Traditional Water Management in the Lower Mekong Basin
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W. J. van Liere

Introduction

Water management is difficult in the flat lowlands of the large monsoon rivers, since these lands are subject to an annual cycle of flood and drought. Yet, in the case of the Mekong River and its tributaries, it is precisely on the lowlands that highly developed civilizations came into being (fig. 1). These civilizations had their economic base in agricultural productivity, which was achieved through water management. The millions of small plots, neatly levelled and bunded to keep the rainwater on the land, and the thousands of small devices to manipulate water in the wet season at village and farm level, reshaped the lowlands of the lower Mekong Basin, and of many other rivers in south-east Asia, transforming them into productive, well populated human habitats, truly man-made landscapes.

This is in great contrast with the tropical zones of Africa and much of South America, where the lowlands have never been reclaimed and agriculture has been confined mainly to uplands with usually poor and transitory forms of agriculture. Thus, south-east Asia is an exception. Why? Is it that the wild ancestor of rice, the staple food, was present in the area? This is unlikely. Botanists agree that, although wild members of the *Oryza* family occur all over south-east Asia, the ancestor of the domesticated species *O. sativa* originated further north, in a belt stretching from southern China through Assam to northern India (Chang 1976: 143).

Nor is it true that soil conditions, in the lowlands of the lower Mekong Basin at least, are more favourable than elsewhere in the tropics. These lowlands, although of smooth topography, are not at all uniform. Several morphological elements can be recognized. First, there is the channel or channels of the main river, with adjacent levees or river bank deposits. Then, behind the river banks, are the back swamps, connected with the main channels by distributaries and acting as natural flood regulators when the monsoon river rises rapidly. Back swamps are very common in the lower Mekong Basin. They vary greatly in size, the largest being the Great Lake in Cambodia, which covers one million hectares when the Mekong is in flood. Around the back swamps are the alluvial plains and low terraces. The latter are remnants of the alluvial plains of successive older generations of the river.

Alluvial plains are intermittently flooded in the rainy season, while the low terraces are normally not flooded at all. Away from the alluvial landscape are the uplands and hills.

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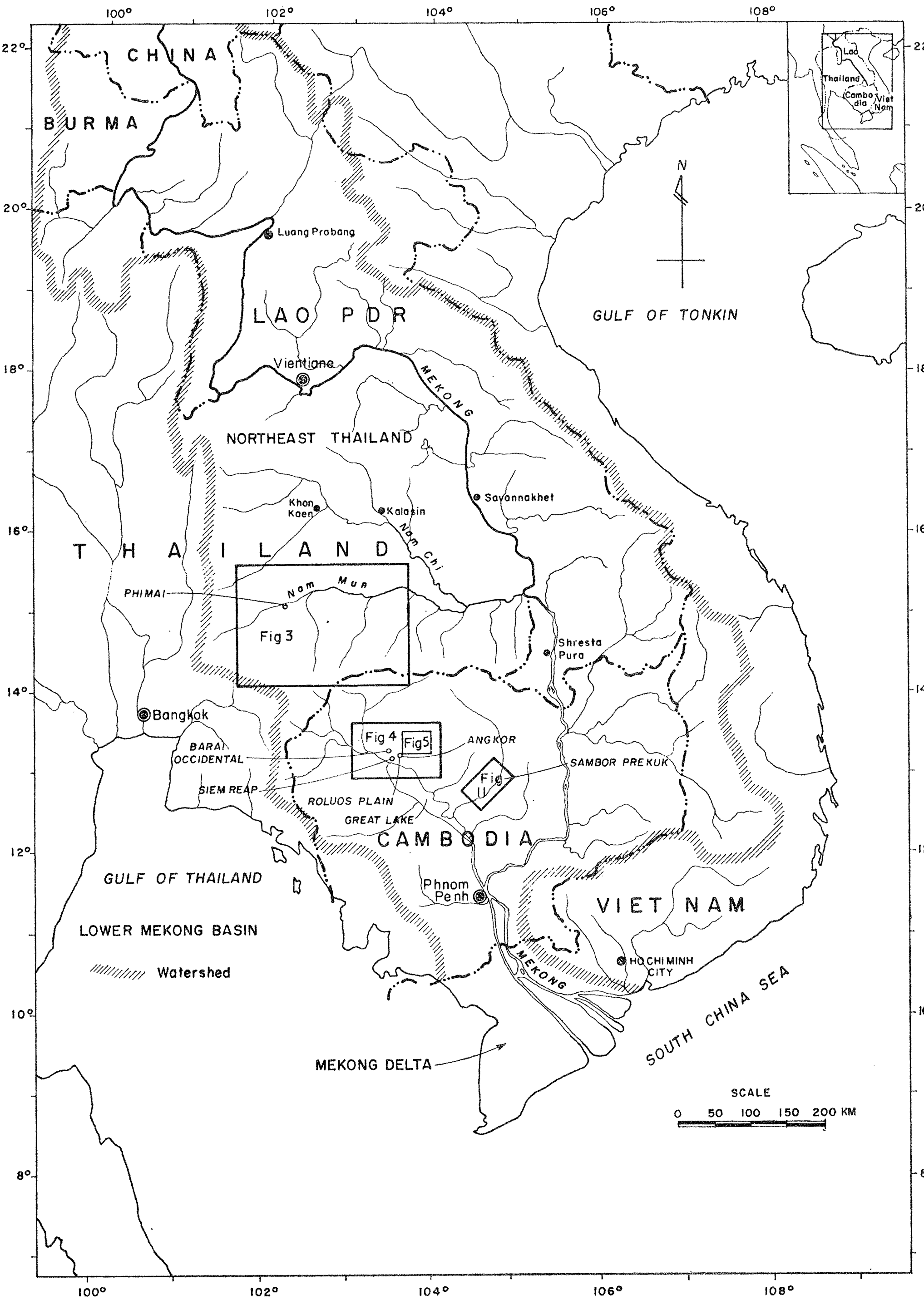

Figure 1 Index map showing location of places and figures in the text

Natural vegetation, successive phases of settlement and traditional water management techniques are all closely related to the morphological elements of the landscape.

As far as natural vegetation is concerned, the original landscape can still be reconstructed with a fair degree of accuracy through the study of relics of natural vegetation and of soils and hydrological patterns. Dense evergreen and mixed deciduous forests would have covered the hills, particularly the flanks with high rainfall, as well as valleys and lowland terraces with fluctuating groundwater tables near the surface. Dry deciduous forests, and sometimes pines, thrived on plains and plateaux with mature lateritic surfaces and on sandy soils with low water-holding capacity. The wide flood plains carried a grassy type of flooded savannah vegetation. Finally, the riverine and tidal lands were overgrown with dense, inundated riverine and tidal forests. This is the general setting, schematically represented in fig. 2.

It can be seen that vast floodplains with open savannah vegetation existed in the Mekong delta and in the Mun-Chi basin in north-east Thailand.

The non-inundated plains and low plateau lands of north-east Thailand, Laos and Cambodia carried an open, dry deciduous vegetation, alternating with dense gallery forests along the streams and on the many low hills. Freshwater mangroves were (and still are) found around the Great Lake and in the backwater areas of the distributaries in the Mekong delta, formerly merging into salt water mangrove and associated woody vegetation of the coastal belt.

Three main successive phases of settlement can be distinguished in this environment. Pre-historic settlement is common near the backswamps. However, no pre-historic water management works are known from the lower Mekong Basin and, therefore, the period is not further considered here.

Early floodland rice farmers preferred the alluvial plains watered by natural flooding. The later, bunded-field farmers reclaimed the heavily forested low terraces, transforming them into anthropomorphous landscapes. These periods are discussed here below.

The floodland farmers

During the early centuries of our era, two main areas in the Mekong Basin, namely the Mekong delta and the Mun-Chi river basin in north-east Thailand, had been settled by farmers growing broadcast rice watered by natural flooding.

Three factors dominated the choice of sites of these early Mekong farmers: year-round availability of usable water, ease of reclaiming the land, and a gentle flood regime. However, areas that have water near the surface year-round are usually covered with dense vegetation, and are thus difficult to reclaim. And as a rule early farmers tried to avoid the strenuous labour of clearing densely overgrown lands; they appreciated the value of farm systems that required little or no labour.

The zone of dense mangrove vegetation along the coast of the Mekong delta, and extending inland along river branches and tidal creeks as freshwater mangrove, was not considered fit for settlement. Further inland, the natural levees were equally avoided, no doubt because of their dense cover.

The floodlands of the Mun and Chi in north-east Thailand are dotted with village

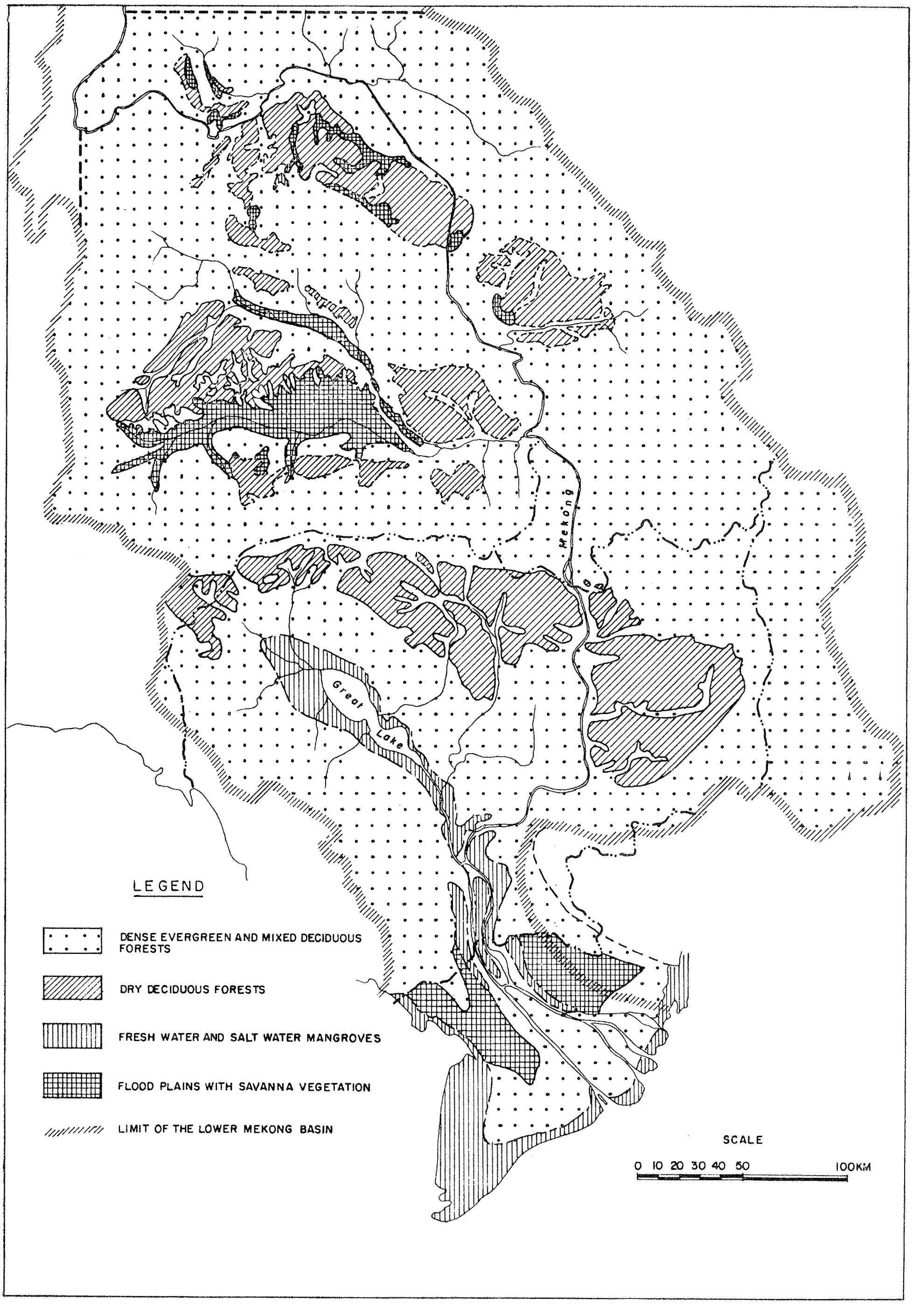

Figure 2 Reconstruction of the natural environment of the lower Mekong Basin at the dawn of history

sites (Thiva and Srisaka 1972). These villages were abundant in areas where the floods rise and fall gradually and on lands which are not too deeply flooded. This is particularly the case on the wide floodplains of the Mun River (fig. 3). The occurrence of these villages almost exclusively in floodlands with gentle flood regimes is a sure indication that the villages had flood rice. This type of rice can be broadcast (as is still done in certain areas), needs little land clearing, no levelling or bunding of the fields and requires little land preparation, and this is undoubtedly why the early rice farmers settled in such a narrowly restricted ecological niche. It also explains why population could grow so suddenly once flood rice came into use. It is the period of early urbanization.

A fair number of written records, dating back as far as the third century, have come down to us from Chinese pilgrims travelling to and from India and from Chinese histories recording the exchange of embassies between the early states and China. These accounts describe the many city states that then existed. Modern aerial photographs locate these city states with precision.

The early floodland farmers became quickly Indianized, even in remote corners such as the Vientiane plain in Laos. Undoubtedly the Indian religions were introduced by the rulers of the day and were economically sustained by the large agricultural surpluses produced by flood rice. Following this adoption of Indian religion, the early urban civilization produced masterpieces of religious art in stone, clay and wood that have never been equalled, not even in the later, more sophisticated, structured and prosperous Angkor period. In north-east Thailand early Indianization is characterized by a peculiar form of worship, reminiscent of a pre-historic culture. Hundreds of upright stones, erected to mark sacred areas, witness the ancient tradition. Many of the stones are decorated and the decorations denote, without exception, the worshipping of Hinayana Buddhism (Srisaka 1975). The stones are still regarded as sacred objects, although their cultic function may have changed.

These early farmers left us a record of an astonishing feat of resculpturing the landscape. They dug canals and moats of colossal size, even by today's standards. It has generally been assumed that these were used for irrigation and for drainage, but this was not the case. Moreover, the moats were of a length and shape to suggest that defence must have played at most a minor role. It appears that the banks of the canals and the moats were built up and that they had a multiple function. In the first place they served as water reservoirs to supply domestic water during the dry season. In north-east Thailand, an area sorely lacking in water during part of the year, such moats are extensive, often double or even triple (plate 1).

Even today the banks of the old moats and canals are inhabited. Examples are still to be seen along the moats of Vientiane city and along many canals in Thailand and Viet Nam.

Dwellings are often on stilts, partly built over water along the bank. Such living conditions are quite satisfactory from several points of view: easy transportation in both the wet and the dry season by boat or over land; fish in the canal and rice on the floodlands; coconut and other useful garden trees along the bank and aquatic vegetables in the canal. A report of Angkor from the sixteenth century describes this form of habitation, which shows that it was also in use at Angkor at that time (Groslier 1958: 106).

The early period is characterized by a tendency to construct round moats enclosing

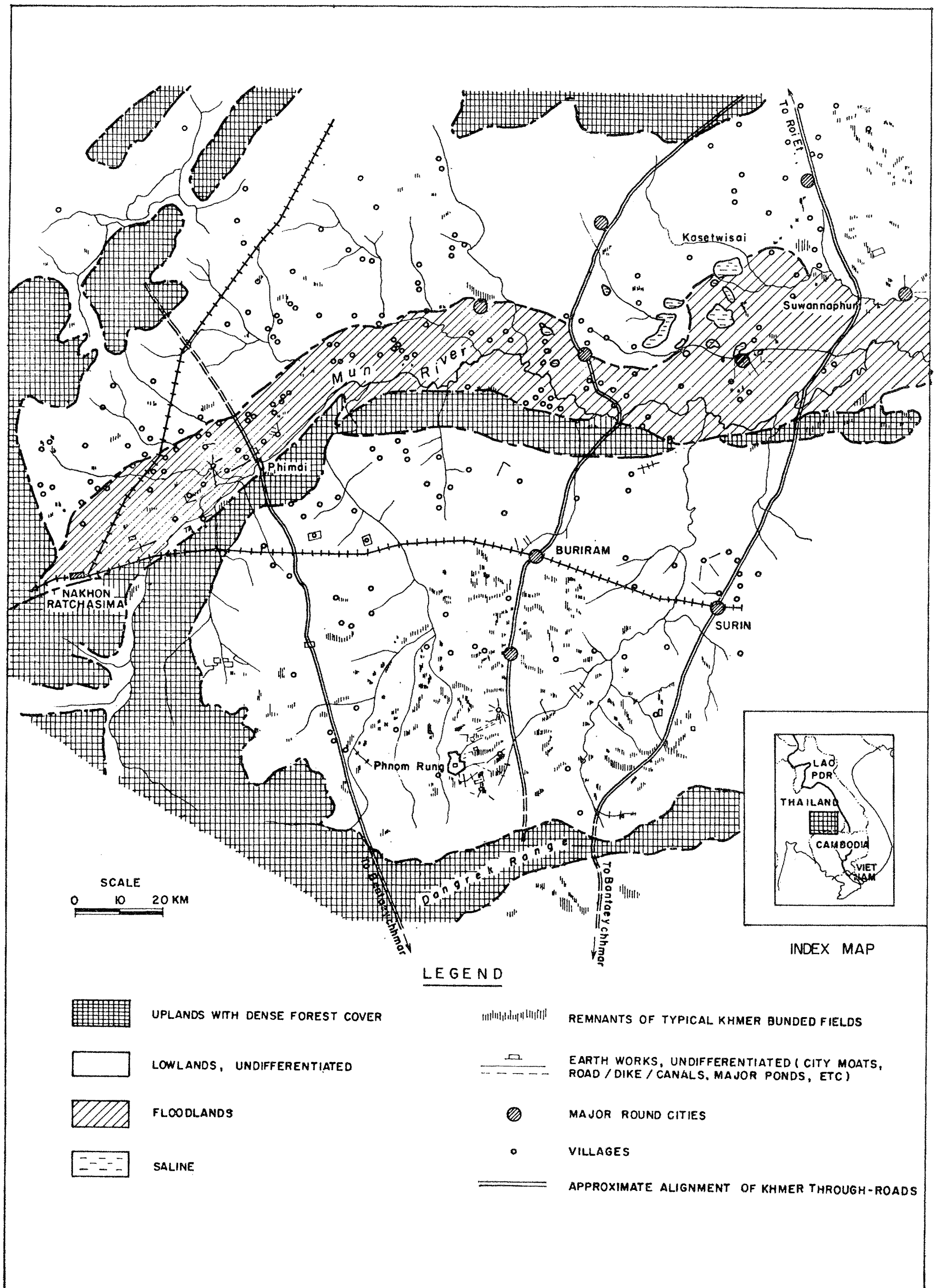

Figure 3 Archaeological sites and earthworks in part of the Mun River basin. In the floodplains of the Mun River and its tributaries remnants of canal/road embankments radiating from larger townships towards neighbouring villages are still visible. The later Khmer period, dominated by Angkor, is represented by: rectangular moats; remnants of a systematic road network around Phi Mai; waterspreading devices across the valleys on the upper course of many tributaries, and remnants of typical Khmer type bunded fields. It appears that in the Mun basin the Khmer technology affected only to a limited extent the older traditions, which probably continued to flourish. The densely forested higher lands were never exploited

villages and cities, with canals and roads radiating from the settlements (plate 2). The round moat is undoubtedly the continuation of a pre-historic tradition, while the radiating road and canal system is indicative of an administrative organization more localized and less systematic than, e.g. the following Angkor period.

By the tenth century, the floodlands of the Mekong delta and the original settlements in the Mun-Chi basin were almost entirely abandoned. This occurrence is yet to be fully explained, but the change is so general that one is tempted to think that there was a change in the flood pattern of the major streams.

The bunded-field farmers

A gradual change in land use took place from about the eighth century onwards. Large areas of the lowland forests around the Great Lake in Cambodia and also in the Mun-Chi basin in north-east Thailand were reclaimed into small bunded fields (plate 3). Agricultural development during these centuries is a feat of tremendous magnitude; the fields can still be recognized on aerial photographs, even in areas that have long since been abandoned, and it is a safe estimate that more than 50 million existed in the period dominated by Angkor. The rice grown on bunded fields is transplanted from nursery beds (paddy) and is therefore much more labour intensive than flood rice, which is broadcast. Transplanting is necessary, mainly because the moisture regime on the lowland terraces is insecure, due to the irregular rainfall pattern.

The bunding and levelling of the ricelands is a form of water control at farm level. It was executed by farmers, but, judging from the lay-out of many blocks, it was done as a cooperative effort at the village level. There are many other activities to control or manipulate water for agriculture, individually or at village level. Most small streams, and even the somewhat larger ones, have bunds across the flat valley floor. These bunds are seen as local flood retardation devices. Other cross-bunds, some the size of small dams, are built across many streams, without reaching the sides of the valley. These are seen as flood spreading structures. Often the bunds were so large that the course of major streams was modified. Well known is the diversion of the Stung Siem Reap at Angkor, but also the Nam Mun in north-east Thailand follows partly an artificial course. Smaller streams follow, almost without exception, artificial alignments (plate 4).

Flood spreading devices in the lower floodlands also include ditches, usually dug parallel to the main river bed, because in many streams floodwaters flow in from the sides. All these devices served to retain, retard, spread or deflect water during the rainy season.

Obviously, agriculture was adapted to differences in the lie of the land, the nature of the soil, and the hydraulic regime, leading to a great variation in paddy fields and traditional agricultural technology. In this, a remarkable degree of sophistication was achieved, by optimizing the size and the shape of the fields and by developing a large variety of different rice strains. For example, some traditional rice varieties, meant for drought-susceptible fields, have growing periods as short as 90 days, whereas others, for lands that are moist during most of the year, have a growing period of as long as 270 days.

The settlement pattern of the bunded field farmers differed from that of the floodland farmers. The alluvial plains and low terraces have a fluctuating water table, and water supply cannot be secured by moats or canals. Therefore, ponds were dug for domestic use. These ponds were often cleverly situated so that they tapped clear and fresh groundwater throughout the year. The bunded field farmers lived in small communities around the ponds. 'Every family has a pond – or, at times, several families own one in common', wrote Chou Ta Kuan of Cambodia in the twelfth century (Chou Ta Kuan 1967: 39).

The bunded fields were reclaimed from the dense forests of the alluvial plains and terraces. The Khmer, Lao and Thai civilizations never removed the forest completely, but preserved remnants for economic and sacral purposes. The result was a remarkable equilibrium between man and his environment. Unfortunately only rare examples of such equilibrium are still met with.

Formal irrigation of bunded fields, that is, irrigation with water drawn from a source other than direct rain or floodwater, is rare in the lower Mekong Basin. Only where the water source was easily captured and distributed, was formal irrigation practised. This was the case, for example, at Shrestapura (Champassac), where, below permanent springs, a regular network of channels can be recognized (van Liere, 1977). Similar situations are known in north Thailand and in Laos. However, the areas irrigated were always small.

It is possible that bucket irrigation was practised in the neighbourhood of cities, but there is no evidence that this was the case. The Persian wheel exists near Siem Reap and near Korat in north-east Thailand. It is possible that its use goes back to Angkor times.

The receding-flood farmers

A sophisticated type of agriculture developed in the area round the Great Lake in Cambodia, as a function of the annual incursion and retreat of water from the Mekong River. Particularly in the zone between 5 and 11 m. above mean sea level (MSL), so-called 'receding-flood' agriculture was practised. This zone has a distinct micro-relief consisting of broad levees along the tributaries to the Great Lake and shallow depressions in between the levees. The reflux of the Mekong meets the floodwaters of the tributaries, which are spread out laterally (largely in man-made ditches) before reaching the Great Lake. The rising of the flood in this zone is slow and gradual but the flood recedes rapidly. The higher portions of the tributary levees are generally not flooded.

Flood retardation is achieved by controlling the run-off from the higher lands which drain towards the depressions. From these depressions the natural drainage is to the lake, but the water can be, and is, bunded and retained in swampy areas. These areas, although generally small, usually have a clay foundation, and they are so numerous that sufficient water can be impounded to supply many paddies situated below the swamps. This means that farmers can transplant or broadcast rice immediately after the retreat of the flood. Water is available for one irrigation, which is necessary within 2–3 weeks to obviate damage to the young rice plants due to the clayey soil drying up too quickly.

Even today, farmers still make use of the local topography to hold back and to spread out the receding floodwaters. Villagers know that it is less risky to grow paddy on the lower land, below the depressions, since in many years there may not be sufficient water to irrigate the higher land. Watering of the paddies with retained floodwater can sometimes be achieved by gravity, but primitive water-lifting devices are commonly used. Water-spreading is achieved by means of a multitude of small ditches. These ditches are quickly made and easily blocked, when necessary, and quickly removed or changed. As a result of the changing patterns, all the tributaries around the Great Lake have some form of artificial delta. Some streams have their entire flow diverted so that the main channel dries up.

The system starts working only when the flood begins to recede in November; during the high water period (July to November), the farmers cannot direct the flood. Until the end of January the tributaries maintain a useful flow, but from February only an insignificant amount of water is left and the number of diversion channels is therefore limited. On the Siem Reap River, for example, from February on, there is only water enough for nurseries of 'riz hatif' (spring rice), to be transplanted in the spots where the flood recedes slowly. Some storage is achieved in the receding flood zones by means of simple earth works (called *tnub* in Cambodian). These tnub, common in the Roluos plain, are rectangular, elongated east–west, with the northern side open (the general slope of the terrain is NNE.–SSW.). A wedge of water is retained in the tnub when the flood retreats, but the volume is not sufficient to irrigate downstream lands. Instead, crops are grown inside the tnub in accordance with water depth and in accordance with the speed of recession through evaporation and infiltration.

Thus, receding-flood agriculture is quite diversified; in permanently inundated areas, in low depressions in the lower parts of the tnub, lotus is the main crop. The fields are separated by ditches which are navigable for small boats. Weeding is done by boat, using hooks on long sticks. In areas where the flood waters are retarded, where watering is assured, and in the upper parts of the tnub, transplanted paddy is grown. These are the best paddy lands, with sufficient moisture and clayey soils, enriched by neutral flood waters. On the other hand, in areas where the flood is rapidly receding or on lands watered from non-permanent diversions, paddies depend on the irregular flow of the tributaries. In dry years, when the soil cracks quickly, the diversion channels are insufficient to enable paddy rice to be grown. However, certain other crops can be grown here without risk. Some of these crops even do best in conditions of rapid drying out.

These diversified agricultural practices, which still continue to some extent, apparently, to this day, corroborate a description by an ambassador from the Imperial Court, named Chou Ta Kuan, who resided for a year in Angkor at the end of the twelfth century. Chou Ta Kuan wrote of various crops of rice, including floating rice, and of many other crops that were grown, such as sugar cane, bananas, pomegranates and sour oranges as well as many vegetables such as onions, mustard, leeks, egg-plants, watermelons, cucumbers and others. However, Chou Ta Kuan pointed out that fields were not fertilized, since dung was considered impure (1967: 35).

The theocratic superstructure

Superimposed on this productive, profane world there developed from the eighth century onward a theocratic superstructure: the philosophy of the Devaraja, the God-king. Pushed to its limits by the Khmer kings, it is an attempt to create heaven, as conceived in the Indian cosmology, on earth. As a consequence, the city is not so much a centre of commerce, as in the Western classical world, but a replica of heaven, with a copy of Mount Meru in its centre, the seat of a divine king and populated by a large priesthood. The city moats of the Khmer are square, oriented east–west, north–south; and so are the sacred temple ponds, which are often of huge size. But it was not only the cities that were expressions of the Indian cosmology; so too was the countryside. Wherever the topography permitted, a network of east–west and north–south oriented roads or canals was built, with temples and monasteries at cardinal points of intersection (fig. 4). It is remarkable that the lay-out of this checker-board pattern of roads and canals was not deterred by local undulations of the topography: the canals of the wet lands continued as roads on the uplands and vice versa. Perhaps these canals and roads, although undoubtedly inspired by the Khmer cosmology, had an economic impact as well, although certainly not as much as the modern roads in north-east Thailand or the canals in the Mekong delta.

The grandiose scheme of projecting heaven on earth was never completed. It is well developed in the area around Angkor, the capital, and remnants are visible in north-east Thailand, but elsewhere the goal remained elusive.

To satisfy the need for year-round water supply for city moats and temple ponds, a system of theocratic hydraulics was developed. This system is often considered to be related to the profane, down-to-earth agricultural hydraulics, but there is no such relationship. For example, nowhere are temple-ponds or city moats equipped with distribution systems to water the surrounding rice fields. Even the Barai Occidental at Angkor, the largest temple-pond of the lower Mekong Basin, had no distribution system. Groslier (1974: 100) assumes that water from the Barai seeped through the base of the dike that surrounds the Barai, whence it flowed into a collector channel parallel to and outside of the dike, and thence to the fields. Such a supposition cannot be supported technically. The present author does not know a single case where a temple pond was equipped with a distribution system to water the fields, although he has examined all of the major ponds from aerial photographs and many of them on the ground.

In fact, in some cases theocratic hydraulics was harmful to agricultural production. Where water supply was limited, much of it was reserved for sacral purposes; in some lowland areas theocratic hydraulics impeded drainage. Many examples are still visible. However, theocratic hydraulic works were severely restricted by the limited technology of the Khmer. They could not build permanent structures in monsoon rivers since they lacked the technique of constructing weir foundations. They also lacked the technique of using clay cores in dams, so that they could not build sizeable reservoirs in the hills to store water throughout the dry season.

Khmer dams are always small earth-works on minor streams, built with simple spillways which are often reinforced with laterite slabs. The present author has never seen a permanent off-take structure to regulate the outflow from a Khmer dam, although one such structure is reported from the Phnom Kulen (J. Boulbet, pers. comm.). There, in the walls of a channel cut in sandstone on a small tributary of the Stung Siem Reap, slits have been carved. Wood boards may have been used to hold the water in the channel. By removing the planks one could have regulated the outflow from the channel. However that may be, this case certainly remains an exception.

Undoubtedly the greatest density of dams in the entire Khmer realm is found in the

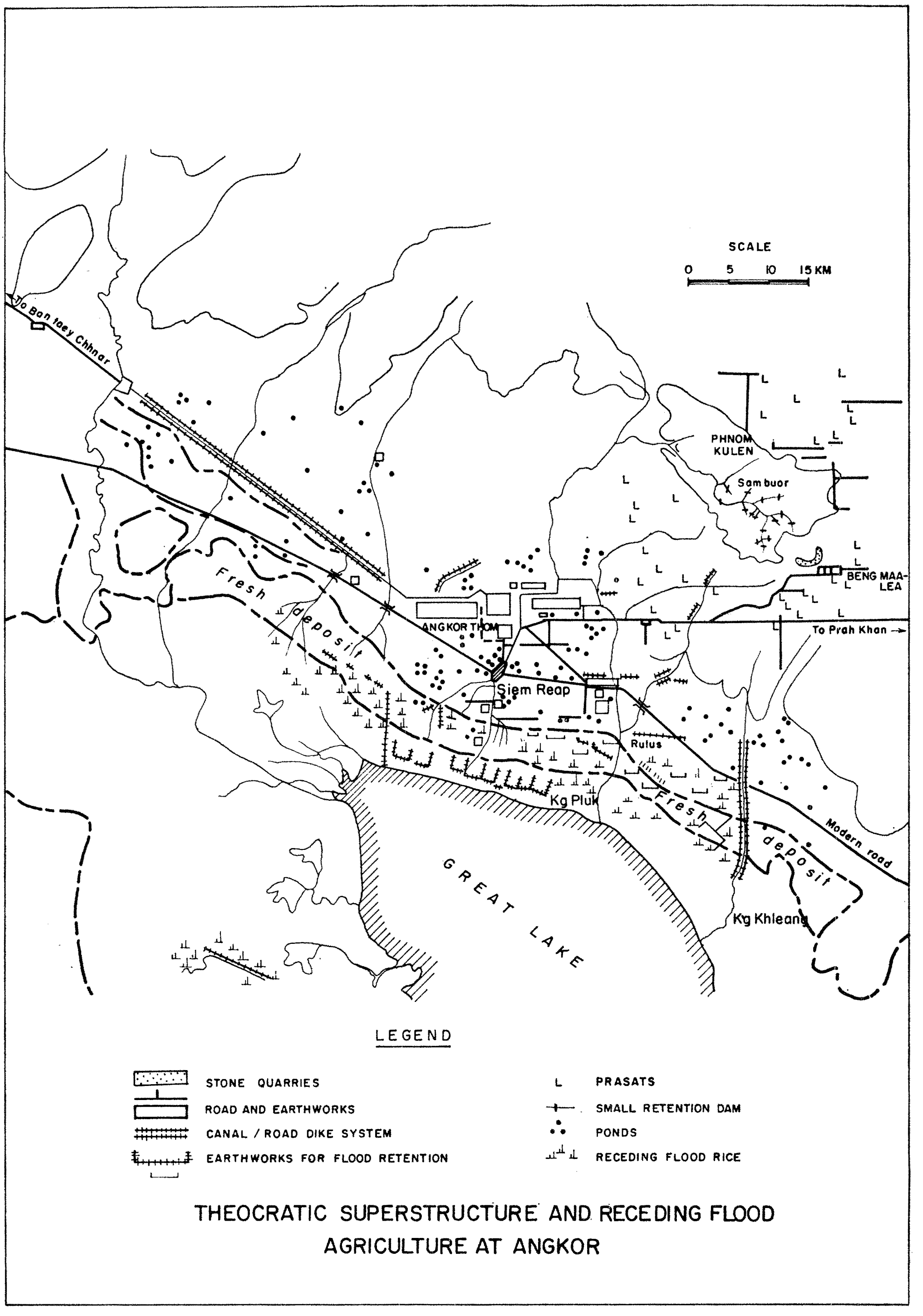

Figure 4 At the headwaters of the Stung Siem Reap on the holy Mount Mahendra (Phnom Kulen) a number of small earth dams regulated the runoff for supplying the huge temple ponds of the capital. This theocratic superstructure has no relationship to the profane world of agricultural production, part of which is indicated on this map. A key feature of the agricultural practice was the *tnub* earthworks used to retain the floodwaters from the Great Lake and in which crops were grown after retreat of the floods

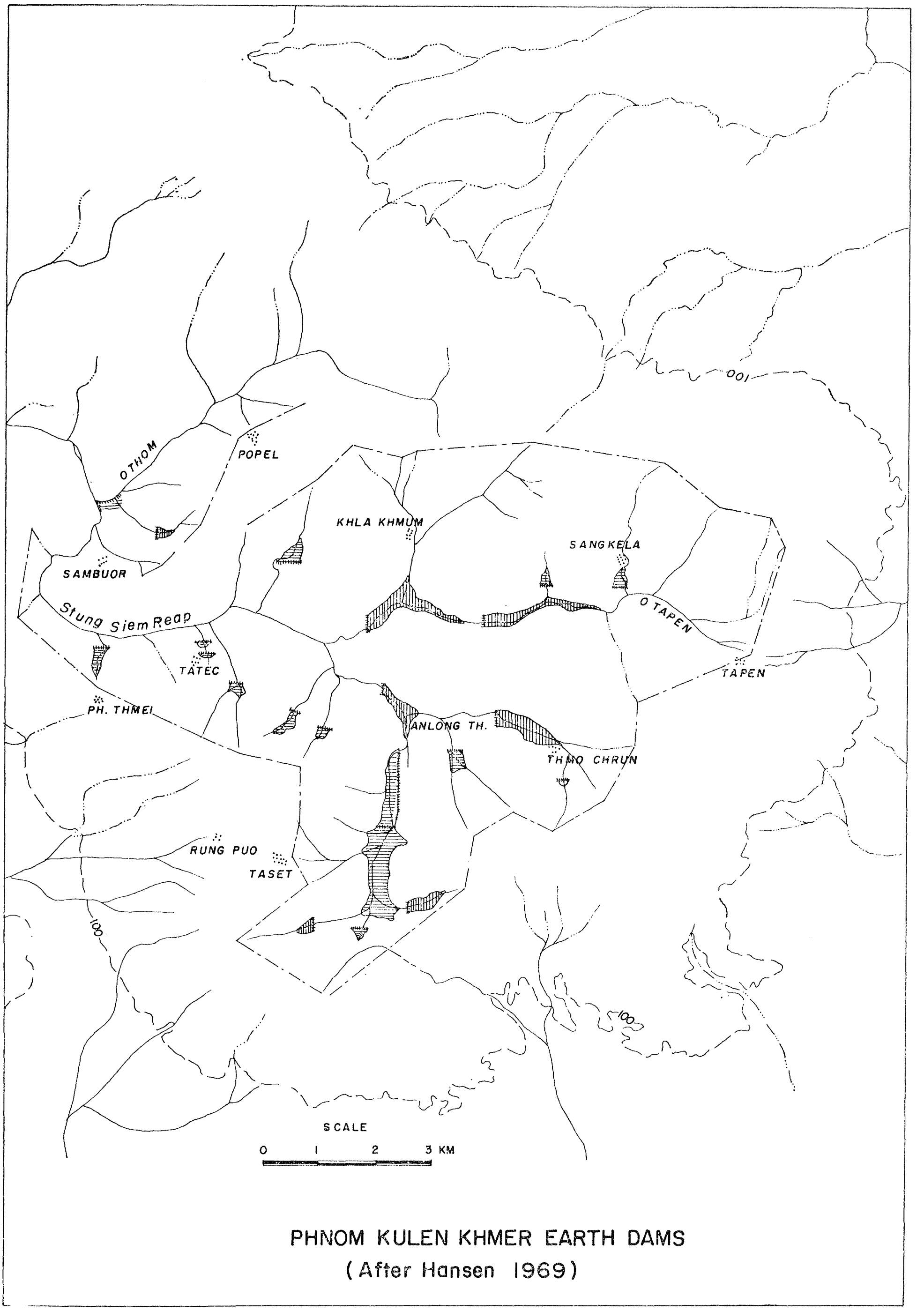

Figure 5 Phnom Kulen. Small earth dams, often in combination with ponds (*srah*) regulated the headwaters of the Stung Siem Reap. Lingas were carved in the rocky riverbed and the water reached downstream Angkor as holy water. Chou Ta Kuan wrote that 'the people of Cambodia often cure themselves of the many illnesses by plunging into water and washing the head again and again' (1967, 31)

Phnom Kulen. Some twenty dams have been surveyed and mapped as part of a former government's effort to develop the Phnom Kulen into a tourist attraction (fig. 5) (Hansen 1969). All the dams are earthworks without gated outlet structures. Therefore these dams are flood retardation devices, not dams to store water for the dry season. That was the role of ponds, many of which are also to be found in the Phnom Kulen, often located below the flood regulator. It should be noted that, from the point of view of engineering, slopes of 1:5, which the Khmer usually applied for their dams and large bunds, is quite good for earthworks without clay core (fig. 6).

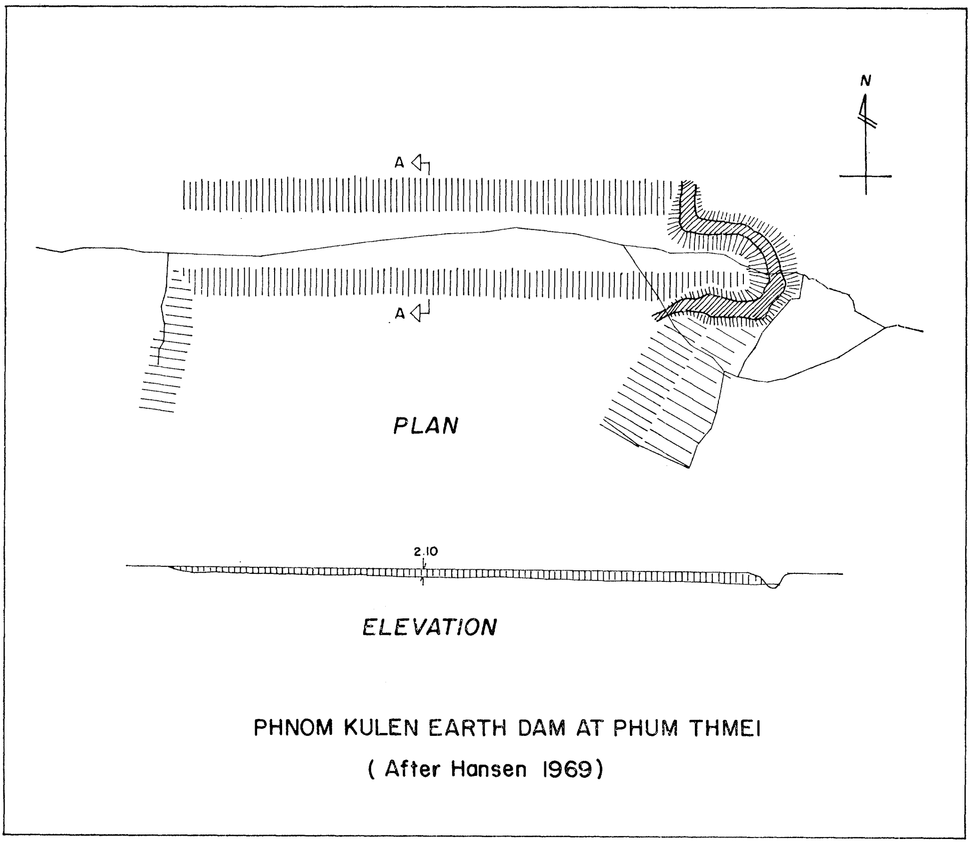

Figure 6 Phnom Kulen. Example of small earth dam near Phum Thmei. Such dams, dating back to Khmer times, are still to be seen in north-east Thailand and the Central Highland in Viet Nam

The dams of the Phnom Kulen are also interesting since, entirely in accordance with the Khmer cosmology, all are oriented east–west and north–south.

Finally, it should be realized that the total capacity of all the Khmer dams built on the Siem Reap River is in the order of 4 million m.[3] If all that water were to be efficiently distributed to the fields for the purposes of irrigated agriculture, it would be sufficient to irrigate only about 400 ha.

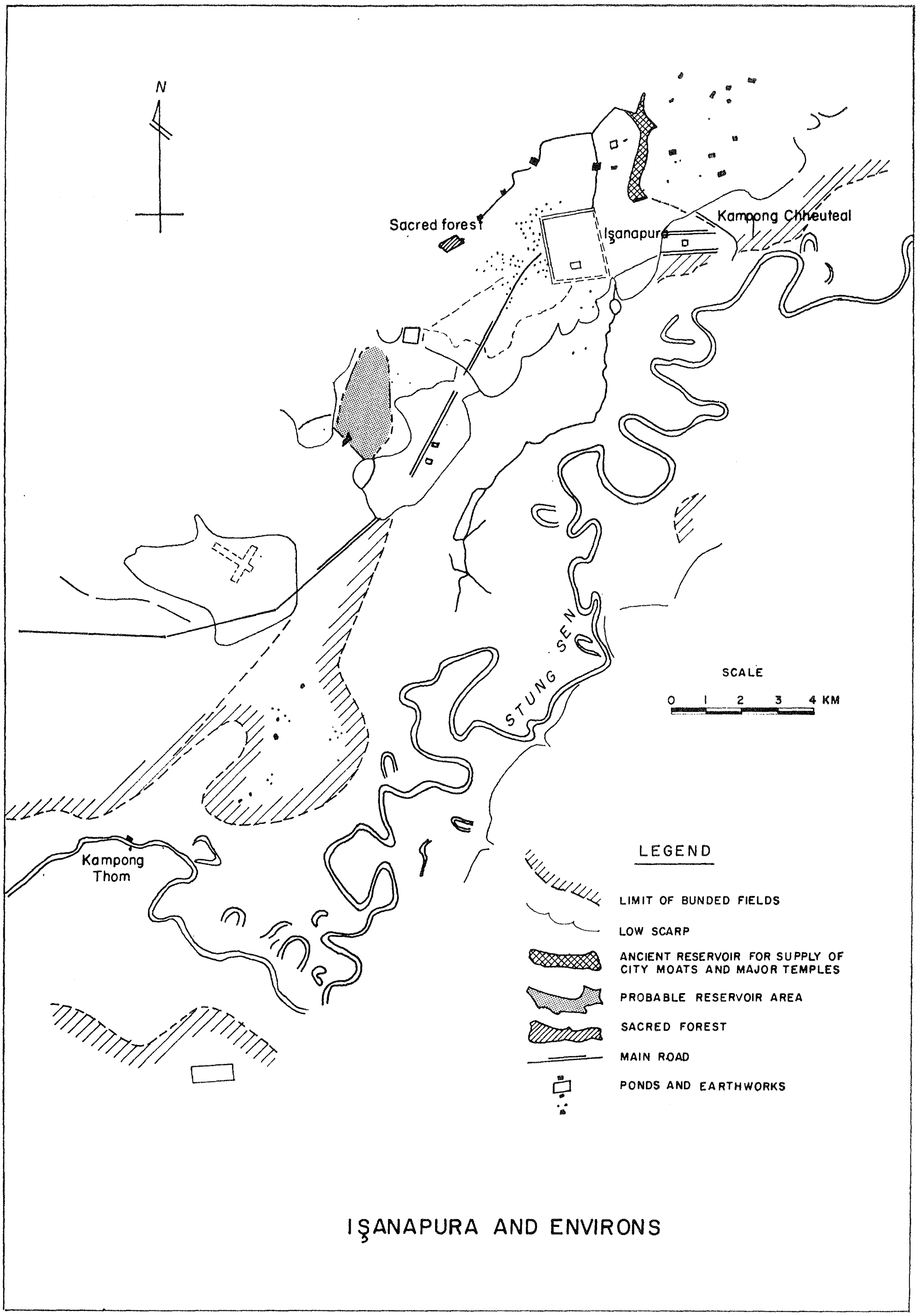

Figure 7 Işanapura on the Stung Sen. The square city moat and major temple ponds are supplied by a small reservoir. A double road leads to the river, probably to the Royal landing, situated to the east of the city. A main road leads south-west and then westward to Angkor. A large flood retardation bund (now broken in the middle like all other Khmer dams) is built in a depression between the low scarps of the sandstone terrace, with off-take ditches, dug in the sandstone to water the downstream fields

There is other overwhelming quantitative material to show that dry season irrigation, beyond what was described as flood manipulation at farm level, was just not possible at Angkor.

Another good example is the water supply of Işanapura (Sambor Prei Kuk) on the Stung Sen (fig. 7). This city, a capital before Angkor, was supplied by a small reservoir, but no water was drawn from the Stung Sen. The situation at Işanapura is interesting, since it shows that even in Khmer times the fertile, but densely forested, riverine lands of the Stung Sen were not used for agriculture. The bunded fields are all away from the river on the less fertile terrace lands. Until the twentieth century, Khmer farmers never exploited the fertile river banks of the major streams.

If the arguments of the irrigation engineer are accepted, one more problem still has to be answered, however. It may perhaps be admitted that royalty at Angkor was too remote from earthly problems to attempt to solve them, but what about the local governors, the mandarins in charge of domains or manors; did they not develop the land? Apparently not. There are many large earthworks, enclosures, etc., the function of which eludes the comprehension of the present author. These works were certainly constructed at great cost, probably on the orders of a local mandarin, but were quite ineffective for agricultural production.

This analysis will leave some readers dissatisfied. The main conclusion we may perhaps draw from it is that the service of the Gods had much higher priority than the service of man.

Epilogue

What can be learnt from the history of water management? The theocratic superstructure largely broke down after the thirteenth century. However, the profane basement structure of the society continued to exist and many traditional technologies are perpetuated to the present day.

The Mekong Basin farmer still manipulates rainwater and floodwater, but he does not make use of the water provided in the concrete lined canals of the technocratic superstructure which are, nowadays, certainly built in the service of man. When the Barai Occidental was equipped with a distribution system some fifteen years ago, not a drop of water was used to irrigate the paddy fields of the project area. The farmers themselves extended the laterals and distributaries to reach the receding flood zone. There they watered their receding flood rice in the manner described above. This is one example out of many to show that the modern engineer lacks insight into traditional technologies. If he had such insight, many irrigation projects would be conceived differently and undoubtedly would be much more successful. The standard data-collecting procedure, including topographic surveys, socio-economic surveys, soil surveys, etc., are too stereotyped and are too often executed in a routine manner so that they do not provide a suitable basis for efficient project planning in south-east Asia.

Acknowledgements

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Abstract

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Traditional water management in the lower Mekong Basin

Traditionally there are two separate and independent systems of water management in the lower Mekong Basin: one at the level of the productive, profane farmer and one at the level of the theocratic superstructure. Both systems were quite sophisticated in the past. However, there was no connection between the two, and the water management schemes of the theocratic superstructure did not contribute to agricultural production in a technical sense.