The confluence of water and power: water management in the Brantas river basin from the tenth to the sixteenth century CE

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Chapter 2

River Polities in Mainland Southeast Asia

This chapter attempts to explore the relationship between rivers and polities through an examination of water management in mainland Southeast Asia which then I can use as a comparison to the East Javanese water management. It suggests that the development of polities within river basins in the Southeast Asian mainland was greatly facilitated by the existence of the river(s). Therefore, this chapter places significant emphasis on how the river basins' physical geography has shaped the political geographies of mainland Southeast Asia. Moreover, a comparison will be made between ancient Burmese, Thai, and Cambodian polities regarding how the physical geography of the river basins contributed to shaping river-basin polities.

I deliberately chose the three locations for comparison because all three have large rivers with fairly wide drainage basins and tributary systems: the Irrawaddy in Burma, the Chao Phraya in Thailand and the Mekong in Cambodia. In addition, all these rivers were used for upstream-downstream transportation routes and vice versa. Like the Brantas, all three large river systems have similar physical and ecological features which also decisively shaped the polities that surrounded them.[1] Hence, I have made no systematic comparison with other river basins in Indonesia which may be less distant but have altogether different characteristics. Bali, for example, has been relatively well studied, but its smaller basins are narrower and

1 H. Sutherland, "Geography as Destiny? The Role of Water in Southeast Asian History", in: *A World of Water. Rain, Rivers and Seas in Southeast Asian Histories*, ed. Peter Boomgaard (Leiden: KITLV Press, 2007): 32.

its rivers steeper than in the Brantas river system. For a different reason, I have not used the Musi and Batanghari basins in Sumatra because these simply lack the archaeological and historical data to make a comparison fruitful.

Southeast Asia consists of a large variety of geomorphological areas. While some of these are unsuitable for human settlement, its river valleys offer good opportunities for human settlement by providing nutrient-rich water and alluvium which people can use to carry out agricultural activities. In the valleys of the Irrawaddy, Chao Phraya, and Mekong, the people were dependent on those rivers and their valleys to carry out their agricultural activities and also, in many cases, as a means of transportation. These rivers make many parts of Southeast Asia more easily accessible, especially the hinterlands.[2]

In what follows, I will look at the development of these three river-basin societies in mainland Southeast Asia. Moreover, I will also compare the development of a number of polities within the river basins on the basis of a dialogue between the people and the rulers, on the one hand, and their environment, especially with its river basin environment, on the other. Three regions will be explored and compared, those comprising modern Burma, Thailand, and Cambodia.

2.1. THE IRRAWADDY BASIN: UPPER BURMA AND LOWER BURMA

Today, Myanmar (Burma) is the largest country in Southeast Asia, stretching from the isthmus of the Malay Peninsula in the south up into Central Asia. As it lies on a number of different latitudes, it has a wide variety of flora, fauna, and climates. Most of Myanmar, including its northeastern area, Arakan, the delta, and along the coast of the Malay Peninsula, sees 1,000 mm to 2,000 mm of rainfall annually. However, the heartland of the country, surrounding the Irrawaddy River, has a Dry Zone climate with no more than 1,000 mm of annual rainfall.[3] Although it is an arid region, almost all Burmese polities were based in and centreed on this region of Upper Burma.[4] Aung-Thwin has explored why almost all ancient civilizations were based in this area and has shown that it has long and wide plains that were easy for people to move through, both south to north and vice versa. In contrast, it was more difficult for people to move west to east or east to west due to the presence of mountains.

2 J. Rigg, *Southeast Asia. A Region in Transition* (London and New York: Routledge, 1991): 12.

3 The reason that there is less rainfall in Upper Myanmar is the existence of Rakhine Mountain, which creates a barrier that prevents rain from reaching the Irrawaddy basin. See: E. H. Moore, *Early Landscape of Myanmar* (Bangkok: River Books, 2007): 33. See also: A. Gupta. "Landforms of Southeast Asia", in: *The Physical Geography of Southeast Asia*, ed. Avijit Gupta (Oxford: Oxford University Press, 2005): 46.

4 J. Stargardt, *The Ancient Pyu of Burma, Volume One, Early Pyu Cities in A Man-made Landscape* (Cambridge: PACSEA, 1990): 3.

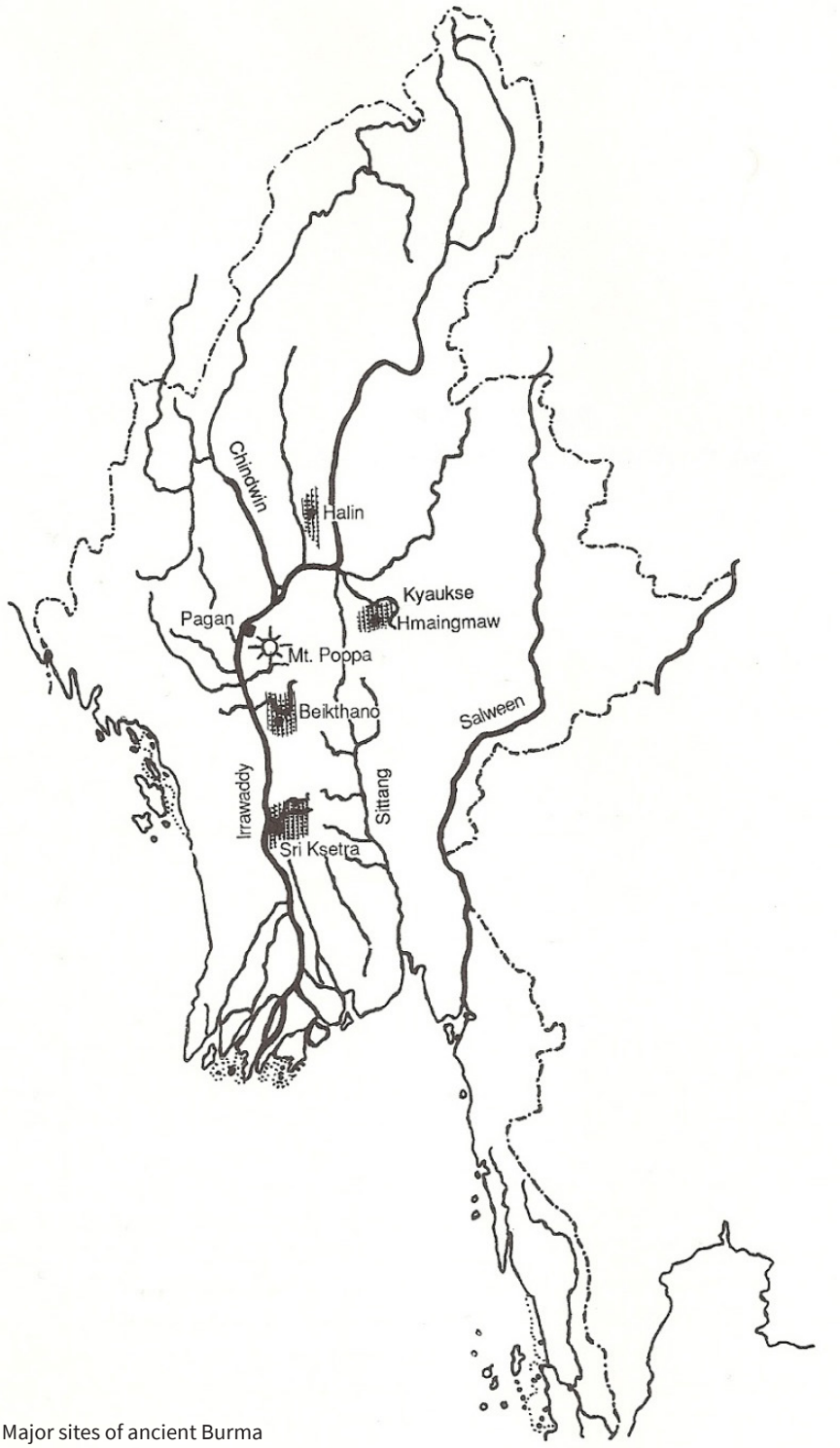

Fig. 2.1. Major sites of ancient Burma
(Source: Stargardt, 1990: 2)

Moreover, he explains that every polity that was able to control this area of Upper Burma could also control the rest of the country.[5]

In the Arid Zone of Upper Burma, ancient settlements did exist near various rivers, but not near the main one, the Irrawaddy, except Bagan. Instead, they existed in the vicinity of its tributaries. This is fascinating. Most of the ancient sites of Upper Burma were located inside the Irrawaddy valley where there is less alluvial land rather than on the Irrawaddy's banks. The reason for the creation of this type of settlement pattern was to avoid large floodplains, by settling on smaller ones one would be able to manage floodwater more easily. On the other hand, settlements still needed to be "not too far" from the main river because it was needed for transportation.

The Arid Zone around the Irrawaddy has been inhabited from prehistoric times, but cities began to emerge around 200 BCE as the Pyu culture started to dominate the area. The Pyu period dates from approximately 200 BCE to the ninth century CE. The Pyu migrated south from southern China, entered the Irrawaddy Valley, and then settled along tributary rivers in Upper Burma, including the Sittang, Chindwin, and Mu rivers.[6] The ancient Pyu were known for their mastery of water control techniques, brick making, and ironworking, and their skill in water management. As the Pyu settlements were located in valleys to the side of the great Irrawaddy Valley, they were compelled to construct extensive irrigation networks.[7] Of the Pyu urban centres, Halin, Beikthano, and Śrī Kṣetra were the most important.

Śrī Kṣetra

Śrī Kṣetra (Thiri Khittaya in Burmese) is situated near the Navin river—a highly seasonal but perennial tributary of the Irrawaddy—at a distance of 5 km from this main river. Śrī Kṣetra was the largest brick-walled city in ancient Southeast Asia, the walls of which enclose an area of 17 km^2, which is twice as large as any other walled site in Burma. The features that archaeological studies have found within it include earthen embankments and water control channels, brick water control channels and wells, brick-bounded platforms, and more than 250 brick religious monuments.[8] The chronology of Śrī Kṣetra is still debated. According to the Burmese chronicles,

5 M. Aung-Thwin, "Irrigation in the Heartland of Burma: Foundations of the Pre-Colonial Burmese State", *Occasional Paper No. 15, Northern Illinois University Center for Southeast Asian Studies* (1990): 2.

6 W.J. Topich and K.A. Leitich, *The History of Myanmar* (Santa Barbara: Greenwood, 2013): 16.

7 Stargardt, *The Ancient Pyu of Burma*: 3.

8 B. Hudson and T. Lustig, "Communities of the Past: A New View of the Old Walls and Hydraulic System at Sriksetra, Myanmar (Burma)", *Journal of Southeast Asian Studies* 39 (2008): 271.

the city dated from 443 BCE to the second century CE,[9] but many scholars have dated it from the fifth to the ninth century CE.[10] Lwin, Kyaing, and J. Stargardt have divided the development of Śrī Kṣetra into three periods, namely: (1) Early-Phase Śrī Kṣetra, from the second century BCE to the fourth century CE; (2) Phase I of Pyu Buddhism at Śrī Kṣetra, from the fourth to the sixth century CE; and (3) Phase II of Buddhist Culture at Śrī Kṣetra, from the seventh the ninth century CE.[11] I will focus my explanation on the final phase of Śrī Kṣetra's development, from the seventh to the ninth centuries, as it is a foundation for the later developments of the Bagan period (849-1287 CE).

Śrī Kṣetra city was an irregular oval or squarish space with rounded corners surrounded by walls and moats that suffered severe damage not long after they were built, perhaps as the result of human actions. On each side of the enclave there is a different number of walls; for instance, there were three walls on the southeast side while the eastern part of the city was protected by only one. Both inside and outside the enclave there are many ancient water tanks that have long been viewed as hydraulic works. Small tanks, some of which form a pattern, are associated with the ancient burial terraces. Besides the tanks, there are also ancient canals. Recent research has revealed that these canals together form a network, being connected to each other and to the tanks both inside and outside the enclave. The canal network has seven outflow points and the direction of the water flow was from the north and east of the city to the fields outside it.[12] Furthermore, Janice Stargardt has calculated that the tanks and moats at Sri Ksetra could hold about 9,502,000 m^3 of water.[13]

The function of Śrī Kṣetra's waterworks is also significant. The high level of technical expertise and management skill required to maintain these water networks suggest a strong desire to achieve their goal. Their prime function was related to irrigation, through which the rice fields were watered. However, another function was the religiously symbolic meaning of both water and waterworks through the belief that water infrastructure symbolized the city as being a macro-cosmos. Recent

9 G.H. Luce and B. B. Shin, *Old Burma: Early Pagán. Volume One: Text* (New York: Artibus Asiae and The Institute of Fine Arts, New York University, 1969): 6-7.

10 Aung Thaw, *Historical Sites in Burma* (Rangoon: Ministry of Union Culture, 1972): 16; J. Stargardt, "The Great Silver Reliquary from Sriksetra: The Oldest Buddhist Art in Burma and One of The World's Oldest Pali Inscriptions", in: *Fruits of Inspiration: Studies in Honour of Professor J. G. de Casparis*, ed. Marijke Klokke and Karel R. van Kooij (Groningen: Royal Netherlands Academy of Arts and Sciences, Egbert Forstern, Gonda Indological Studies, 2001).

11 T. Lwin, W. Kyaing, and J. Stargardt, "The Pyu Civilization of Myanmar and the City of Śrī Kṣetra", in: *Lost Kingdoms: Hindu-Buddhist Sculpture of Early Southeast Asia*, ed. John Guy (New York: The Metropolitan Museum of Art, 2014): 64-68.

12 Stargardt, *The Ancient Pyu of Burma*: 84-90.

13 With the estimation of the average depth of the canals being 3m. See: Stargardt, *The Ancient Pyu of Burma*: 101.

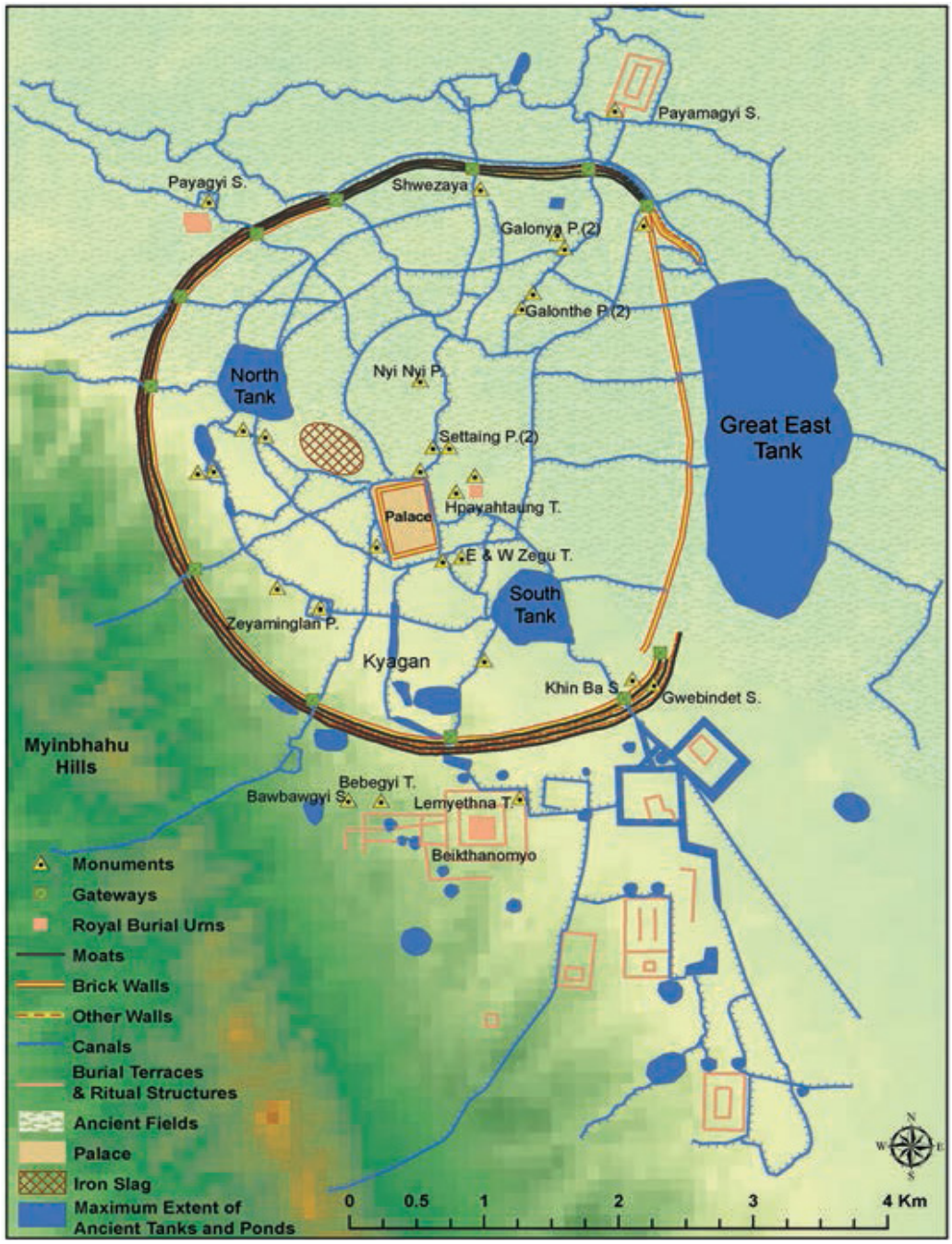

Fig. 2.2. Map of Śrī Kṣetra (Source: Lwin, Kyaing, and Stargardt 2014: 63)

studies of the waterwork networks using multi-temporal and multi-spectral satellite imagery confirm that there were close links between the water networks and ancient ritual ponds and burial terraces in Śrī Kṣetra (Fig. 2.2).[14] The practical and symbolic functions of water merged neatly into the religious, political, and economic structures.

With its fortified city, monumental buildings, and dense system of hydraulic networks, Śrī Kṣetra was most certainly an urban settlement of a strong socio-political polity. However, like other urban settlements in Pyu-period Burma, Śrī Kṣetra has not provided us with many textual sources. Using only local chronicles, Chinese chronicles, and a small number of inscriptions—supported by remote sensing data, archaeological features, and artefacts—researchers have agreed that Śrī Kṣetra was one of the greatest urban settlements of early Southeast Asia. It had a highly advanced and aesthetically sophisticated waterwork network, as well as other important elements of urban life—such as skills in iron-working and brick-making—which were maintained by the well-organized social, economic, and political structures of the polity.[15]

The water management processes of Śrī Kṣetra and their relationship to the city's political dynamics, however, have not been explored in any great detail because evidence is lacking. What can be said, though, is that the management of Śrī Kṣetra's water was in the hands of the city council. As there is no information on the council itself or on the officials whose task it was to manage the water, it may be assumed that the city's leaders and inhabitants worked together to construct and manage the water infrastructure. In Toshikatsu Ito's view, Pyu's irrigation was organized at village level and, because it was small-scale infrastructure, there was no need for a large labour organization.[16]

It cannot be denied that the Pyu polity was the forerunner of its successor in Myanmar in terms of its economic, cultural, and political development. It is clear that Pyu's achievements were continued and developed by the next polity, for instance in the construction of water works. Bagan, its successor in the Irrawaddy basin, followed the approach it had forged.

14 J. Stargardt, G. Amable, and B. Devereux, "Irrigation is Forever: A Study of the Post-Destruction Movement of Water Across the Ancient Site of SriKsetra, Central Burma", in: *Satellite Remote Sensing. A New Tool for Archaeology*, ed. Rosa Lasaponaral and Nicola Masini (Dordrecht: Springer, 2012): 247-268.

15 See: Lwin, Kyaing, and Stargardt, "The Pyu Civilization of Myanmar and the City of Śrī Kṣetra"; and also: J. Stargardt, "The Great Silver Reliquary from Sriksetra", and J. Stargardt, "From the Iron Age to Early cities at Sri Ksetra and Beikthano, Myanmar", *Journal of Southeast Asian Studies* 47/3 (2016): 364–365.

16 T. Ito, "Pagan and the Kharuin Irrigation System in the Ayeyarwady Basin", *The Journal of Sophia Asian Studies* 18 (2000): 80.

Bagan

The origin of the Bagan polity is still debated. The Glass Palace chronicle states that it was founded in 849 CE, during the reign of Pyinbya (*c.* 846-878 CE), although other traditions claim that Bagan was established by a Pyu king in the first century CE.[17] Some researchers, including G.H. Luce, date its beginnings to the eleventh century CE.[18] Recent research by B. Hudson has suggested that the domination of Bagan culture and politics over the Pyu probably did not occur suddenly, but was more gradual.[19] Indeed, the beginning of Bagan's dominance came in the middle of eleventh century when Anawrahta, the king of Bagan, ascended the throne. As well as unifying Burma, he also expanded the cultural life of Bagan, which became an important centre of religious study in Southeast Asia, while the architecture of Bagan grew in both quality and quantity. During the reigns of his successors, Kyanzittha (1084-1112 CE) and Alaungsithu (1112-67 CE), there were more than 2,000 temples and pagodas, and thousands of stupas, surrounding the city. Its decline began in the early twelfth century CE, but the beginning of the end for Bagan came in 1287 CE, when the Mongols invaded. This was not, in fact, the primary cause of Bagan's demise; instead, it was the result of a long-term process involving other factors including economic depression and environmental stress.[20] Subsequently, Bagan broke up into the smaller kingdoms that had revolted against its rule.[21]

Bagan authority covered the whole area of Upper Burma—at least in the eleventh and twelfth centuries—while in the thirteenth century it expanded to the area of modern Myanmar. It also seems that Bagan's hegemony was seen primarily in big Pyu cities—like Halin, Beikthano, and Śrī Kṣetra —as they remained inhabited during Bagan rule.[22] The only newly-incorporated territory was the region of Kyaukse, which has more irrigation features and was an important agricultural area for Bagan. Indeed, many scholars claim that Kyaukse had the most advanced and efficient water management system in Burma during the Bagan period.[23]

Kyaukse covers an area of 1,460 km^2 and is located south of Mandalay and west of the Shan hills. It has four rivers, namely the Zawgyi, the Panlaung, the Samon,

17 Topich and Leitich, *The History of Myanmar*: 23.

18 B. Hudson, *The origins of Bagan* (Ph.D. diss., University of Sydney, 2004): 182.

19 Hudson, *The Origins of Bagan*: 153 and 182.

20 P. Gutman and B. Hudson, "The Archaeology of Burma (Myanmar) from the Neolithic to Pagan", in: *Southeast Asia from Prehistory to History*, ed. Ian Glover and Peter Bellwood (London and New York: Routledge Curzon, 2004): 169-170. See also: D.M. Stadtner, *Ancient Pagan. Buddhist Plain of Merit* (Bangkok: River Books, 2005): 26-27.

21 Topich and Leitich, *The History of Myanmar*: 24-28.

22 Hudson notes that there are Bagan style buildings at Sri Ksetra, Bagan inscriptions at Halin, and Bagan style temples at Beikthano; see: Hudson, *The Origins of Bagan*: 128, 132, 137 and 184.

23 M. Aung-Thwin, *The Origins of Modern Burma* (Honolulu: The University of Hawaii Press, 1985); M. Aung-Thwin, "Irrigation in the Heartland of Burma": 14.

and the Myitnge. Its sophisticated water management system used technology such as canals, weirs, and tanks. Besides the four perennial rivers, the Kyaukse water network was supported by roughly 14 canals, 16 weirs, and 4 tanks. Weirs were invented sometime during the Bagan period, likely in the tenth or eleventh century. Aung-Thwin describes them in this way:

> The weirs were constructed by forming rows of stakes driven across the riverbed and tied together with cross pieces of palmyra or bamboo. The spaces between the rows of stakes were filled in with stones picked up in the riverbed or neighborhood, covered with a layer of larger stones brought specially for the purpose.[24]

Moreover, Aung-Thwin calculates that the Kyaukse water network irrigated over 460 km^2 of agricultural land.[25]

The increased attention paid by the Bagan authorities to the development of irrigation infrastructure shows the important role of agriculture in the state. The innovation in, or at least improvements to, earlier water control technology demonstrates how Bagan adapted to and adjusted the Dry Zone environment in order to enhance agricultural productivity. Aung-Thwin argues that Bagan paid more attention to agriculture than trade because agriculture was more important for economic stability than was trade. Moreover, he argues that irrigated agriculture provided economic stability, consistency, and predictability. That is why the Burmese polity's centre returned to Upper Burma after a period of around sixty years based in Lower Burma.[26] However, Hudson has a rather different view: that the development of irrigation infrastructure was also related to the development of water transportation, and that the former also led to the trade, military dominance, and administrative system of the Bagan polity. His argument is based on the fact that Bagan sites are spread all along the river.[27] In my opinion, the Bagan polity used both strategies: maintaining agricultural productivity and increasing water transportation. Agriculture was found in all the productive perennial river watersheds in Upper Burma while, on the other hand, the role of water transportation was increased through the location the centre of the polity near the main river or right on the bank of the Irrawaddy.

Bagan's agricultural production was mainly concentrated in three regions: Kyaukse, Minbu, and Taungbyon. On the basis of epigraphic records, Ito divides the land into three types of agriculture, namely *lay* (rice fields), *ryā* (upland), and *kuiṅ* (seasonally flooded land). Because rich soil from upstream of the Irrawaddy was deposited in *kuiṅ* areas, *kuiṅ* was a suitable place to grow rice and other crops. Rice, however, can only grow in *kuiṅ* areas when the water is not too deep. In Kyaukse,

24 Aung-Thwin, "Irrigation in the Heartland of Burma": 17.

25 Aung-Thwin, "Irrigation in the Heartland of Burma": 19.

26 Aung-Thwin, "Irrigation in the Heartland of Burma": 62-63.

27 Hudson, *The Origins of Bagan*: 185.

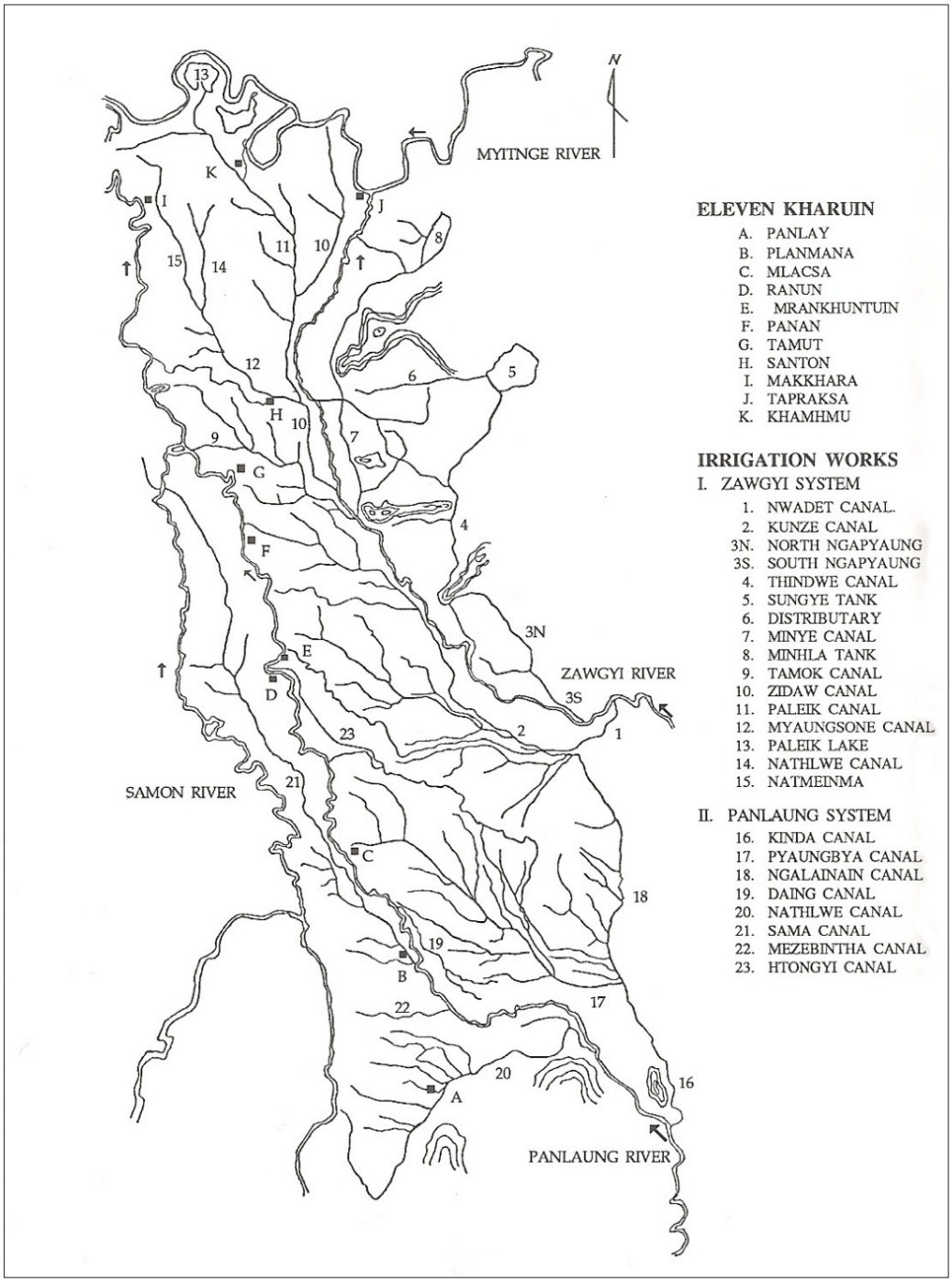

Fig. 2.3. Map of the irrigation works at Kyaukse. (Source: Aung-Thwin 1990: 70)

rice planting was dependent on rainfall or irrigation, and this was supported by a nearby river that acted as a water source for that irrigation.[28] From the middle of the Bagan period, there was an irrigation system based on the *kharuin*—a hydro-agricultural core area surrounding the capital—which produced a surplus of food and supported the economy of the kingdom.[29] The *kharuin*s were under the direct supervision and administration of the royal court because they were the main economic foundation ensuring the continuing existence of the Bagan kingdom. Therefore, it had a centralized water management system that was under the direct control of the court.

After the Bagan polity weakened and then collapsed around 1287, the Irrawaddy basin split into at least two main kingdoms, the Hanthawaddy Pegu (1287 to 1540) and the Ava kingdom (from 1364 to 1555). When the Ava kingdom declined in 1555, the Toungoo emerged and succeeded in reunifying the former territories of the Bagan.[30]

In the period *c.* 1300-1550—or, as Lieberman terms it, the era of fragmentation—agriculture was relatively stagnant in the basin, except along the southern fringes of the Dry Zone and in some cities that had older irrigation systems, as new canals and water tanks were constructed and old irrigation structures renovated in those areas.[31] This development of the water infrastructure resulted in an increased variety of crops and higher yields of those crops.

The Irrawaddy with its tributaries, as Aung-Thwin has noted, was the decisive factor in defining the cultural and geopolitical regions of Burma.[32] The river split Upper Burma and Lower Burma into two distinct geopolitical and cultural regions, excluding ethnicity. Yet in addition, other differentiating factors include the various geographic locations, the environment, and the climate. Although in one sense it divided upstream and downstream Burma, the Irrawaddy also formed a riverine link between the two regions, and thus shaped the whole geopolitical scene of the region.[33] Similarly, many other large rivers in mainland Southeast Asia also linked disparate regions.

28 Ito, "Pagan and the Kharuin Irrigation System in the Ayeyarwady Basin": 67-69.

29 N. Tarling, *The Cambridge History of Southeast Asia, Volume One. From Early Times To c.1800* (Cambridge: Cambridge University Press, 1999): 240-241.

30 Topich and Leitich, *The History of Myanmar*: 26-36.

31 V. Lieberman, *Strange Parallels. Southeast Asia in Global Context, c.800-1830. Volume 1: Integration on the Mainland* (New York: Cambridge University Press, 2003): 139-148.

32 M. Aung-Thwin, "Lower Burma and Bago in the History of Burma", in: *The Maritime Frontier of Burma. Exploring Political, Cultural and Commercial Interaction in the Indian Ocean World, 1200-1800*, ed. Jos Gommans and Jacques Leider (Amsterdam and Leiden: Koninklijke Nederlandse Akademie van Wetenschappen and KITLV Press, 2002): 30-31.

33 T. Frasch, "Coastal Peripheries during the Pagan Period", in: *The Maritime Frontier of Burma. Exploring Political, Cultural and Commercial Interaction in the Indian Ocean World, 1200-1800*, ed. Jos Gommans and Jacques Leider (Amsterdam and Leiden: Koninklijke Nederlandse Akademie van Wetenschappen and KITLV Press, 2002): 59-78.

2.2 THE CHAO PHRAYA BASIN: DVĀRĀVATĪ, LANNA, SUKHOTHAI, AND AYUTTHAYA

The Chao Phraya river basin is the largest in Thailand, draining an area of 157,924 km^2. As such, it covers approximately 30% of the nation's land. It originates in the mountains of northern Thailand and flows through the Ping, Wang, Yom, and Nan rivers. The Chao Phraya begins at the confluence of the Ping and Nan rivers at Pak Nam Pho, in Nakhon Sawan Province, and flows southwards for 370 kilometres from the central plains to the Gulf of Thailand. In Nakhon Sawan, the Chao Phraya is 23.5 metres above sea level and, at Ayutthaya, where the Pa Sak river joins the Chao Phraya, it is only 3.5 m above sea level.[34]

Its basin is relatively isolated from the surrounding areas, except to the southeast. The western and northern parts are bordered by mountains—Burma to the west and southern China to the north—while the eastern part of the basin forms a boundary with the western margin of the Khorat Plateau and the Gulf of Siam is to the south. The easiest access to the basin is from the southeast, the western regions of modern Cambodia. This environment has shaped the characteristics of the social and political development of Thailand from prehistoric times.[35] As in all mainland Southeast Asia, the movement of social, economic, and political power has generally occurred in a north-south rather than a west-east direction.

Yoshikazu Takaya divides the basin into three areas: the mountains, the floodplain, and the delta.[36] The area of the mountains has two different systems, a tributary system on the mountains themselves and a distributary system in the area between them. While the tributary system is characterised by streams that have eroded the sides of the mountains and by paddy fields, the distributary system is typified by shallow streams that can be easily used as irrigation channels by farmers. Through this distributary system, the Chiangmai and Sukhothai polities increased their power in these areas—which, according to Takaya, tended to be "traditional rice growing regions"—via a process of centralization.[37]

34 A. Gupta, "Rivers of Southeast Asia", in: *The Physical Geography of Southeast Asia, ed. Avajit Gupta* (Oxford: Oxford University Press, 2005): 74-75.

35 Charnvit Kasetsiri terms this specific geographical character a "natural geopolitical unit", see: C. Kasetsiri. *The Rise of Ayudhya. A History of Siam in the Fourteenth and Fifteenth Centuries* (Kuala Lumpur: Oxford University Press, 1976): 12.

36 Y. Takaya, "An Ecological Interpretation of Thai History", *Journal of Southeast Asian Studies* 6 (1975): 190-195. Other scholars divide Thailand into five geographical regions: The Northern regions (mountainous region stretches along the northern border of Thailand), the Central region (Chao Phraya basin and the delta), the Northeastern regions (Khorat Plateau), the Southeastern region (between Sankamphaeng range and the Gulf of Thailand), and the South (Thailand Peninsula or part of Malay Peninsula). See: C. Higham and R. Thosarat, *Early Thailand: From Prehistory to Sukhothai* (Bangkok: River Books, 2012): 15.

37 Takaya, "An Ecological Interpretation of Thai History": 193.

To the south of the mountains is the floodplain, characterised by heavy flooding during the rainy season. However, these floods benefit the region and its communities because they provide an easy means of transportation, water for paddy fields, and fish. A number of polities emerged from this rich land from the fourteenth to the eighteenth centuries, one of which was Ayutthaya. Takaya has suggested that there were different water control systems in the pre-Ayutthaya period from the Ayutthaya polity. Whereas the pre-Ayutthaya kings built irrigation canals, the Ayutthaya kings themselves dug short canals to facilitate the movement of water into the gulf. In consequence, the earlier polity put significant efforts into managing the irrigation system while the latter was more ignorant of water control matters and, as such, the farmers were more independent from the authorities.[38]

The delta area is flat land that is covered by floodwater during the rainy season but which dries up in the dry season. Takaya explains that these conditions were manipulated by the digging of canals in order to construct waterways and help grow places of habitation along the banks of canals, and to provide drinking water. The polities of the Bangkok period did exactly the same, and as such Bangkok became the centre of rice production and its trading ports grew rich during this period.[39]

The following exploration will be focused on the Chao Phraya basin area. I will explore the development of the polities within it from the tenth to the sixteenth century, in the period of Dvārāvatī, Lanna, Sukhothai, and Ayutthaya. However, since the pre-tenth century development of Thailand cannot be separated from the rest of Thai history, I will begin my narrative in the sixth century, which is the background and marks the starting point of Thailand's history.

The emergence of culture in the Chao Phraya basin began around the sixth century, when Dvārāvatī culture began to spread in central Thailand. Dvārāvatī sites can be found all across the central plain of Thailand—especially in the Chao Phraya basin—and most sites have an encircling moat located in or near a stream or river.[40] The Dvārāvatī polity was based on three main aspects: its cultural dominance, *muang*, and the role of streams and rivers.

Dvārāvatī culture spread across the whole of the Chao Phraya basin region, mainly in the form of Buddhist art and culture. Archeological findings have highlighted that Lopburi, Nakhon Pathom, Uthong, and Suphanburi were the main cities and that they formed the centre of Buddhist culture in the Central Plain.[41]

38 Takaya, "An Ecological Interpretation of Thai History": 194.

39 Takaya, "An Ecological Interpretation of Thai History": 195.

40 It seems that this type of site emerged long before the Dvaravati period, not only in the Central Plain but also in the Khorat Plateau. O'Reilly and Scott's archaeological research has described sites in the Mun and Chi valleys of the Khorat Plateau that flourished from 500 B.C. to A.D. 600. See: D.J.W. O'Reilly and G. Scott, "Moated Sites of the Iron Age in the Mun River Valley, Thailand: New discoveries using Google Earth", *Archaeological Research in Asia* 3 (2015): 9–18.

41 Higham and R. Thosarat, *Early Thailand*: 223-334.

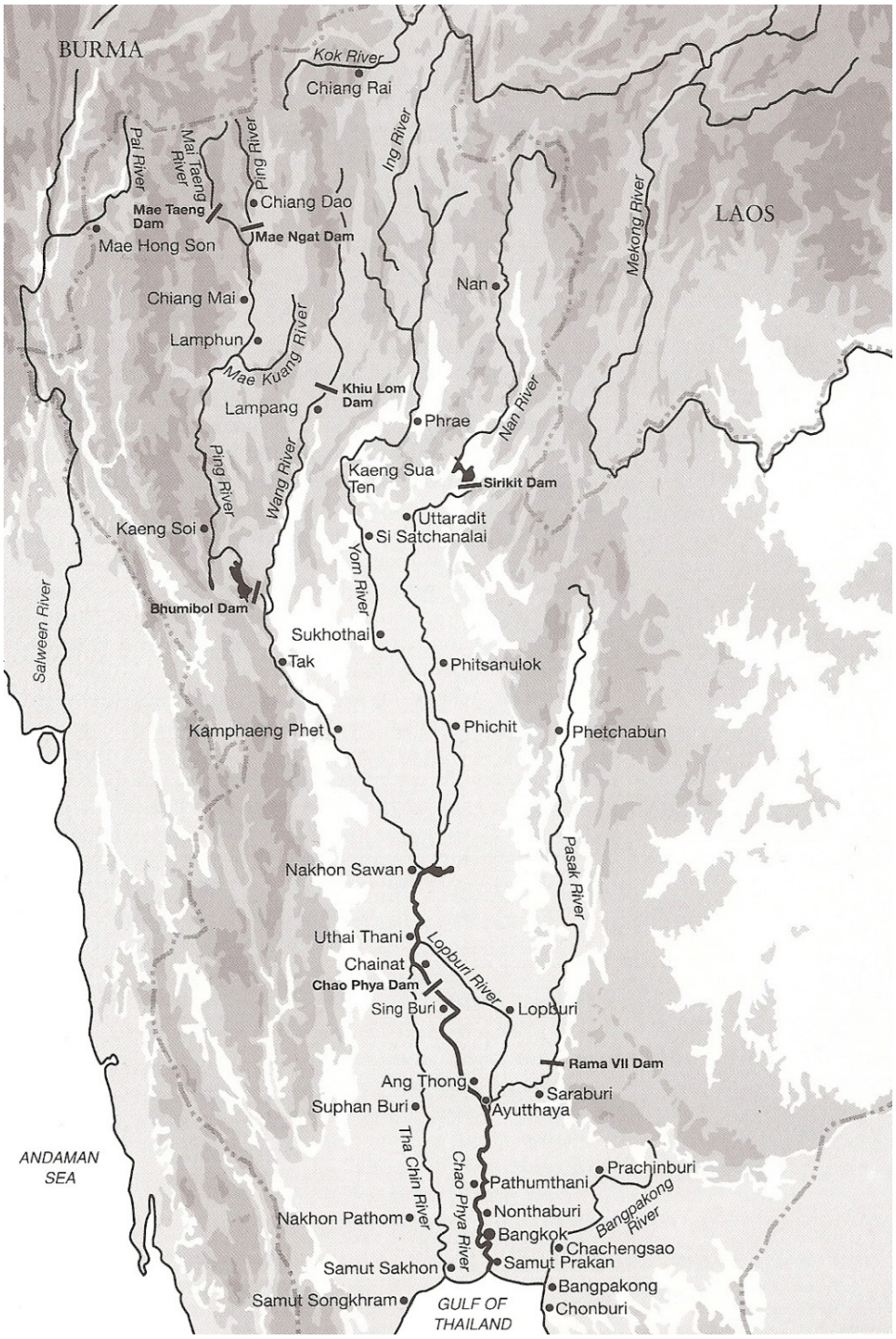

Fig. 2.4. The Chao Phraya basin. (Source: Van Beek 1995: xii)

Although the influence of Dvārāvatī culture stretched over the whole area, no one kingdom came to dominate. The unity of Dvārāvatī depended more on an alliance of cities known as *muang* in Thai, which was formed through marriage ties and cultural relations.[42] Higham views this as a Dvāravatī form of *maṇḍala*s, which, he believes, existed from the seventh century.[43]

Another important characteristic was the role played by streams and rivers in the development of the cultural, economic, and political Dvārāvatī *muang*. Most of the streams and rivers—principally the Chao Phraya and its tributaries—flow from north to south, thereby making movement between the northern and southern parts easy. Some of Chao Phraya's tributaries also flow slightly to the east and west, thereby also allowing access to the western and eastern regions of the Central Plain; in some cases, this could even reach as far as some of the outer regions of the Central Plain. The consequence of this was that, when Dvārāvatī culture reached its peak, it could be easily disseminated in all directions. Politically, this accessibility also played a significant role in controlling the *muangs* that were situated along the Chao Phraya river and its tributaries. The distribution mechanism for the culture and power of the Dvārāvatī *muang* was then increasingly utilized and exploited by successor polities after Dvārāvatī collapsed. As a result of the Chao Phraya river and its tributaries, its basin is a tremendously fertile agricultural area that produces huge quantities of rice, not only for the population of the basin itself but also for export.[44] The combination of control of rice production and the ability to control communication routes between the hinterland and the coast meant that Dvārāvatī was the first polity in the Chao Phraya basin to have a powerful culture, economy, and politics.

The collapse of Dvārāvatī is still debated, but most scholars agree that its power diminished in the eleventh century. The region came under the control of the Khmer Empire, which, from the ninth century, had slowly expanded its territory and, by the eleventh and twelfth centuries, occupied the Central Plain as well as north-eastern, northern, and southern Thailand.[45] At the Khmer Empire's peak during the reign of Jayavarman VII, it controlled almost all of present-day Thailand.[46] Archaeological evidence shows that Khmer culture spread through the Chao Phraya

42 Kasetsiri, *The Rise of Ayudhya*: 16.

43 C. Higham, *The Archaeology of Mainland Southeast Asia* (Cambridge: Cambridge University Press, 1989): 269-279. Phasook Indrawooth argues that the term used by Dvaravati to refer to "state" was Cakravartin; see: P. Indrawooth, "The Archaeology of the Early Buddhist Kingdoms of Thailand", in: *Southeast Asia. From Prehistory to History, ed. Ian Glover and Peter Bellwood* (London and New York: Routledge-Curzon, 2004): 138-140.

44 Kasetsiri, *The Rise of Ayudhya*: 18-19.

45 Indrawooth, "The Archaeology of the Early Buddhist Kingdoms of Thailand": 140-142.

46 D.F. Rooney, *Ancient Sukhothai. Thailand's Cultural Heritage* (Bangkok: River Books, 2008): 18.

and its surrounding areas, especially from the final decade of the twelfth century.[47] However, the historical sources are of limited help in explaining the socio-political processes of the period.

After Jayavarman VII, the Khmer king, died around 1219 AD, the power of the Khmer over the Thai polities weakened, and new polities arose in Thailand: Lanna in the north and Sukhothai in the Central Plain. The most important aspect is that Thai people, who entered the region from the north, became dominant and pushed back the Mon (who are still an ethnic group in present-day Burma/Myanmar) and ended Khmer power in the region, marking the starting point of the rise of Thai power in the area that has continued until today. The origins of the Thai and how they came to occupy these regions are still debated, but most scholars agree that they came from north of the Chao Phraya basin.[48] Kasetsiri argues that the coming of the Thai was part of a much longer historical process, one facilitated by rivers—namely the northern tributaries of the Chao Phraya and Mekong rivers—as they made use of these waterways to help them move southward.[49] As new powers in the Chao Phraya basin, the Lanna and Sukhothai kingdoms forged a new geopolitical path there.

The kingdom of Lanna emerged in the northern part of Thailand and was founded by Mangrai. It was established formally in 1292 in Chiang Mai, although, according to the Chronicles of Chiang Mai, Mangrai had moved his kingdom from the Yonok region, near the Mekong River, and had changed his capital several times before: to Chiangrai in 1262, Fang in 1272, Haripunchai in 1283, Wiang Kum Kam in 1286, and finally Chiang Mai in 1292. During his sixty-year reign, Mangrai succeeded in founding a powerful kingdom that unified many *muangs* in the northern part of the Chao Phraya basin. This was possible due to the compact administration that Mangrai had created. As his kingdom's bureaucracy operated well, the court could easily control its various regions, and the ruler of Lanna could manage their provision and management of labour for the rice fields as well as their military aspects.[50] The court's involvement in water control seems to have been particularly intense in the Lanna period. The Yonok Historical Records tell that the king of Chiangsaen ordered a large irrigation canal be dug in order to draw water into the rice fields for the benefit of the farmers.[51] The Mengraisat laws, issued by King

47 H.W. Woodward, *Studies in the Art of Central Siam, 950-1350 A.D.* (Dissertation, Graduate School of Yale University, 1975); P. Kanjanajuntorn, et al. "Tracing Post-Dvaravati Culture from Space: Applying Remote Sensing Technique in West-Central Thailand", *Asian Perspectives* 53/1 (2014): 29-52.

48 Higham and R. Thosarat, *Early Thailand*: 253-254.

49 Kasetsiri, *The Rise of Ayudhya*: 36-39.

50 D.K. Wyatt, Thailand. *A Short History* (New Haven and London: Yale University Press, 2003): 33-38, 63-71.

51 Although the date of this record, from 757 AD, is still questioned, it is certain that it came from an ancient period, see: S. Van Beek, *The Chao Phya: River in Transition* (Kuala Lumpur: Oxford University Press, 1995): 16.

Mengrai in 1296, regulated water control and management and were overseen by an official called Khun Nai Fai. His duty was to organize the construction of waterworks, find construction workers, control the water, collect maintenance fees, and repair the waterworks. The waterwork most commonly used in Lanna areas was the *muang fai* system. This sought to divide a stream into two watercourses through the construction of a weir in the stream. This is still used today, albeit with some modifications.[52]

The rivers and streams were also important for the life of the Lanna kingdom because they were used as transportation and communication channels by the people who lived along their banks. The Ping river enabled the movement of people and goods around Lanna lands and assisted people both there and in the other areas of the Chao Phraya basin—in central and southern parts—to communicate with each other. In many cases, the river was also used as a natural defence against outside invasion as it was used to construct moats.[53]

On the other hand, the Ping river also caused natural disasters to strike the Lanna kingdom, of which flooding was the most common. Sometimes the flood was larger than expected, something associated with environmental change such as a large-scale La Nina phenomenon. Flooding would threaten cities, and so efforts were made to prevent or control this by constructing embankments and walls. However, these measures were not always capable of preventing floodwater from inundating cities. The Lanna chronicles record that a palace compound was buried by a flood, an event which made King Mengrai realize the danger from flooding and caused him to move his capital from Wiang Kum Kam to Chiang Mai.[54] Research conducted by Serene Ng, Spencer H. Wood, and Alan D. Ziegler confirms that Wiang Kum Kam was flooded many times. Their research also found that a large flood struck the city of Wiang Kum Kam.[55]

The other kingdom that emerged following the decline of Dvārāvatī was Sukhothai, in the Yom river valley around 300 km south-east of Chiang Mai. The Sukhothai kingdom attempted to take control of the whole of the Chao Phraya basin, or even the entire region of present-day Thailand. It seems that the Sukhothai polity was more centralized than was Dvārāvatī. Theravada Buddhism was declared the state religion in the thirteenth century—although it had actually been adopted by both Mons and Dvārāvatī many centuries earlier—while many other belief systems were also in use, such as local beliefs and Hinduism. Ceramics became an important new trade good, and extraordinary examples of all kinds of arts and handicrafts were produced during the Sukhothai period. Sri Satchanalai, located on the banks of the

52 Van Beek. *The Chao Phya*: 14-17.

53 S. Ng, S.H. Wood and A.D. Ziegler, "Ancient Floods, Modern Hazards: The Ping River, Paleofloods and the 'lost city' of Wiang Kum Kam", *Nat Hazards* 75 (2015): 2248.

54 Van Beek, *The Chao Phya*: 21.

55 Ng, Wood and Ziegler, "Ancient Floods, Modern Hazards": 2258-2260.

Yom river, was one centre of ceramic production, and there were many hundreds of kilns along the right bank of the Yom river. Its famous ceramics were exported, and as such it became a major contributor to the Sukhothai economy.

Another significant cultural development that took place in the Chao Phraya basin in the period of Sukhothai rule was the invention of the Thai script by King Ramkhamhaeng. This script was simply a reworking of those that had been used before, but it has been used by the Thai people ever since.[56] The most famous inscription that uses this script is "Inscription Number One" or the "Ramkhamhaeng Inscription." Thus, since the period of Sukhothai rule, and especially the time of King Ramkhamhaeng, the Thai polity has had a unique political and cultural identity.

The inscription's content demonstrates the prosperity of Sukhothai, although perhaps the substance of the inscription has been given too much emphasis. The land is described in the inscription as such: "There are fish in the water and rice in the fields."[57] From this quotation, we can infer that the Sukhothai was a fertile region that produced these two foodstuffs.

Nikom Musigakama's research on the Sukhothai irrigation system supports the belief that this polity and the surrounding regions were productive areas, enhanced by natural and man-made irrigation.[58] Moreover, Musigakama also details the irrigation system used by the Sukhothai dynasty. The types of hydraulic infrastructure built by the Sukhothai kings included dams, dykes, reservoirs/*baray*s, ponds, city moats, canals, and wells. From the many examples of these various types of hydraulic systems, each of which was a huge structure, he explains that the water infrastructure supported Sukhothai's capital and the surrounding areas by providing irrigation for agriculture, preventing floods, providing drinking water, and offering protection against enemy attacks. He also notes the possibility that there were Khmer influences in the construction of the water control systems, especially in the building of the reservoirs (*baray*s) and wells, which were very common in Khmer regions. The construction of waterworks is also seen in Sukhothai inscriptions. For example, the Ramkamhaeng stone inscriptions record a dam construction that was completed in 1327 by King Ramkamhaeng; Inscription III—dated to 1357—tells how King Maha Thammaracha employed a *muang fai* irrigation system to supply rice fields with water; and Inscription XIII—dating from 1510—describes the restoration of a city and its infrastructure, and that, as part of this, a canal was built.[59]

The Sukhothai kingdom weakened in the first half of the fourteenth century, and

56 B. Gosling, *Sukhothai. Its History, Culture, and Art* (Singapore: Oxford University Press, 1991): 29.

57 This sentence is written on the first side of the stone pillar; see: Rooney, *Ancient Sukhothai*: 28.

58 Musigakama, "Irrigation Development under the Sukhothai Dynasti", *The Journal of Sophia Asian Studies* 18 (2000): 53-63.

59 Van Beek, *The Chao Phya*: 25-27.

the centre of power around Chao Phraya shifted to Ayutthaya, which was established by Uthong in 1351.[60] However, the Sukhothai polity continued to exist alongside that of Ayutthaya—including at times being subjugated to Ayutthaya power—until 1438, when its last king, Maha Thammaracha IV, died, and Sukhothai completely collapsed. After that, Ayutthaya was the most powerful polity in the Chao Phraya basin. Its rise wrought many changes to social and geopolitical life across the entire Chao Phraya basin. Ayutthaya emerged as a powerful centre with a more influential military and a more rigidly structured political system than had been the case with previous political centres.[61] Through its military power, Ayutthaya expanded its dominion to both the northern-most part of the basin and southward, to the upper peninsula. In so doing, the Ayutthaya did not seek to bring other states into a rigidly-controlled political system but instead ruled the territory in a much looser way. Perhaps it is true, as Chris Baker argues, that the goal of Ayutthaya's military expansion was merely to maintain commercial links and glorify its rule.[62]

As well as its political strength, another central aspect of the Ayutthaya state was its water management technology. Inside the capital are numerous building-works related to water management, including a 12km city wall with 20 water gates as well as 56km of canals or waterways with 28 bridges across.[63] The canals were built for three different purposes: to make the waterways easier for ships to navigate; to join the eastern and western parts of the city; and to protect the city from attacks.[64] Because Ayutthaya historical sources related to state involvement in water control are very rare, it is very difficult to reconstruct the Ayutthaya water management. However, on the basis of sources from after the eighteenth century, H.T. Brummelhuis has attempted to trace Ayutthaya involvement in water management. He argues that the Ayutthaya ruler did not involve himself in water control, and especially not in that which involved the management of the water required for rice field irrigation. Indeed, from the eighteenth to the nineteenth centuries, while there is evidence that the rulers of the kingdoms involved

60 Some scholars argue that the Ayutthaya polity in fact existed long before 1351; see: *Kasetsiri, The Rise of Ayudhya*: 51-72. Chris Baker even states that the polity existed two centuries before 1351; see: C. Baker, "Ayutthaya Rising: From Land or Sea?", *Journal of Southeast Asian Studies* 34/1 (2003): 41 – 62.

61 Kasetsiri, *The Rise of Ayudhya*: 114. Kasetsiri also calls the beginning of Ayutthaya polity in Chao Phraya basin "the beginning of a new chapter in Siamese history"; see: C. Kasetsiri, "Ayudhya: Capital-Port of Siam and Its 'Chinese Connection' in the Fourteenth and Fifteenth Centuries", Presented at a seminar on "*Harbour Cities Along the Silk Roods*," 10-11 January 1991, Surabaya, East Java, Indonesia, Centre for Social and Cultural Studies, Indonesia Institute of Sciences.

62 Baker, "Ayutthaya Rising": 56.

63 V. Rojpojchanarat, "Ayutthayya: Influences of Water on Settlements and Ways of Life", *The Journal of Sophia Asian Studies* 18 (2000): 303.

64 H.T. Brummelhuis, *King of the Waters. Homan van der Heide and the Origin of Modern Irrigation in Siam* (Leiden: KITLV Press, 2005): 17-18.

themselves in water control matters in order to protect the rice crop, this was in fact more to maintain both rice tax revenues and the regime's legitimacy.[65] In addition, the construction of canals by the ruler was not directly related to supplying water for agriculture. As such, it is clear then that the task of maintaining water for agriculture was in the hands of individual households or groups of farmers.[66] In other words, local farmers were independent as regards water control in order to irrigate their rice fields.

Compared with the centres of the earlier Chao Phraya basin polities, Ayutthaya was located both further south and nearer to the sea. The city of Ayutthaya was located near the Chao Phraya river, on the southern part of its floodplain, giving it easy access to the sea despite being in the hinterland. Consequently, Ayutthaya was ideally located as a commercial port and it succeeded in exploiting this. From the middle of the fifteenth century, it developed as a trading port, especially after King Trailok's reforms of the Ayutthaya administration and bureaucracy (from 1448 to 1488 CE) had placed control of trade in the hands of the court. Ayutthaya was the first hinterland political centre to also act as a commercial port within the Chao Phraya basin.[67] The main achievement of the Ayutthaya polity, however, was to combine the best aspects of a hinterland polity with the commerciality of a trading port; in the words of Chris Baker, Ayutthaya was "the powerful coastal-hinterland hybrid of the high Ayutthaya period."[68]

In sum, after examining the development of the Dvārāvatī, Lanna, Sukhothai, and Ayutthaya kingdoms we recognize that there were three distinctive geographical zones that generated three different water management systems. They are the northern zone, the central zone, and the southern zone, and each was represented by the Lanna, Sukhothai, and Ayutthaya kingdom, respectively. Dvārāvatī had a very different role. In the development of the Chao Phraya basin, Dvārāvatī was never a centralized political power; instead, it represented both a culture and a conglomeration of city-states. However, it also provided a foundation for further development in the Chao Phraya river basin, which each region then cultivated in accordance with its own specific geographical and political characteristics.

The three zones trace a gradual shift in water management from north to south, particularly in the involvement of the central power or the court. The northern zone saw the firm and direct involvement of the ruler in almost everything related to water, from the management of the rice-field water supply to the prevention of flooding; this occurred less in the central zone and the least of all in the southern. It seems that the more dependent on rice as a source of revenue the kingdom was,

65 Brummelhuis, *King of the Waters*: 23-31.

66 Yoshikaru Takaya described the relation between the power center and farmers as "the two communities lived independently of one another", see: Y. Takaya, "An Ecological Interpretation of Thai History", *Journal of Southeast Asian Studies* 6/2 (1975): 194.

67 Kasetsiri, "Ayudhya": 78.

68 Baker, "Ayutthaya Rising": 62.

the greater the involvement of the central power in water management. Northern kingdoms, like Lanna, depended greatly on rice production, while the middle and southern parts had various other means of generating income, particularly because the southern part is nearer to the sea and so its maritime trade could be more intensive.

2.3. THE MEKONG BASIN: ANGKOR

Angkor is situated near the Tonle Sap river, not far from the Tonle Sap lake, in Cambodia. Although it is quite far from the Mekong, about 230 km west of it, it is still part of the Mekong river basin. The Mekong itself is the largest river in Southeast Asia, being 4,909 km in length and having an 813,000 km^2 catchment area. The river originates in the Tibetan Plateau in western China and discharges into the South China Sea. The Tonle Sap connects the Mekong with the Tonle Sap lake, where Angkor is located on the former's alluvial plains.[69]

Śrī Yaśodharapura ("Glory-Bearing City") or Angkor was made the capital of the Khmer Empire in the ninth century CE and lasted until the fourteenth century. The city was one of the largest preindustrial urban complexes in mainland Southeast Asia. Many scholars view it as a "hydraulic city", an urban complex marked by sophisticated water management infrastructure.[70] The city had many impressive features, including highly-developed water management systems, demonstrated in its network of reservoirs, channels, moats, and embankments, across a region of around 1,000 km^2.[71] Recent research has uncovered an even more extensive hydraulic network.[72] One of Damian Evans' research conclusions—part of an attempt to create an archaeological map of Angkor—has revealed that "Angkor as an extensive settlement landscape [was] inextricably linked to the water resources that it increasingly exploited over the first half of its existence."[73]

The development of Angkor was started by Jayavarman II (802-835 CE), when

69 D. Penny, "The Mekong River system and the End of the Angkor Civilization. A Water Historical Perspective", in: *Rivers and Society: From Early Civilisations to Modern Times. A History of Water, Series II Volume II*, ed. T. Tvedt and R. Coopey (London: I.B. Taurus, 2010): 128-129.

70 One of the scholars is Groslier, see: B. Groslier, "La Cité Hydraulique Angkorienne: Exploitation ou Surexploitation du Sol? BEFEO 66 (1979): 161-201.

71 M.B. Day et al., "Paleoenvironmental History of the West Baray, Angkor (Cambodia)", *PNAS* 109/4 (2012): 1046–1051.

72 R. Fletcher et al., "The Greater Angkor Project 2005–2009: issues and program" in: *Uncovering Southeast Asia's Past: Selected Papers from the 10th International Conference of the European Association of Southeast Asian Archaeologists*, ed. E.A. Bacus, I.C. Glover, and V.C. Pigott (Singapore: NUS Press, 2006): 347–354.

73 D. Evans et al., "A Comprehensive Archaeological Map of the World's Largest Preindustrial Settlement Complex at Angkor, Cambodia", *PNAS* 104/36 (2007): 14277–14282.

he founded a capital at Roluos or Hariharālaya. However, his successor, Indravarman I (877-889) built many temples and irrigation works in the city. His most impressive construction was the Indratataka ("Sea of Indra") reservoir, which covered 650 acres and could hold as much as 7.5 million cubic metres of water. He also constructed two temples: Preah Ko, a six-tower temple complex dedicated to his ancestors and to his wife; and Bakong, a pyramid-shaped temple. The city of Angkor itself was begun by Yaśovarman (889-900), Indravarman I's son, in the ninth century after he moved the capital of the Khmer kingdom from Roluos to Angkor, a new settlement near the Tonle Sap lake. The shift of the capital happened for two reasons. The first was religious in nature: that the new place had better characteristics and was, according to Hindu concepts, the ideal place for a capital, especially due to the existence of both water and a hill.[74] The second reason was more practical: the Indratataka, the *baray* in the old capital, was beginning to silt up.[75] Moreover, the Yaśodharapura had much higher subsurface water than did Hariharālaya, meaning that the former was agriculturally more productive than the latter.[76] After the capital was moved to Angkor, more and larger water infrastructure features were built there than had been the case before.

The water management at Angkor is very impressive and reveals how the Khmer rulers and community managed the water. Matti Kummu, one of the most important scholars on the subject, describes water management at Angkor as being primarily based on four water sources: natural rivers, groundwater, precipitation, and the Tonle Sap lake.[77] There are three rivers in the area: the Puok, Siem Reap, and Roluos, all of which originate in the Kulen hill before flowing down to the Tonle Sap lake. The groundwater is easily accessible, as its depth varies from 11 to 40 metres. Tonle Sap lake is the largest freshwater lake in Southeast Asia, although its size, length, and volume of water vary considerably over the year. Furthermore, Kummu explains that water management at Angkor can be viewed from two different perspectives: water management levels and water management zones. He defines the two classifications as follows:

> The water management levels are based on the water management structures while the zones are derived from the ways the water was managed through the landscape at a larger scale. The levels highlight the diversion of water management at different scales, and also within each of the zones.[78]

74 W.J. van Liere, "Traditional Water Management in the Lower Mekong Basin", *World Archaeology* 11 (1980): 265–280.

75 J. DiBiasio, *The Story of Angkor* (Chiang Mai: Silkworm Books, 2013): 21-22.

76 B. Acher, "Mysteries of Angkor Revealed: Hydrology and the Siting of Angkor", in: *Old Myths and New Approaches: Interpreting Ancient Religious Sites in Southeast Asia*, ed. Alexandra Haendel (Clayton: Monash University Publishing, 2012): 38.

77 M. Kummu, "Water Management in Angkor: Human Impacts on Hydrology and Sediment Transportation", *Journal of Environmental Management* 90 (2009): 1413–1414.

78 Kummu, "Water Management in Angkor": 1416.

There were three levels of water management: household, village, and city. At the household level, water was provided by a well that was dug in the water table. At the village level, the *trapeang*—a pond—supplied water for the village, as well as being related to a temple, around which was also a moat. At the highest level, the city, there were *baray*s (enormous reservoirs) and channels. The water in the *baray*s originated in the rivers and was siphoned off through channels. At the city of Angkor there were four major *baray*s: Indratataka (Baray of Lolei), Yaśodharatataka (East Baray), West Baray, and Jayatataka (North Baray).[79]

As regards the water management zones, the other perspective used by Kummu in his article, there were also three: the collector zone, the aggregator and holding zone, and the drainage and dispersal zone. These water management zones were defined according to the elevation of their major features and how water was used.[80] As he concludes:[81]

> The location of Angkor was, from a water management point of view, very convenient for many reasons. Firstly, groundwater was close to the surface throughout the year. Secondly, Tonle Sap Lake offered an excellent transport link to the riparian provinces and the Mekong River and, at the same time, secured part of the food supply and maintained a fertile floodplain to cultivate rice. Thirdly, natural rivers originating in the Kulen Hills meandered across the plain. A drawback was the long dry season for which water needed to be stored. Therefore the Angkorian engineers built an extensive water management network of channels and baray around and within the main temple area covering an area of approximately 1200 km^2.

The development of the Angkor water management system has been reconstructed by Fletcher *et al*.[82] They analysed the development of this system on the basis of a new map of the Angkor water management network prepared by the EFEO (École Française d'Extrême-Orient) and the Greater Angkor Project, an international research programme involving Australian, Cambodian, and French scholars. The result is a history of the water management networks in the area, presenting the successive major water constructions within it. Early construction began in the southeast, later spreading to the north and west, before being concluded with major constructions along the central axis of Angkor in the early twelfth century. These final constructions included two channels—the Angkor Wat canal and Siem Reap

79 Kummu, "Water Management in Angkor": 1416. See also: R. Fletcher, D. Evans, and M. Kummu, *The Dynamics of Water Management of Angkor, Cambodia, 9th to 16th Century*. Paper presented in 3rd Conference of IWHA in Alexandria, Egypt (2003): 8-9.

80 Kummu, "Water Management in Angkor": 1416-1418. See also: Fletcher, Evans, and Kummu, *The Dynamics of Water Management of Angkor, Cambodia, 9th to 16th Century*: 9-10.

81 Kummu, "Water Management in Angkor": 1419.

82 R. Fletcher et al., "The Development of the Water Management System of Angkor: A Provisional Model", *IPPA Bulletin* 28 (2008): 57-66.

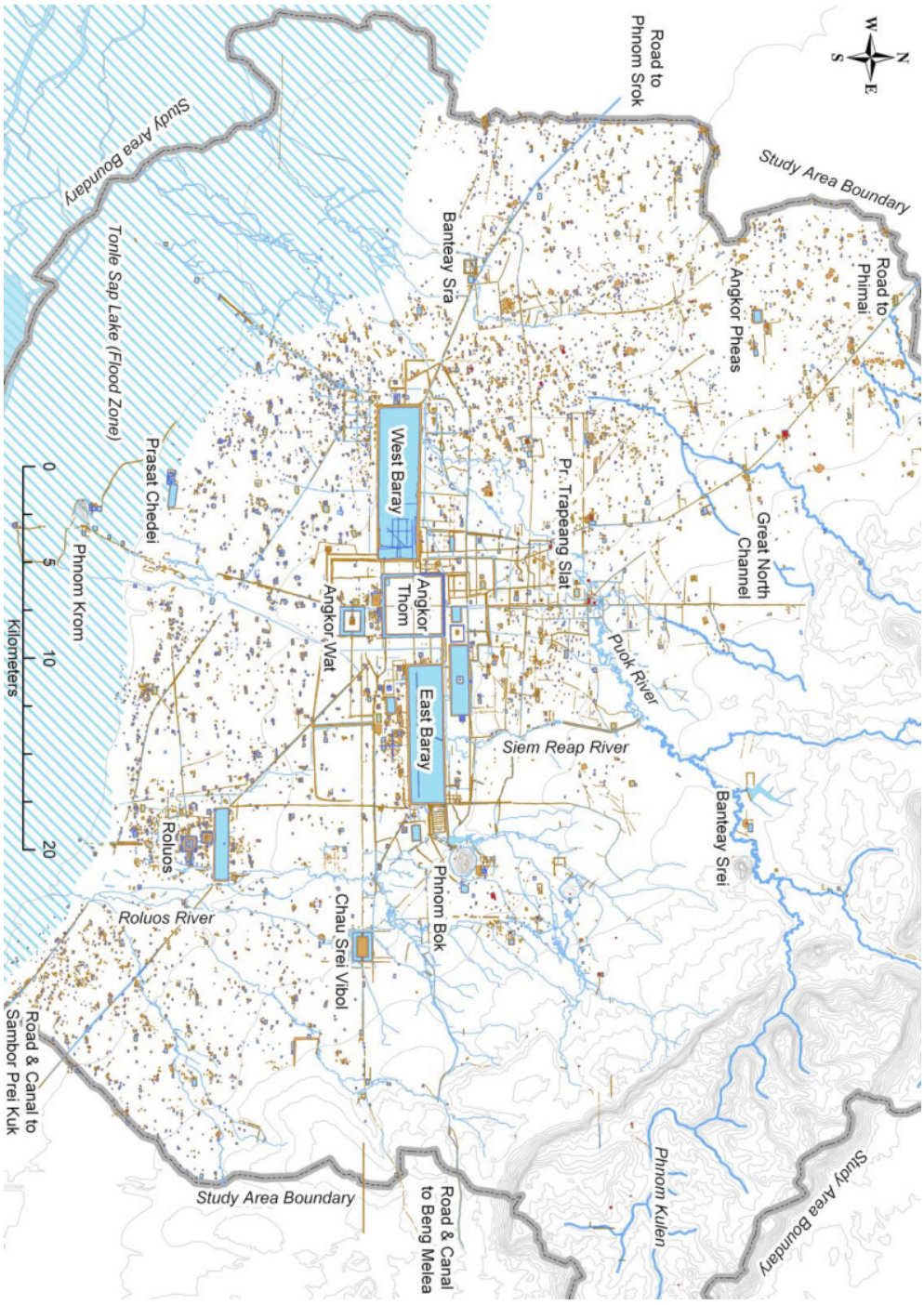

Fig. 2.5. Archaeological Map of Angkor. (Source: Evans *et al.*, 2007)

canal—which discharged water into the lake. The development pattern of water management in Angkor affirms that the main function of the water network was related to flood control and irrigation.[83]

The irrigation role of the water networks was related to rice agriculture in Angkor, which was the state's main source of food and had been one of the founding pillars of Angkor. Although no source details the role of rice production—apart from the *Zhou Daguan*,[84] which only describes the rice production system in the Angkor region, i.e. flood-retreat farming—many scholars believe that Angkor was a rice-based agrarian state.[85] Recent research, using a new approach, has resulted in a very interesting theory regarding the centralization and decentralization of rice production. This research, conducted by Scott Hawken, used a topographic classification of the landscape based on extensive mapping from remote sensing imagery and fieldwork carried out from 2007–10. It found that there were two rice field systems: the cardinal system and the coaxial system. Each was characterised by a different system of rice production; the cardinal system saw the Angkorian elites involved in the establishment of its infrastructure, while the coaxial system was related to the local communities and the state was not directly involved.[86]

The Angkor complex's water management system was developed in response to the region's monsoon climate. The Tonle Sap is greatly affected by annual floodwaters that are the result of the monsoon rain. The Mekong adds 45 km^3 of floodwater to the Tonle Sap, causing an area of 15,000 km^2 around the lake to be covered by floodwater, bringing productive silt to the floodplain and fish to the lake.[87] On the other hand, the monsoon climate caused great destruction to Angkor in the fourteenth and fifteenth centuries, when there was a period of extreme rainfall variation caused by global climate change. Intense droughts in Southeast Asia occurred during the period from the Medieval Climate Anomaly (MCA) to the Little Ice Age (LIA), which reduced average rainfall by 30%.[88] The changing hydrological

83 The previous researchers tended to interpret that the baray had a cosmological function than as for agricultural water work, see: Van Liere. "Traditional Water Management in the Lower Mekong Basin"; E. Moore, "Water Management in Early Cambodia", *The Geographical Journal* 155 (1989): 204-214; P. Stott, "Angkor: Shifting the Hydraulic Paradigm", in: *The Gift of Water, ed. Jonathan Rigg* (London: School of Oriental and African Studies, University of London, 1992): 47-58.

84 Zhou Daguan was a Chinese envoy who visited Angkor in 1296-97 and wrote *A Record of Cambodia: The Land and Its People* after his return to China.

85 No Khmer inscriptions describe rice production in detail, instead detailing rice offerings made to God. See: J.M. Scott, "The Ecology of Angkor: Evidence from the Khmer Inscriptions", in: *Nature and Man in Southeast Asia*, ed. P.A. Stott (London: School of Oriental and African Studies, 1978): 110-111.

86 S. Hawken, "Designs of Kings and Farmers: Landscape Systems of the Greater Angkor Urban Complex", *Asian Perspectives* 52/2 (2013): 347-367.

87 Kummu, "Water Management in Angkor": 1415.

88 Penny, "The Mekong River System and the End of the Angkor Civilization": 135. See also:

conditions could not have been predicted by the existing hydraulic network; as such, the water network was not able to adapt to such changes.[89] It was a combination of increasing aridity and incidental flooding that may have been a cause of the decline of the Khmer kingdom.

2.4 CONCLUSION

To sum up, the development of the three river basins—the Irrawady, the Chao Phraya, and the Mekong—from *c.* the tenth to the sixteenth centuries displays both similarities and dissimilarities. First, topographically speaking, each basin forms a relatively low area of land stretching from north to south and bound by mountains and highlands. These mountains and highlands create three geographically separate regions: the Tanasserim Hills separate the Irrawaddy from the Chao Phraya valley while the Khorat Plateau separates the Chao Phraya from the Mekong valley. The only connecting pass, the Three Pagodas Pass, is a narrow lowland area south of the Khorat Plateau that creates a pass between the Chao Phraya basin and the Mekong basin. The north-south shape of each basin makes the movement of people and goods in that direction much easier than is possible across the mountains, between east and west.

Second, most of the main polities were located near perennial rivers or streams that were themselves both not far from the main river and within its basin. Angkor was situated close to the Siem Riep, a tributary of the Mekong; and Lanna and Sukhothai were near tributaries of the Chao Phraya.

Third, and related to these two conclusions, there was a trend towards interaction between downstream and upstream communities along the main river, for which they used the river as a means of transportation. To a large extent, they employed it as a means of distribution for political power and to trade goods. However, there is less evidence of this in the case of Angkor.

Fourth, the climates of the three basins are fairly similar. The centres of political power grew up in relatively dry areas with comparatively low rainfall, and the political centres of Burma were even situated in the driest area of Southeast Asia. Lanna, Sukhothai, Ayutthaya, and Angkor were located in good positions, being in

Day et al., "Paleoenvironmental History of the West Baray, Angkor (Cambodia)": 1050.

89 See: R. Fletcher and D. Evans. "The Dynamics of Angkor and its Landscape", in: *Old Myths and New Approaches: Interpreting Ancient Religious Sites in Southeast Asia*, ed. Alexandra Haendel (Clayton: Monash University Publishing, 2012): 60-61.
The Medieval Climate Anomaly, also called The Medieval Warm Period, was a time of warm climate from about 900–1300 CE in which relatively warm conditions are said to have prevailed in various parts of the world, though predominantly in the Northern Hemisphere from Greenland eastward through Europe and parts of Asia, but, at the same time, raifall rised in others such as the tropical Pacific. The period was followed by The Little Ice Age, from about 1300 to 1850 CE, some parts of the world were, on average, slightly but significantly colder.

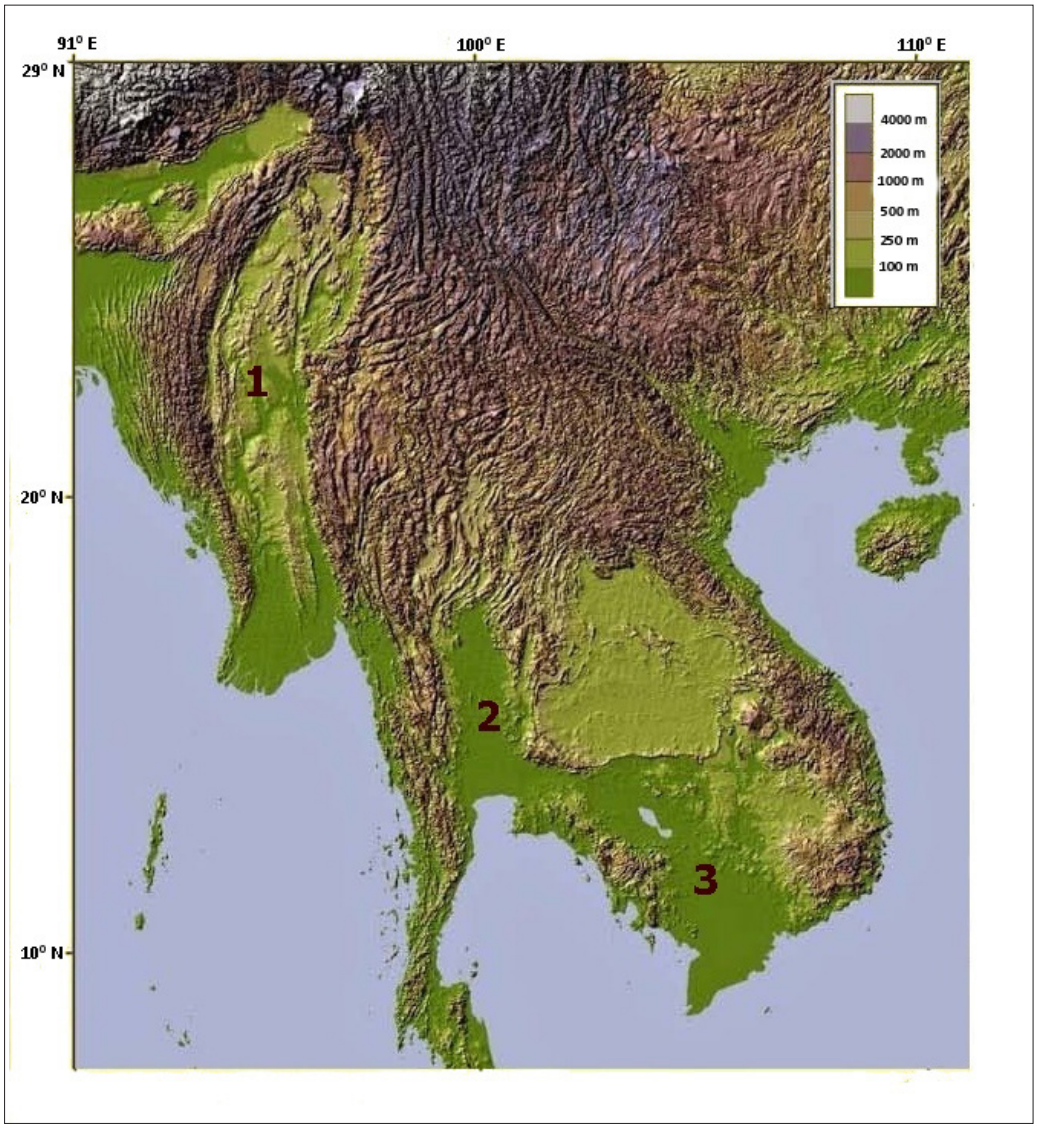

Fig. 2.6. Topographic map of three river basins: The Irrawaddy basin, (2) The Chao Phraya basin, and (3) The Mekong basin. (Souces: www.treehouse-maps.com with modification)

semi-dry areas but still able to take advantage of the frequent inundations of the areas around them.

Fifth, global climate change seems to have influenced the cultural, economic, and social development of the societies in each basin. A wetter climate—a consequence of climate change that occurred *c.* 900/1000-1300—supported kingdoms in the three basins by increasing their agricultural productivity. Moreover, increased

rainfall also led to an expansion of waterworks and water management programmes. When the climate change occurred after 1300 CE in which several droughts existed, the kingdom such as Angkor probable was unsuccessful to cope it caused in declining of the kingdom.

Sixth, it seems that the river-polities adjusted to their environments by creating and/or employing suitable water technologies: Angkor with its canals, moats, and lake; Upper Burmese polities with canals, moats, small tanks, and weirs; and the Thai ones with dams, dykes, reservoirs, ponds, city moats, canals, and wells. At first glance, it seems that these three basins show similar waterwork constructions. However, if we look at them more closely, differences are revealed. For example, the Thais—especially those of Lanna—and the Burmese built and utilized weirs because they needed to distribute water in order to enlarge the area of irrigated land in their hilly region.

Seventh, there is a difference between polities in the Southeast Asian mainland as regards the authorities' role in managing the water. According to Victor Lieberman the mainland states of Southeast Asia generally tended towards increasing administrative centralization.[90] It remains to be seen, though, to what extent such centralization is also reflected in the state's involvement in water management. Indeed, the Burmese, Thai, and Khmer rulers paid increasing attention to the construction of water infrastructure, yet they differed in how involved they were in maintaining the irrigation waterworks. The Burmese rulers, especially those of Bagan, directly supervised the *kharuin* irrigation system while Ayutthaya left the management of rice field irrigation to local communities or even households. The Khmer rulers held tightly the water management in their hands.

These water managements in the three river basins of mainland Southeast Asia will be compared with East Javanese water management in the period of the tenth to the sixteenth centuries CE. The act of comparing both regions (mainland Southeast Asia and East Java) is guided by aspects related to the geographical conditions and development of the polities and is aided by the amount of written evidence and artefactual sources from both. Comparing the water management of the two regions will not only contribute to understanding the trajectories of water management development in both, it will also sharpen my analysis of East Javanese water management, which focuses on the relationship and division of power between the East Javanese authorities and the local population. It is also significant that the explanation of water management in the three regions of mainland Southeast Asia helps create the following premise for the development of water management in ancient East Java: that the relationship between political power and water management correlates with geographical characteristics, the state's economic base as an agrarian state, climate change, and the socio-political structure of the region.

90 V. Lieberman, "South East Asia and Eurasia during a Thousand Years", *South East Asia Research*, 19, 1 (2011): 11. See also: Lieberman, Strange Parallels: 459.