The two fifty-five and sixty-eight kilometre constructions are not considered to have been a canal even though Sukhothai hydraulic engineers are known to have gained considerable experience in canal construction by this time. Nevertheless, they avoided attempts to manage the major rivers and areas subjected to deep inundation, concentrating on diversion of flood waters. It was the Tai who mastered the management of water directly from large rivers such as the Ping at the Kamphaengphet site.[43] A barrage construction also serving as a road would have assisted Khmer management of regions away from the Sukhothai and Sisatchanalai complexes; one may assume that such developments reflect a mode of extending Khmer political influence and incidentally an approach to agriculture. The significance in barrage construction to Thai agriculture lies in its blending with Tai irrigation systems for eventual control of the waters of the Central Plain.

The construction of urban dams and dykes by the Khmer appears to have been based on gravity feed tanks feeding fields via canals with water control managed through wooden sluice gates.[44] That these are considered by most observers to have been oriented to religious purposes may hide an earlier agricultural purpose overtaken by the religious State. Nevertheless, rice culture in the Khmer period seems to have been simple and reliable, and was probably only marginally dependant on the major water works presented in Table 1.

[43] van Beek, S. (1995)
[44] Murray, S.O. (1996)

Table 1 *Water Related Construction Sites of the Khmer*

Name	Size	Comment
Indratataka		Reservoir built 877
Yashodharatataka	30,000,000 cubic metre	Also linked to modification of the
(eastern Baray)	reservoir	course of the Siem Reap River.
Rahal	360 x 1,200 metre.	Built on tributary of the Siem Reap River south east of Prasat Thom.
	40,000,000 cubic metre capacity	Largest of all Khmer reservoirs; eastern section silted.
	Up to 14 x 100 metre brick ponds and fountains.	Fed by Siem Reap River and rain water; drinking, fish ponds and bathing.
Jaytataka	900 x 3,700 metre.	Designated the holiest of the waters.
(north Baray)		

Much of the information concerning Khmer agriculture and life is derived from Zhou Daguan, a Chinese adventurer who wrote of his visit in 1296–1297. From his descriptions and other evidence we know that rice was hulled through bruising with mortar and pestle rather than by grinding stones, and that women were a dominant part of agriculture, and in particular trading. Small trading transactions at the time were effected through barter of rice, cereals, and objects from China, medium sized transactions included fabrics, and large transactions included gold or silver. Such a civilisation required a sound land use and food production system.

The Khmer land use system was an evolution of India's as an adjunct to the religion. Initially and for some 400 to 500 years, rice production was based on the use of naturally flooding areas. Forested areas were lightly used until the later large Empire converted forests to bunded rice fields. Resulting square rice fields and bunds suited an overall auspicious shape for city layout, possibly planned with a cosmological intent. The clearing of forests for rice and city development limited water run-off through the millions of paddy fields, retained wet season silt in these fields and in canals and reservoirs, and changed soil chemical and physical characteristics in paddy fields on a scale hitherto unknown. The wetting and drying of soils allowed reduction and oxidation of silica among other soil components, increasing crystallisation and hence the sand component of the soil profile. Agriculturally generated environmental change, in some cases irreversible, appears to start at this stage of Thai agriculture - around 1,200. Nevertheless, wet rice cultivation under the different Tai traditional conditions continued to yield

satisfactorily on such impoverished soils for centuries because of the essential benefits of the modified aquatic environment for the rice plant.[45]

Khmer influence on agriculture extended beyond techniques adopted by the Tai as it extended deep into the psyche of the persons that would assume the Khmer cities of Lopburi, Ratchaburi, and Muang Singh, among others.[46] The slow immigration of Tai from the north down the river valleys led to a significant number of Tai persons in the Khmer Empire. This force may have developed influence and seized an opportunity at a time of weakness of the Khmer Empire in outlying Sukhothai as the Empire began to decline after 1,150 when massive investment in construction and deification of kings, caused neglect of water management and food production. Canals accumulated silt, and rice production plummeted, forcing large scale emigration to other flood plains in the Mekong delta system.[47] The imposts of malaria and Tai attacks possibly hastened the final rapid fall of the Empire.[48]

The Khmer Empire provided a pervasive Indian influence in religion and culture which continues to flow through Thai agricultural development and culture. Through much of the Khmer period, a parallel although technologically different form of agriculture evolved to the west centring on Pagan.

Pagan Agriculture

Khmer influence from the east met Mon influence from the west in what is now Thailand. This Mon-Khmer culture, with Tai infusions, represents the source of Thai art and language, and likewise of Thai agriculture. While the Khmer Empire developed large State-religious edifices, the ancient Mon culture within Thailand was less well represented architecturally and as a consequence, is less well understood.

Mon-Pyu authority across large areas of Myanmar was interrupted by immigrants displaced from Nanchao in southern China who possibly assumed the

[45] van Liere, W. J. (1989)
[46] Rogers, P. (1996)
[47] Rogers, P. (1996)
[48] Groslier, B.P. (1962)

power of the Pyu from about the ninth century. As a consequence, the Mon centre on the coast at Thaton fell and the Mon migrated predominantly to Pagan. The Pagan Empire of the Mon, who united with the Pyu and Burmans from about 1,200 to repel invasions from both the mountains and the seas, was based on an agriculturally sufficient Empire located in the dry zone on the banks of the Irrawaddy River. The initial headquarters was between the two rice production areas of Minbu and Kyaukse, both of which had extensive irrigation systems. Pagan's success relied on its ability to mobilise agricultural resources and, in common with the Khmer, develop an inland rice-based culture which overshadowed coastal trading cultures. Pagan also developed monumental religious sites, at least in its immediate area of control. By the thirteenth century, various power struggles, including land control issues within the monkhood, led to the establishment of a new Mon Kingdom at Pegu.[49]

The period known as Dvaravati in Thailand had also been linked to the rise of Mon influence from the west. Intensification of iron production and probably of copper, lead, and silver, indicate an advanced culture which enabled such architectural feats as the first large *chedi* constructed at Nakhon Pathom. The attraction of the region appears to have been the consistent ability to produce surplus from relatively low labour inputs. This stability and wealth stimulated trading in food and forest products through Thailand and brought new ideas and technology. Named from a coin found at the site, the major Dvaravati centre appears to have been at Nakon Pathom utilising the city's then coastal location to combined the benefits of regular agricultural production and trading access to the protected Gulf. Other Dvaravati sites in Thailand include U Thong, which was probably a sub-centre of Nakhon Pathom, Kubua south west of Nakhon Pathom with access across the Tenasserim mountain range to Mons in the west, Khao Ngu caves in Ratchaburi province, and overland routes through Petchaburi and other centres in the south of Thailand.

The pre-existing agro-city of U Thong is thus a probable site of agricultural technology transfer starting with trade and contact with overseas powers in the second century. Rising population stimulated the development of a more suitably located city at Nakhon Pathom, which was known to be well established by the end of the sixth century. By the seventh century, the three important cities of

[49] Taylor, K. W. (1992)

Nakhon Pathom, U Thong and Kubua provided the western interface[50] to a rising Khmer culture which produced the Mon-Khmer period of Central and Northeast Thailand, with effects in the North, east and the South. Khmer suzerainty over Mon Kingdoms in the North and South were complemented by working relationships in areas of central Thailand. Throughout this period Tai were increasing in number through continual southward migration. Insignificant at first, this tribe was to become important as an integrator of agricultural and other technologies across the region. The first indication of a rising political ambition of the Tai appears in this disjointed history of Myanmar.

Neither the Mon nor the Burmans appear to have been interested in the upland valleys of the Shan States which were being populated by Tai. The Mon culture was largely absorbed into other cultures including the Pyu, Burman and Khmer as a result of its inferior military force in the ninth and tenth centuries when the Kingdoms of Myanmar were smaller than that of the Khmer. A strong military pressure from Nanchao from the mid-eighth century until the mid-ninth century accelerated the demise of the Pyu State at Prome and Shwebo allowing Burmans to move into the extensive irrigated rice lands of the Mandalay region. The relatively smaller new State at Pagan developed from the mid-ninth century coincided with the new Mon Kingdom which was developing at Pegu.

Through the ninth and tenth centuries, Tai were living in the relatively peaceful river valleys between the major States that surrounded them. However, various military drives through these valleys from Nanchao, Burman, Khmer, and Vietnamese interests inevitably led to Tai being pressed into Nanchao and other armies; as war captives, slaves, traders and religious pilgrims[51] they began to learn of wider world. To this stage the Tai, had not yet featured in Southeast Asian history, although their technologies developed in managing rivers were to prove critical in assuming a political profile upon the demise of the Mon-Khmer.

The influence of the Tai in the Burmese centre of Pagan rose around the thirteenth century when Tai Shan from northern river valleys assisted the then weak Pagan to repel the Mongols. In helping the Pagan kings, the Shan gained sufficient

[50] Saraya, D. (1989)
[51] Wyatt, D.K. (1989)

influence to assume power. The subsequent establishment of the centre at Ava adjacent to the Kyaukse rice fields and the Mon centre at Pegu was one of the first mixed Tai States. However, their power was balanced against the other closeby independent Kingdoms at Arakan and Prome.[52] Further information about Tai peoples and these Kingdoms is limited; early Shan contact with Pagan was probably as slaves and soldiers, which accounts for Tai presence down to the Isthmus of Kra as part of the twelfth century campaigns of the Burmans against the Malays.

The irrigated agriculture of the Mon and Burman cultures complemented that of the Khmer. They included canal irrigation associated with major rivers across ancient alluvial flood plains. Tai with their small *muang fai* river valley irrigation[53] systems were to learn from this for their eventual domination of the delta. With the rise of the inland agricultural Kingdoms, coastal regions remained exposed to foreign trade and ideas, with the South, through its strategic location, receiving quite different influences from the inland regions of what is now Thailand.

Southern Thailand

The agriculture of southern Thailand has been historically determined by the sedimentation of clay and mud in this relatively young geological area. As soils determined the patterns of agricultural settlement, the geographical location of trading centres and subsequent Indianisation follows the development of agriculture. Variations in rice cultivation methods across southern Thailand reflect its many micro-environments, as well as variations in cultural influences associated with trading and migration.[54]

Sea trade routes and the narrow land connection across the Isthmus of Kra shaped further development of the South. With new nautical technologies in the fourth century, trade via the Straits of Melaka led to Palembang and Sumatra becoming a major trading centre, incidentally attracting Buddhism and Chinese culture. The Malay-controlled trading system was managed on a cooperative basis which attracted avaricious invaders including Javanese and Tai who sought to

[52] Taylor, K.W. (1992)
[53] Surareks, Vanpen. (1998)
[54] Trebuil, G. (1984)

vassallise the Malay rulers of the Straits region.[55] The rich archaeology of the ceremonial centre Palembang derives from its regularity of rice production from extensive rice fields. Gaining further influence through international trade, it traded and dominated the Srivijaya Kingdom of Java. The Majapahit State of Java relied on a decentralised agrarian culture which was unprepared for the dealings of wealthy commercial centres which its own wealth had helped to create. Such transition from food security through agricultural Kingdoms to domination by trading powers flows through Thai agricultural and political history.[56]

The agriculture of the South therefore combined technologies from Java, Malaysia, India, and China from extensive trading connections. Technologies emanating from Java and Sumatra, which differ from the rest of Thailand are still evident today, such as rice harvesting techniques. The first Tai may have reached southern Thailand as soldiers or slaves from Burman armies, or have been attracted from Khmer-dominated Thailand by the trading wealth of the south. Their influence in the South was to become significant in the fourteenth and fifteenth centuries, by which time Melaka had instituted a modified version of the Srivijaya model to accommodate Chinese protection from invading Tai. By the fifteen century, rulers adopted Islam. Prior to these developments, a rapid rise of Tai power in Nakhon Si Thammarat occurred in the thirteenth century to subjugate Khmer, Malay, Burmese, Mon, and south Indian rulers in what was probably the major centre of the region. Nakhon Si Thammarat had become at that time a major centre for Theravada Buddhism, being the point from which monks carried this new message to the Khmer-Angkor Empire, Lopburi, Sukhothai, and elsewhere.[57] The rise and fall of such Tai influence remains an anomaly, except as an illustration of the rising influence of Tai across wide areas of Southeast Asia. Perhaps, alternative explanations of the origins of the Tai people's[58] and Asian settlement[59] have something to add to future interpretations.

To this stage, no Tai ruler had developed a centralised means of governance which could incorporate remote territories. Individual principalities

[55] Taylor, K.W. (1992)
[56] Hall, K.R. (1992)
[57] Wyatt, D.K. (1984)
[58] Jumsai, Sumet. (1997)
[59] Oppenheimer, S. (1999)

remained the basis of Tai governance, and yet their widening influence suggested that, with control over manpower, the Tai could establish a State. In a region with surplus agricultural production capacity, manpower shortages defined military and State infrastructure requirements. Harnessing these resources was to prove the essence of forming a Tai nation, provided sound agricultural management remained the central focus.

Summary

Key points pertinent to Thai agriculture which may be elicited from this introduction of its origins include:

- The origins of Thai agriculture are part of a wider Asian agriculture, known through various archaeological sites many of which are in modern Thailand, and indicate a slow domination of hunters and gatherers by migrating agriculturists who had determined means of encouraging reliable production from a crop which suited the tropics after climate changes, wet rice.
- Rice dominated and became the preferred staple over the previously domesticated millet, and technologies which exploited natural recession of flood waters allowed experience to innovate rice production towards a controlled environment production system and so to provide a reliable food base for the development of agro-cities and then State-religious Empires, most notably that of the Khmer.
- While these Empires managed their agriculture well, security over rice production allowed inland cities to become more influential than coastal trading centres, except in the South; the differing agricultural technologies of the eastern Khmer, western Pagan, and increasingly widespread Tai among others, provided for a future interaction which would expand agricultural production across the region.