Agriculture Comes to Cambodia

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Rice is "the staple food of Southeast Asia."[1] The region's total rice production in 2010-11 reached 110 million tonnes and is expected to reach 128 million tonnes by 2021. This is clearly not a matter of a subsistence crop. Rice economics in Southeast Asia is "multifaceted." Cambodia, one of the smaller Southeast Asian countries, alone exported 1,250,000 metric tonnes of rice in 2017-18. Its western neighbor, Thailand, was (after India) the world's second-largest rice exporter, selling 10,200,000 tonnes of its rice abroad. Cambodia's eastern neighbor, Vietnam, was the world's third-largest, exporting 6,700,000 tonnes of rice in 2017-18.[2]

How did this situation come about ? How did rice cultivation become such a dominant activity in Southeast Asia ? And how did Southeast Asia come to play such an important role in world rice production ? The origins of rice cultivation in Southeast Asia lie in a long prehistory of geophysical change, climate variation, ecological and biological evolution, and importantly, human adaptation.

Mainland Southeast Asia has been called "one of the richest habitats known." The common prehistory of human settlement in a region that includes the valleys of the Mekong, Chao Phraya, and Red Rivers, and their intervening uplands, is in part related to its environment:

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[1] Arief Subhan, "The Economics of Rice in Southeast Asia," ASEAN Post, 11 April 2018: https://theaseanpost.com/article/economics-rice-southeast-asia-0

[2] Arief Subhan, "Economics of Rice in Southeast Asia."

high temperatures and high annual rainfall, usually upwards of 1000 mm., over four-fifths of which falls during the summer monsoon from May to September, and is followed by a dry season from November to April. This seasonality enables annual varieties of plants like rice to flourish. In addition the long rivers, extended coastlines, and numerous lakes of the Southeast Asian mainland all offer "abundant, naturally replenished food resources."[3] Cambodia's large Tonle Sap lake is the world's richest source of fish.[4] These special ecological conditions are the result of millennia of geophysical and climatic transformations.

The Ice Age

The landmass of the Southeast Asian peninsula was far larger during Last Glacial Maximum, when the glaciers of the most recent Ice Age reached their greatest extent and the world's sea levels were at their lowest. The surface level of the South China Sea had dropped by up to 120 meters. The Gulf of Thailand was exposed and dry, part of a contiguous land area of mainland Southeast Asia which had spread across 3.2 million square kilometers. What is now

[3] Ian C. Glover and Charles F.W. Higham, "New Evidence for Early Rice Cultivation in South, Southeast and East Asia," in *The Origins and Spread of Agriculture and Pastoralism in Eurasia*, ed. David R. Harris, London, UCL Press, 1996, 413-441, at 423, 419; W.J. Van Liere, "Early Agriculture and Intensification in Mainland Southeast Asia," in *Prehistoric Intensive Agriculture in the Tropics*, Part ii, ed. I.S. Farrington, Oxford, BAR International Series 232, 1985, 829-34, at 829.
[4] P. Chevey, "The Great Lake of Cambodia: The Underlying Causes of its Richness in Fish," *Proceedings of the Fifth Pacific Science Congress*, Canada, 1933, vol. 5, p. 3812.

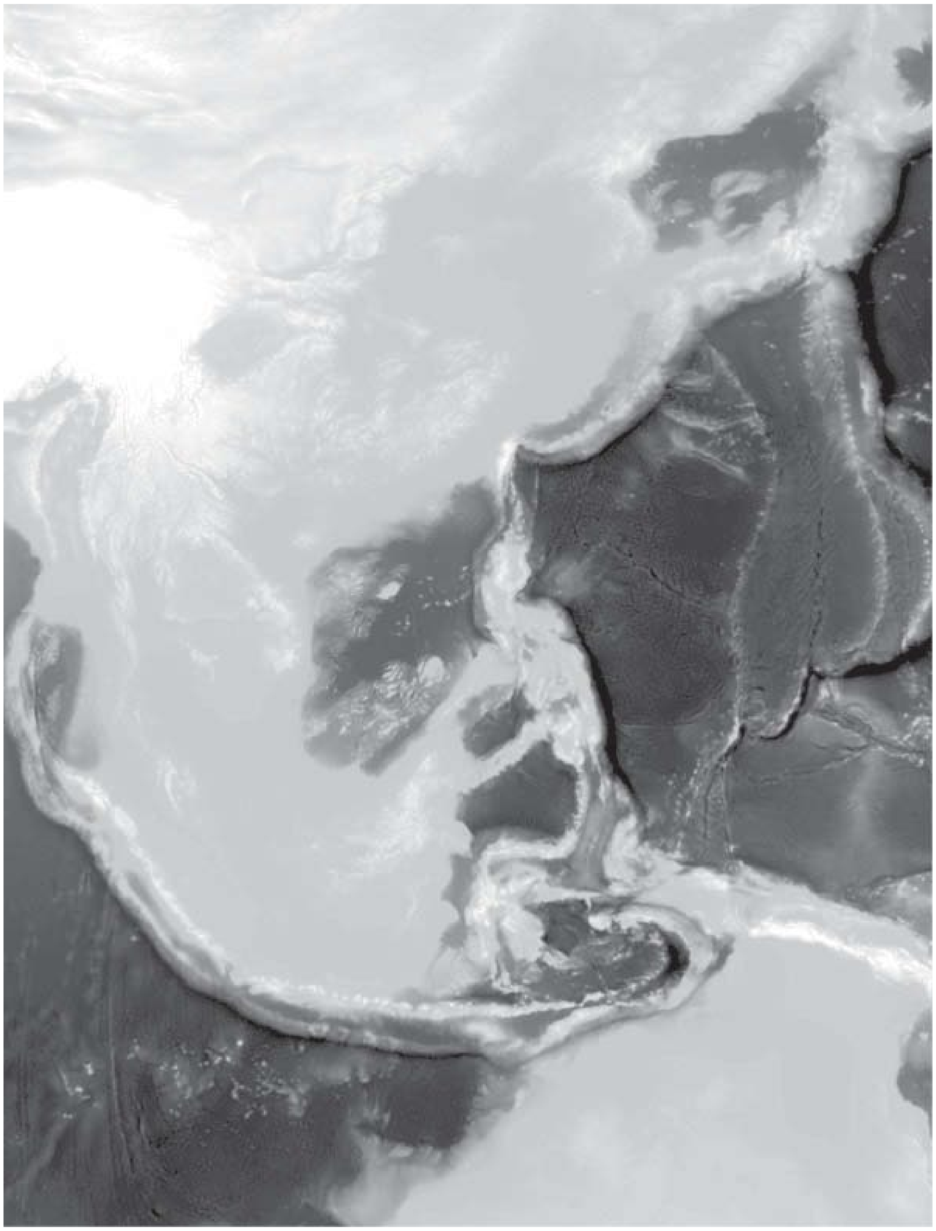

Fig. 1. East and Southeast Asia, showing topographic and bathymetric relief.
Modern geopolitical boundaries (black lines) and the −120m isobath (white line), which marks the approximate sea level minimum at the last glacial maximum, are also shown. Topographic and bathymetric data is ETPO1 Global Relief Model (Amante, C. and B. W. Eakins, ETOPO1 1 Arc -Minute Global Relief Model: Procedures, Data Sources and Analysis, National Geophysical Data Center, NESDIS, NOAA, U.S. Department of Commerce, Boulder, CO, July 2008).
From Dan Penny, "China and Southeast Asia," Fig. 6.1.

Thailand's Chao Phraya River flowed far out across dry land into a then landlocked bay of the South China Sea north of Borneo.[5] The Last Glacial Maximum lasted from 26,500 to 19,000 years ago.[6] It was not only a cold but a dry period that also saw global growth of grasslands, dry shrubland, desert, and tundra. All kinds of forests, from tropical to temperate, receded.[7] In mainland Southeast Asia, including what was to become Cambodia, this occurred in some (though not all) of the lowland and coastal regions.[8]

But in the peninsula's interior, forests do not seem to have retreated on the same scale. Palaeogeographer Dan Penny finds this "striking."[9] The flora of the uplands of what are now northeast Cambodia and northwest Thailand, and of lowland northeast Thailand (near to modern Cambodia), Penny writes, were dominated by "apparently immutable" stands of pine and oak forests "throughout the glacial period and the subsequent de-glaciation."[10] Remaining traces of these forests still provide a major source for our knowledge of the region's longterm environmental history. For instance, just as pollen and charcoal records from northern Australia provide evidence for increased burning there from about 40,000 years ago, similar records from mainland Southeast Asian confirm that a dry period characterized by high fire activity began as early as 38,000 years ago, and lasted until around 10,000 BCE.[11]

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[5] Dan Penny, "China and Southeast Asia," in *Quaternary Environmental Change in the Tropics*, ed. Sarah E. Metcalfe and David J. Nash, London, Wiley, 2012, 207-235, at 208 (Fig. 6.1), 225; Andrew Lee Maxwell, "Holocene Monsoon Changes Inferred from Lake Sediment Pollen and Carbonate Records, Northeastern Cambodia," *Quaternary Research* 56, 2001, 390-400, at 398. I have converted all uncalibrated and calibrated radiocarbon dates Before Present (BP) to years BCE, using Table 2.2 in Andrew Lee Maxwell, "Holocene Environmental Change in Mainland Southeast Asia: Pollen and Charcoal Records from Cambodia," Ph.D. diss., Louisiana State University, 1999, 54.

[6] Peter U. Clark et al., "The Last Glacial Maximum," *Science* 325, Aug. 7, 2009, 710-14, at 711.

[7] B.A.A. Hoogakker et al., "Terrestrial biosphere changes over the last 120 kyr," *Climate of the Past* 12, 2016, 51-73, at 52, 68.

[8] Maxwell, "Holocene Monsoon Changes," 398; Penny, "China and Southeast Asia," 226.

[9] Penny, "China and Southeast Asia," 223.

[10] Maxwell, "Holocene Environmental Change," 192; Penny, "China and Southeast Asia," 223.

[11] Dan Penny, "A 40,000 year palynological record from north-east Thailand: implications for biogeography and palaeo-environmental reconstruction," *Palaeogeography, Palaeoclimatology, Palaeoecology* 171 (2001), 97-128, at

Globally, the period from 15,000 to 12,000 BCE saw episodic higher temperatures and increased rainfall. But then came a rapid, severe return to cold and dry conditions from 11,000 to 9,500 BCE, a period known as the Younger Dryas.[12] In the northern latitudes of Southeast Asia, including the mainland, the evidence indicates that recovery from this new cold dry era took centuries longer than in other parts of the globe, lasting until about 9,200 BCE.[13] Following the Glacial Maximum, then, the Ice Age itself continued until 9,700 BCE, and in mainland Southeast Asia in particular, its effects were felt for many hundreds of years after that. Nevertheless, over much of the region, forests flourished, and in that same period before 9,300 BCE, scientists have uncovered early evidence of human settlement.[14] These people's relationship to the forests around them is a key question in Cambodia's earliest history.

Even ten thousand years ago (c. 8,000 BCE), Cambodia was still experiencing some of the key effects of the Last Glacial Maximum. By 9,300 BCE, with the melting of the glaciers, the sea level had risen in the Gulf of Thailand but it remained 40 meters below the present level. A millennium later the Gulf of Thailand had joined up with the South China Sea, but its level was still more than 20m. lower than it is today even by 6,800 BCE. In addition, around 8,000 BCE the Tonle Sap and lower Mekong Rivers were much narrower than they are now, and they flowed through dry savannahs, not the extensive floodplains and moist vegetation of today. Therefore, in that period of the late Glacial Maximum, the southwest monsoon winds reaching Cambodia across the Gulf of Thailand and the lower Mekong basin were still unable to pick up

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108-9, 110-11, Fig. 5; Andrew L. Maxwell, "Fire Regimes in north-eastern Cambodian monsoonal forests, with a 9300-year sediment charcoal record," *Journal of Biogeography* 31, 2004, 225-239, at 226.

[12] Peter Bellwood, *First Farmers: The Origins of Agricultural Societies*, Malden, MA, Blackwell, 2005, 46.

[13] J.W. Partin et al., "Gradual onset and recovery of the Younger Dryas abrupt climate event in the tropics," *Nature Communications*, Sept. 2, 2015, 1-9, at 4: https://www.nature.com/articles/ncomms9061 (accessed April 15, 2017).

[14] Maxwell, "Fire Regimes in north-eastern Cambodian monsoonal forests," 226; Charles Higham, *Early Cultures of Mainland Southeast Asia*, Chicago, 2002, 47.

the significant quantities of moisture for monsoon precipitation over Cambodia for which the country is now known.[15] This drying effect was exacerbated by the rainshadow of the Cardamom Mountains in Cambodia's southwest, which shelters much of central Indochina and in particular, most of Cambodia.[16]

Pollen and charcoal records in sediment cores retrieved by paleogeographer Andrew Maxwell from the bed of upland lakes in Cambodia's northwest provide environmental information on the Late Glacial period as far back as 8,500 BCE. As Maxwell has summarized his findings, from then until about 7,300 BCE the region remained "slightly cooler and drier" than it is now, and the water level in upland lakes was lower. Along with highland subtropical forests such as pines, and semi-dense tropical forest of a type tolerant of the drier conditions, grasses were a key part of the upland flora. These were easily susceptible to burning, and fires were more active than at any time since. High fire periods recurred at least every 100-300 years. Here in upland Cambodia the dry conditions of the late Glacial Maximum persisted for more than a thousand years after it had ended in southwest China.[17] This was the final stage in the local transition from the Pleistocene era (roughly, the previous two million years) to the Holocene era.[18]

What caused these fires in Late Pleistocene Cambodia ? In northeast Thailand, archaeologist Lisa Kealhofer has analyzed the types of plants burned over the long transition from the Late Pleistocene to the Early Holocene. She found that they "track the climatic and vegetation changes" from one era to the next. That, she concludes, suggests human activity

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[15] Maxwell, "Holocene Monsoon Changes," 398; Maxwell, "Holocene Environmental Change," 197-98; Penny, "China and Southeast Asia," 225.
[16] Penny, "China and Southeast Asia," 225.
[17] Maxwell, "Holocene Environmental Change," 189-90, 192-94, xi.
[18] Maxwell, "Holocene Monsoon Changes," 398.

distinct from agriculture: “the landscape itself was being burned, not a more limited and controlled burn of weedy fields.” The fires most probably indicate “hunting, clearing of undergrowth, and selected habitat maintenance.” Burnings increased in the late Early Holocene, but the plant species represented indicate “burning or clearance of the dry deciduous forest understory,” which grows on soils that rarely support “slash and burn” agriculture.[19]

The historian of fire Stephen J. Pyne writes that Southeast Asia’s monsoonal forests, with their “well-defined fire seasons,” were “filled with species adapted to fire disturbances . . . landscapes in which pyrophilic humans could thrive.”[20] Upland Cambodia shared a similar pattern to that prevailing elsewhere in mainland Southeast Asia. Pollen and charcoal records from lake beds in nearby northeast Thailand show an initial increase in charcoal around 13,500 BCE and then, after the known arrival of humans in the region, a sharp rise in burning from 7,800-7,600 BCE, especially of grasses, and an increase in pine pollens. It is possible that at least the later fires were deliberately set, a human strategy to facilitate movement and hunting in the dry, monsoonal forest.[21] In northern Australia, the pollen and charcoal evidence for large-scale burning from about 40,000 years ago follows the arrival of humans on that continent around 65,000 years ago.[22] The people whose traces archaeologists have found in mainland Southeast Asia from the period before 9,300 BCE had, after all, also managed to survive the Ice Age, including most recently the severe Younger Dryas. Fire must have been a key to that survival, and they were now likely turning it to their advantage as they moved into a new landscape in

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[19] Lisa Kealhofer, “The Human Environment During the Terminal Pleistocene and Holocene in Northeastern Thailand: Phytolith Evidence from Lake Kumphawapi,” *Asian Perspectives* 35:2 (1996), 229-54, at 243, 248.
[20] Stephen J. Pyne, *Vestal Fire: An Environmental History, Told Through Fire, of Europe and Europe’s Encounter with the World*, Seattle, University of Washington Press, 1997, 33.
[21] Penny, “40,000 year palynological record from north-east Thailand,” 109; Maxwell, “Fire Regimes in north-eastern Cambodian monsoonal forests,” 226.
[22] Chris Clarkson *et al.*, “Human Occupation of Northern Australia by 65,000 Years Ago,” *Nature* 547 (20 July 2017), 306-10; Maxwell, “Fire Regimes in north-eastern Cambodian monsoonal forests,” 226.

changing climatic conditions. As leading prehistorian Peter Bellwood points out, the hunter-gatherer lifestyle, "in terms of long-term stability and reliability, has been the most successful in human history."[23]

It is difficult to identify these early inhabitants of mainland Southeast Asia, or the languages they spoke. However, most scientific analyses of skeletal remains of the foragers then expanding widely across the mainland have demonstrated the "Australo-Melanesian" features of their cranial morphology, suggesting that they were related to ancestors of Australian Aborigines and modern Melanesian populations.[24] It is possible, then, that what we know of their activities may be culturally akin to the much earlier use of fire in northern Australia.

Hunter-gatherer manipulation of their environment could have included the use of fire not only for hunting but also to gather edible plants that were difficult to access. In northeast Thailand, archaeologist Joyce White points out, local farmers still set fires to collect *man pōerm*, yams that grow densely in mixed deciduous forest thickets which have defenses such as thorns, biting ants, and stinging fruits. "During the dry season the thickets can be burned, or even cut and burned. The collector then digs along the soil surface to locate the tops of yams." White comments: "Similar use of fire by preagricultural societies in Southeast Asia seems highly likely."[25]

Domestication of cereal crops, however, required the annual rather than the perennial forms of the cereals, and a reliable seasonal climate. As Francesca Bray writes in her study of the

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[23] Peter Bellwood, *First Farmers: The Origins of Agricultural Societies*, Malden, MA, Blackwell, 2005, 2.
[24] Hirofumi Matsumura, Kate M. Domett, and Dougald J.W. O'Reilly, "On the Origin of pre-Angkorian peoples: perspectives from cranial and dental affinity of the human remains from Iron Age Phum Snay, Cambodia," *Anthropological Science* 119:1 (2011), 67-79, at 73.
[25] Joyce C. White, "Modeling the Development of Early Rice Agriculture: Ethnoecological Perspectives from Northeast Thailand," *Asian Perspectives* 34:1 (1995), 37-68, at 58.

origins of Chinese agriculture, "perennial cereals do not form seed reliably, but annual forms must do so as it is essential to their survival." Annuals produce more seeds to allow for wastage, and their seeds are frequently bigger than those of a plant's perennial form. The annual forms started to spread more widely, according to Bray, as a result of "climatic stress" around 10,000 or 9,000 BCE, when "temperatures in the northern hemisphere generally rose and rainfall levels fell; as a result of progressive dessication the number of annual plants increased."[26] The monsoonal climate of Thailand, Cambodia, and other parts of Southeast Asia was of course different to that of China, but Lisa Kealhofer points out that in the Late Pleistocene it included stronger cool, dry winter monsoons than the summer (warm, wet) monsoons, making the environment of mainland Southeast Asia "considerably more arid and more seasonal than today." This aridity and strong seasonality also favored "the expansion of *annual* grass species" including rice in its wild varieties, increasing not only "the species available for human exploitation" but their annual production of seeds.[27]

However, the global climate from 18,000 to 9,500 BCE was not only colder and drier and more seasonal but also much more *variable*, with "major swings of temperature and moisture supply" that lasted for decades at a time. Those unsettled conditions would still have made it extremely difficult for humans to begin any experiments with cultivation. But then, the rapid global change from about 9,500 BCE brought not only warmer and wetter overall conditions but a climate that was "a good deal more *reliable* on a short-term basis," writes Bellwood. The seasons now became predictable from year to year. "It was this reliability that gave the early edge to farming."[28] What also helped in mainland Southeast Asia was a now "substantially

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[26] Francesca Bray, in Joseph Needham, *Science and Civilisation in China*, Vol. 6, Part 2, *Agriculture*, Cambridge, Cambridge University Press, 1984, 30-31.
[27] Kealhofer, "Human Environment During the Terminal Pleistocene and Holocene," 233-34.
[28] Bellwood, *First Farmers*, 19-20.

strengthened" Asian summer monsoon, offering a more nourishing growing season.[29] But there is as yet no evidence of the cultivation of crops there.

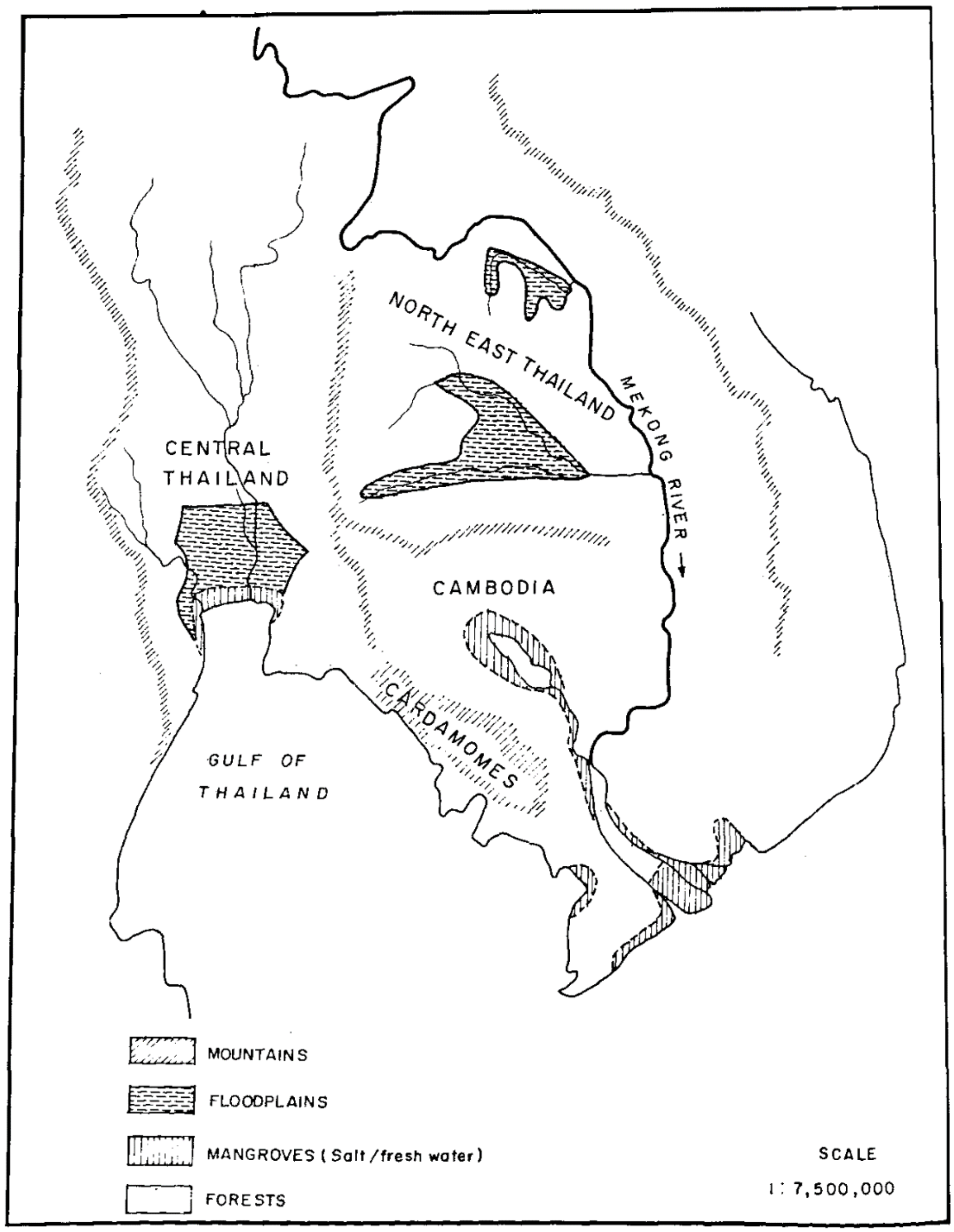

Fig. 2. Central Mainland Southeast Asia. From W.J. Van Liere, "Mon-Khmer Approaches to the Environment," in *Culture and Environment in Thailand: A Symposium of the Siam Society*, Bangkok, 1989, p. 144, Fig. 9.1, "Original Environmental (Schematic)."

[29] Dan Penny, "Palaeoenvironmental Analysis of the Sakon Nakhon Basin, Northeast Thailand: Palynological Perspectives on Climate Change and Human Occupation," *Bulletin of the Indo-Pacific Prehistory Association* 18 (1999), 139-49, at 146.

The Holocene

As we have seen, geophysical factors such as continuing low sea levels and the Cardamom Mountains rainshadow had delayed the arrival of the Holocene amelioration to Cambodia. But then, starting abruptly from 7,300 BCE, a new, warmer, more humid climate came to upland northeast Cambodia. The summer monsoon rains became heavier. The water level in upland lakes began to rise. For about 500 years, fires continued to break out, but they petered out in intensity. Dense semi-evergreen forest replaced highland subtropical forests and grasses around the lake that Maxwell studied, with an understorey rich in palms. There was an "extreme algae bloom" on the lake. The period from 6,800 to 4,000 BCE saw the maximum intensity of the summer monsoon. From about 6,700, after the last big bushfire in the lake watershed, fire activity fell drastically (especially in the period 5,800-4,400 BCE) and remained low until 3,900 BCE. In this warmer, wetter era from 5,800 to 4,000 BCE, evergreen forests came to dominate the Cambodian uplands.[30] Forest-dwellers would have had to adapt their hunting methods, and to rely much less on burning.

The "first prehistoric cave deposit reported in Cambodia" is 150 meters above sea level in the Cardamom Mountains of the northwest, in a limestone cave entered through a rock arch and known as Laang Spean or "Bridge Cave." Excavations there in the 1960s yielded evidence of the first known human habitation of the country. Beginning around 6,800 BCE or slightly earlier, forest-dwelling hunter-gatherers moved into the cave. From their occupation in the seventh and sixth millennia they left grooved sandstone fragments, flakes of chert stone and a few of fine-

[30] Maxwell, "Holocene Environmental Change," 190, 196, 181-82, 201, 194-95.

grained silicate, and animal bones, but no trace of any pottery or signs of agriculture. Theirs was a Paleolithic culture. The presence of the flakes suggests that they produced stone tools inside the cave itself.[31]

In the warmer, wetter climate after 5,800 BCE, other forest dwellers in the uplands of Southeast Asia might conceivably have begun to cultivate rice. In the early 1980s a consensus emerged among archaeologists, botanists, and historical linguists that domestication began in the broad upland region dubbed "the piedmont zone of Southeast Asia" – the hills of the northern mainland and southern China. If so, domesticated rice must have been been first grown there before 5,000 BCE, because by that date it had spread to lowland China's southeast coast where excavations have uncovered an advanced neolithic culture that was largely dependent on wet rice cultivation.[32] Less time might have been required for the technique of rice cultivation to spread downriver from the piedmont zone to the more proximate foothills and plateaux of mainland Southeast Asia. But there as yet is no evidence that it did so at such an early date.[33]

Plant geneticists believe rice was first domesticated under "inundated conditions."[34] One archaeologist has suggested that rice cultivation began on the northeastern Thai plateau in naturally marshy areas, "and that, as their skills increased, farmers were able to spread to non-palustrian sites."[35] White adds that wild rice in its annual rather than perennial form is found in zones of northeast Thailand that are "dampened and gently inundated during the rainy season,

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[31] Cécile and Roland Mourer, "The Prehistoric Industry of Laang Spean, Province of Battambang, Cambodia," *Archaeology and Physical Anthropology of Oceania* 5:2 (July 1970), 128-146, at 144, 131; Roland Mourer, "Laang Spean and the Prehistory of Cambodia," *Modern Quaternary Research in Southeast Asia* 3 (1977), 29-56, at 32; Higham, *Early Cultures*, 45.
[32] Francesca Bray, in Joseph Needham, *Science and Civilisation in China*, Vol. 6, Part 2, *Agriculture*, Cambridge, Cambridge University Press, 1984, 25, 485-87. See also pp. 45-46.
[33] "Nowhere in Southeast Asia is there currently any good evidence for a presence of any form of food production before 3500 BC." Bellwood, *First Farmers*, 130.
[34] White, "Modeling the Development of Early Rice Agriculture," 59.
[35] Chester Gorman, quoted in Bray, *Science and Civilisation in China*, Vol. 6, Part 2, *Agriculture*, 486.

but whose soil surface is dry during most of the dry season." Wild rice grows along streams flowing through mixed deciduous forest that is flooded for no more than two days in the rainy season. These are "intermediate" areas of the drainage system, downstream from stands of dry deciduous dipterocarp forest that are rapidly drained, but upstream from areas of greater plant diversity that are home to shrubs and trees that can withstand flooding for longer than two days at the height of the rainy season.[36] It is in precisely such intermediate areas that archaeologists have so far located the earliest extant agricultural villages found in northeast Thailand, dating from 4,000-1,000 BCE.[37] These early cultivators did not settle near larger lakes or perennial marshes, but seem to have preferred higher altitude, seasonal streams, "probably because of ease of water control."[38] A simple dam on a seasonal stream would first drown the surrounding undergrowth, shrubs and smaller trees, which could then be burned off during the dry season. During the next rainy season, the dam would again flood a substantial area over which rice could be planted under the key conditions: sustaining an inundation of 5-15 cm. and keeping weeds to a minimum by preventing exposure of the soil to the air. White therefore proposes that the first "cultivation of wetland rice in the seasonal tropics of northeast Thailand can be seen as an imitation and expansion of the natural ecological niche for wild annual rice."[39]

Although archaeological evidence is lacking,[40] it is possible that humans began cultivating wet rice in this manner before 4,000 BCE, i.e. in the period of maximum intensity of the summer monsoon and low fire activity. A mid-Holocene phytolith sample (surviving

[36] White, "Modeling the Development of Early Rice Agriculture," 48-50, 45-46, 55.
[37] White, "Modeling the Development of Early Rice Agriculture," 46-47, 50, 38, 43.
[38] White, "Modeling the Development of Early Rice Agriculture," 50, 53.
[39] White, "Modeling the Development of Early Rice Agriculture," 51-52.
[40] White, "Modeling the Development of Early Rice Agriculture," 63n2.

microscopic elements of plant tissue) from around 4,700 BCE in northeast Thailand shows "a unique pattern of burning both weedy grasses and rice, suggesting burning *in* fields."[41]

If rice cultivation had already begun on the hill slopes of northeast Thailand, there is still no evidence of agriculture in either the hills or the alluvial plains of what is now Cambodia. As yet no prehistoric (pre-metal age) settlements have been discovered on the country's flat lowlands or in the Mekong delta.[42] And in the Cardamom mountains of Cambodia's northwest, the habitation deposits in the floor of Laang Spean cave dating from the seventh millennium BCE to as late as the first millennium CE have revealed no biological trace of any agriculture whatsoever.[43]

But from 4,200 BCE, in the cave's second oldest cultural level, securely dated in "stratigraphic conditions that exclude any disturbance," Laang Spean has yielded up Cambodia's oldest pottery. Archaeologists Cécile and Roland Mourer found these potsherds in unusual association with an assemblage of flaked, unpolished, "large worked stone tools" and a variety of faunal remains: from a rhinoceros, many small bovids, a chevrotain, deer, monkeys, small carnivores, porcupines, other large rodents, geckoes, lizards, pythons, a Royal Cobra, and marine mollusc shells from the Gulf of Thailand sixty miles away. Roland Mourer wrote that the 5th millennium BCE date of this cultural layer was "one of the earliest ones for pottery in southeast Asia."[44] The fragments of pottery that were found in layers of the cave floor dating from the late

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[41] Kealhofer, "Human Environment During the Terminal Pleistocene and Holocene," 244, 237 (Fig. 2). Cf. Lisa Kealhofer and Dolores R. Piperno, "Early Agriculture in Southeast Asia: Phytolith Evidence from the Bang Pakong Valley, Thailand," *Antiquity* 68 (1994), 564-72, at 571.

[42] Chester Gorman, "*A Priori* Models and Thai Prehistory: A Reconsideration of the Beginnings of Agriculture in Southeastern Asia," in Charles A. Reed, ed., *Origins of Agriculture*, De Gruyter, 1977, 321-55, at 342, 343, 346; Charles Higham, *The Civilization of Angkor*, Berkeley, University of California Press, 2001, 33.

[43] Mourer, "Laang Spean and the Prehistory of Cambodia," 37; Higham, *Early Cultures*, 45.

[44] C. and R. Mourer, "Prehistoric Industry of Laang Spean," 131 (listing illustrations of the tools in Figs. 2-4), 141, 142; R. Mourer, "Laang Spean and the Prehistory of Cambodia," 53, 36-37; C. Mourer, R. Mourer, and Y. Thommeret, "Première datations absolues de l'habitat préhistorique de la grotte de Laang Spean, province de

5th and more frequently the 4th millennia BCE are sherds of fairly uniform containers made with an anvil and a paddle (i.e. without a pottery wheel) from “a reddish fabric, rather coarse, with sand grains.” Rounded in the base, they are mostly decorated with the mark of the paddle or impressed with cords. Few are painted; many are ornamented by incision or impression, such as in a series of thin vertical lines and cross-hatching.[45] The large stone tools found with this pottery are 9-15 cm. long and 6-10 cm. wide, oval in form, and usually worked on one side only, along their entire circumference. They include side-scrapers, end-scrapers, short axes, and tools with a distal cutting edge. None of the tools had been polished. Only a single flake showed any sign of having come from a polished stone object. No remnant of worked bone was discovered in the cave.[46]

It is possible that rice cultivation would come to Cambodia only with a new population. The next wave of immigrants to the Southeast Asian mainland were ancestral members of the Austroasiatic linguistic family, which includes both Khmer (spoken in its Old Khmer form since at least early historic times in upland east and northeast Thailand as well as upland and lowland Cambodia) and Mon (spoken in lowland central Thailand in the same era). Mitochondrial DNA studies of skeletons in two prehistoric cemeteries in northeast Thailand dating from as early as 1500-1200 BCE reveal a “close genetic affinity” with modern speakers of a local language distantly related to Old Mon.[47] The demographic expansion of the Austroasiatics appears to have

Battambang (Cambodge),” *Comptes rendus hebdomadaires des séances de l’Académie des sciences*, Paris, 270:3 (19 janvier 1970), Série D, 471-473, at 472-3; Michael D. Coe, *Angkor and the Khmer Civilization*, London, Thames and Hudson, 2003, 43-44.

45 Mourer, “Laang Spean and the Prehistory of Cambodia,” 36, 45.

46 C. and R. Mourer, “Prehistoric Industry of Laang Spean,” 132-38.

47 Lertrit, P., *et al.*, “Genetic history of Southeast Asian populations as revealed by ancient and modern human mitochondrial DNA analysis,” *American Journal of Physical Anthropology* 137 (2008), 425-440, at 438; Higham, *Civilization of Angkor*, 14.

been gradual.[48] But their "very disjointed distribution" across mainland Southeast Asia and eastern India suggests, according to prehistorian Bellwood, that the Austroasiatic family "represents the oldest major language dispersal recognizable in Southeast Asia."[49] By early in the first millennium BCE, at least, mainland Southeast Asia "would have been linguistically a solid Mon-Khmer block."[50]

Meanwhile in the lowlands of Cambodia, sea levels now rose significantly and even encroached higher on the land than today's levels. Along with the progressive melting of glaciers, a major accelerating factor was the so-called "8.2 ka" event of 8,200 years ago, around 6,200 BCE. Scientists call this "a really big flood," a catastrophic outburst of water into the North Atlantic from huge, previously ice-dammed freshwater lakes of glacial meltwater in what is now Hudson's Bay, Canada. This event alone released approximately 2 x 10^{14} cubic meters of water into the world's ocean systems.[51] The sea level rises affected Southeast Asia more than any other world region, shrinking its land mass to around half of its Late Pleistocene extent. As one scholar has pointed out, the effects on "human population densities and accompanying modifications in cultural adaptive systems remain to be researched."[52]

We do know that Cambodia's large Tonle Sap lake, connected since the Early Holocene to the Mekong River and the South China Sea and influenced by salt water and tidal flows, had long nourished littoral mangrove swamp-forests, especially in the 6,000s BCE. But by 4,800 BCE the sea-level maximum, a rise of more than 2.5 meters, inundated what is now southern

48 Matsumura, Domett, and O'Reilly, "On the Origin of pre-Angkorian peoples," 76-77.
49 Bellwood, *First Farmers*, 223; see also Lertrit *et al.*, "Genetic history of Southeast Asian populations," 438-39.
50 Michael Vickery, "Champa Revised," Asia Research Institute, Singapore, *Working Paper* 37, 2005, 14.
51 Richard B. Alley and Anna Maria Ágústsdóttir, "The 8k event: Causes and consequences of a major Holocene abrupt climate change," *Quaternary Science Reviews* 24 (2005), 1123-1149, at 1134; Penny, "China and Southeast Asia," 221.
52 Chester Gorman, "*A Priori* Models and Thai Prehistory: A Reconsideration of the Beginnings of Agriculture in Southeastern Asia," in Charles A. Reed, ed., *Origins of Agriculture*, De Gruyter, 1977, 321-55, at 349.

Viet Nam and parts of southern Cambodia. And according to Penny, "given the extremely low relief of the lower Mekong River basin, it is quite probable that tidal influence extended [further] inland along the Mekong and Tonle Sap Rivers, and possibly into the Tonle Sap lake itself."[53] From around 4,000 to 3,000 BCE what is now the Mekong delta remained almost totally underwater. Remnants of coral reefs and sand dunes from the former coastline have been found forty miles inland. Even by the start of the Common Era, much of the delta was still submerged.[54] People clung to higher ground. A prehistoric shell midden at Phnom Kbal Romeas in the limestone hills of coastal Kampot province in southern Cambodia has yielded evidence of human occupation from as early as 3,420 BCE.[55] Potsherds were also found there, possibly of the same era.[56] But the evidence, like that from Laang Spean cave in the northwest, suggests a hunter-gatherer population.[57]

The Neolithic

In the uplands of northeast Cambodia, by contrast, around 4,000-3,900 BCE, an abrupt return of charcoal in the lake sediment cores indicates a noticeable "surge" in burning.[58] The chronology fits well with the outbreak of "widespread" burning in northeast Thailand, a nearby lowland region "with a similar bio-climate and vegetation." There, "sudden regional

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[53] Dan Penny, "The Holocene history and development of the Tonle Sap, Cambodia," *Quaternary Science Reviews* 25 (2006), 310-22, at 318-19, 312, 316.
[54] Nguyen, V.L., *et al*., "Late Holocene Depositional Environments and Coastal Evolution of the Mekong River Delta," *Journal of Asian Earth Sciences* 18 (2000), 427-39, at 437 (Fig. 5); David Biggs, *Quagmire: Nation-Building and Nature in the Mekong Delta*, Seattle, University of Washington Press, 2010, 14.
[55] Cécile and Roland Mourer, "Prehistoric Research in Cambodia during the Last Ten Years," *Asian Perspectives* XIV, 1971, 35-42, at 41; J.P. Carbonnel and G. Delibrias, "Premières datations absolues de trois gisement néolithiques cambodgiens, *Comptes Rendus de l'Académie des Sciences* 267, 1968, série D: 1432-1434.
[56] Mourer, "Laang Spean and the Prehistory of Cambodia," 47.
[57] Michael Dega, *Prehistoric Circular Earthworks of Cambodia*, Oxford, BAR International Series 1041, 2002, 63, appears sceptical of use of the label "Neolithic" in this case, and considers the dating of the pottery as tentative.
[58] Maxwell, "Holocene Environmental Change," xi, 183, 190-91

disturbances" are evidenced by the "strong representation" in local lake sediment cores dating from c.4,400 BCE onward of both charcoal and the pollen of a plant species capable of "aggressive colonization of disturbed ground," whose presence Penny considers "related to an intensification of human occupation."[59] To take further advantage of the heavy summer monsoons, humans had possibly expanded their agriculture uphill, from small permanent wet-rice plots beside seasonal streams to extensive swidden or "shifting" cultivation of numerous rain-fed "dry-rice" plots at higher altitudes. White points out that upland cultivation requires "a moist but not flooded soil that is much higher in plant nutrients than wetland rice requires."[60] This encouraged the burning off of forest to convert the rich nutrients into ash, a practice often called "slash-and-burn" farming. Having developed these techniques of shifting agriculture, rice farmers could now "move into hillier terrain than wet-rice agriculturalists could easily exploit."[61]

The high disturbance of the dense forest in the Cambodian uplands in the same period, Maxwell writes, may similarly reflect the introduction of shifting cultivation there.[62] If so, this would reveal the activities of Cambodia's first known farmers – cultivating the ground by clearing and burning off patches of forest, and planting crops in the fertile ashes. The spread of "slash-and-burn" agriculture in the Cambodian uplands may have emerged from a pre-existing dual economy of wet-rice upland farming alongside seasonal streams and the cultivation of legumes and yams on recently burned patches of land which provided "some sun, support for the vines, and considerable fertilizer from the ash."[63] As Stephen J. Pyne writes in *Vestal Fire*, fire

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[59] Dan Penny, *et al.*, "Holocene Palaeoenvironmental Reconstruction Based on Microfossil Analysis of a Lake Sediment Core, Nong Han Kumphawapi, Udon Thani, Northeast Thailand," *Asian Perspectives* 35:2 (1996), 209-228, at 223-24, 220-21; Penny, "Palaeoenvironmental Analysis of the Sakon Nakhon Basin," 139, 144, 146; Penny, "A 40,000 year palynological record from north-east Thailand," 109.
[60] White, "Modeling the Development of Early Rice Agriculture," 57.
[61] White, "Modeling the Development of Early Rice Agriculture," 60.
[62] Maxwell, "Holocene Environmental Change," 191.
[63] White, "Modeling the Development of Early Rice Agriculture," 58-59, 61.

"liberated nutrients such as calcium, phosphorus, potash, and proteins; it restructured the microclimate of sun and shade, heat and water; it drove off, for a time, soil microorganisms, predacious wildlife, and indigenous plants, enough that in the intervening ash bed humans could establish new species."[64] After several years the shifting cultivators would move on to clear and burn new jungle plots, because of the rapidly declining yields on the "humus-poor tropical soils," particularly for "nutrient-hungry" annual varieties of rice. "The decline in yield is due to exhaustion in the soil of the nutrients released in the burn, and to competition from weeds. The land has to regenerate to forest in order to shade out weeds and produce a significant biomass to act as nutrient storage."[65] Thus in its wake, this slash-and-burn form of dry-rice upland farming led to the expanded growth of secondary forest at the expense of the dense semi-evergreen forests.[66] This is the story told in natural archives – the charcoal and pollen deposits in the sediments at the bottom of local lakes.

Other archives, the linguistic databases that people learn from childhood, store in their memories, and pass on to their children and neighbors, have helped scholars identify the first farmers of Cambodia and northeast Thailand. Historical linguists have reconstructed the vocabulary of Proto-Austroasiatic, the precursor of the Austroasiatic languages spoken today, including Khmer, and have found that it contained terms for rice cultivation.[67] There is a consensus that the early farmers of the interior of the Southeast Asian mainland were ancestral

[64] Pyne, *Vestal Fire*, 34.
[65] White, "Modeling the Development of Early Rice Agriculture," 51-52.
[66] Maxwell, "Holocene Environmental Change," xi.
[67] Bellwood, *First Farmers*, 223.

Austroasiatic speakers, and most likely Khmer not only in Cambodia but in the Sakon Nakhon and Phimai regions and other parts of northeast and northern Thailand.[68]

From around 3,000 BCE a new drier, more seasonal climate fostered a significantly drier upland forest type. And from around 1,800 BCE "fire frequency may have increased further" as a result of a more widespread human impact on the landscape of northeast Cambodia. The continuing spread of swidden cultivation may explain the expansion of dry, open, deciduous forests, with increased grass cover.[69] Similarly in nearby northeast Thailand, the "widespread burning of lowland forest" that had begun around 4,400 BCE persisted until as late as 890 BCE.[70] This is different from what happened in the hills of northern Thailand, where pollen evidence from a peat bog indicates that around 2,000 BCE wet-evergreen forest replaced pine forest, perhaps due to the rising sea levels delivering moister southwest monsoons, from whose influence the Cardamom rainshadow still kept Cambodia itself somewhat protected.[71]

Prehistorians Ian Glover and Charles Higham assert that, probably around 2300-2000 BCE, "a rapid expansion of agricultural groups" began to spread domesticated rice farming across mainland Southeast Asia. Archaeologists have found their settlements "along small tributary streams where the cultivation of rice could have been undertaken in naturally inundated

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[68] W.J. Van Liere, "Mon-Khmer Approaches to the Environment," in *Culture and Environment in Thailand: A Symposium of the Siam Society*, Bangkok, 1989, 142-159, at 154, 155, 157; Richard A. O'Connor, "Agricultural Change and Ethnic Succession in Southeast Asian States: A Case for Regional Anthropology," *Journal of Asian Studies* 54:4 (November 1995), 968-996, at 972, 979, 984; Charles Higham, *The Bronze Age of Southeast Asia*, Cambridge, Cambridge University Press, 1996, 242.
[69] Maxwell, "Holocene Environmental Change," 191, xi.
[70] Penny, "Palaeoenvironmental Analysis of the Sakon Nakhon Basin," 144, 146.
[71] Penny et al., "Holocene Palaeoenvironmental Reconstruction," 209-10.

areas."[72] In the floodplain of the Mun River in northeast Thailand, for instance, the greatest concentrations of prehistoric sites are "not far from the smaller, permanent streams."[73]

But rice farming alone is insufficient to characterize the emergence of a Neolithic culture in Southeast Asia. Other criteria normally required for this designation are sedentism, the development of complete or polished stone toolkits, and the manufacture of pottery.[74] And in 1970 the Mourers, the French archaeologist couple who had just excavated Laang Spean cave in the Cardamom mountains, cautioned: "As the Neolithic in Cambodia, in particular, is practically unknown, its constituent characteristics are not yet defined." They added that "in South-East Asia the development of prehistoric cultures did not necessarily follow the same pattern as in Europe."[75]

The Mourers' most spectacular find at Laang Spean was "a beautiful ring-footed cup" with a flaring neck. Hyperboloid in form, this fully decorated vessel is 140 mm. in height, 211 mm. in diameter, and 98 mm. deep. Although it had been broken in the ground, the fragments were found close together and the cup has been entirely restored. "The peculiarity of its construction lies in the way the ovoid bottom continues into the hollow foot."[76] Although this particular cup may have been made at some later date and then buried into a lower level corresponding to the period beginning around 2020 BCE, the fragments of an "identical" cup base excavated elsewhere in the same cultural layer (and now three-quarters restored) suggest

[72] Glover and Higham, "New Evidence for Early Rice Cultivation," 422, 435.
[73] Van Liere, "Early Agriculture and Intensification," 831.
[74] Dega, *Prehistoric Circular Earthworks*, 5, 63.
[75] C. and R. Mourer, "Prehistoric Industry of Laang Spean," 142.
[76] Cécile et Roland Mourer, "La coupe à pied annulaire de Laang Spean, Phnom Teak Trang, Province de Battambang, Cambodge," *Bulletin de la Société Préhistorique Française* 68, 1971, C.R.S.M, fasc. 5, 156-158; R. Mourer, "Laang Spean and the Prehistory of Cambodia," 34. For a photograph of this cup, see Roland Mourer, "Contribution à l'Étude de la Préhistoire du Cambodge," in François Bizot, ed., *Recherches Nouvelles sur le Cambodge*, Paris, École Française d'Extrême-Orient, 1994, 143-195, at 188, Photo 1.

that this pottery form already existed in the late third and second millennium BCE. What intrigued the archaeologists who excavated Laang Spean, was the fact that similar ring-footed cups found in northern Vietnam and others excavated in Thailand were associated with assemblages of more advanced, polished stone tools, whereas the stone tools found in the same layer as the cup at Laang Spean were not only of an earlier date than elsewhere but showed no trace of polishing.[77] Could it be that pottery technology (without the wheel) was spreading through the uplands of mainland Southeast Asia more quickly than the technology of making polished stone tools or of agriculture ? This period between 2500 and 1500 BCE, Bellwood argues, saw a "rapid, extensive" spread across the Southeast Asian mainland of "a well-defined incised and stamped pottery style associated with rice cultivation in far southern China, Vietnam, and Thailand," a style that owed little to local cultural predecessors.[78]

In northeast Thailand, where the Neolithic period had begun around 2300 BCE, pottery from that era is "very similar" in style to pots found in the nineteenth century at a prehistoric shell midden site at Samrong Sen in northern Cambodia.[79] Embedded in the tempers of a potsherd excavated in 2001 at Samrong Sen by Cambodian archaeologist Ly Vanna from the deepest extant cultural layer, 4 meters below the surface of the surviving mound, was an ancient rice husk that yielded a radiocarbon date of approximately 2050 BCE.[80]

The large site whose remnants are still visible at Samrong Sen is one of several prehistoric phenomena that emerged in Cambodia around the mid-third millennium BCE. In the "red soil" basaltic low foothills of eastern Kompong Cham province, on the left bank of the

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[77] C. et R. Mourer, "La coupe à pied annulaire de Laang Spean," 158.
[78] Bellwood, *First Farmers*, 133.
[79] Higham, *Early Cultures*, 91-93.
[80] Ly Vanna, "Rice Remains in the Prehistoric Pottery Tempers of the Shell Midden Site of Samrong Sen: Implications for Early Rice Cultivation in Central Cambodia," *Aséanie* 9, juin 2002, 13-34, at 19-21, 25-27.

Mekong River and across the border in what is now southwestern Viet Nam, the first of a series of hilltop circular earthwork constructions "suddenly appeared around 2500 B.C." Between 40 and 55 similar structures were built in that relatively small area over the next two thousand years.[81] And in the karst hills of southern Cambodia, a cave at Phnom Loang in Kampot province has yielded a Neolithic deposit of worked bones (quite the opposite of Laang Spean cave in the northwest where the tools were solely of stone) dated at 2420 BCE.[82] These signs of human presence in the foothills overlooking the plains of northern, eastern, and southern Cambodia may be related to the maximum height of the marine inundation of the lowlands, which scientists calculate reached five meters above the current sea level around 2200 BCE.[83]

In 1962 the French archaeologist Bernard Philippe Groslier excavated one of the circular earthworks near Memot in eastern Cambodia. He dated what he called this "Neolithic fortified camp" at approximately 2500-2000 BCE and declared it "one of the most important prehistoric sites in South-East Asia." Groslier coined the term "Memotian culture" for the approximately 1,000 stone objects and over 20,000 potsherds that he had recovered.[84]

Not only a new culture, but a society on a new scale had established itself in Cambodia. As archaeologists Michael Dega and Kyle Latinis have pointed out, "the relatively few site assemblages dating to before 2500 B.C.," such as those documented from the caves at Laang Spean and Phnom Loang, suggest that previously, "most human groups in the area were relatively small forager communities, especially those in the hills and mountains," generally

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[81] Michael Dega and D. Kyle Latinis, "The Social and Ecological Trajectory of Prehistoric Cambodian Earthworks," *Asian Perspectives* 52:2 (Fall 2013), 327-346, at 327, 329, 343, 344n2; Dega, *Prehistoric Circular Earthworks of Cambodia*, 8, 93. For roughly similar radiocarbon dates see Gerd Albrecht *et al.*, "Circular Earthwork Krek 52/62: Recent Research on the Prehistory of Cambodia," *Asian Perspectives* 39:1-2 (2000), 20-46, at 42, Table 3.
[82] C. and R. Mourer, "Prehistoric Research in Cambodia during the Last Ten Years," 41.
[83] Dega and Latinis, "Social and Ecological Trajectory," 343.
[84] Bernard Philippe Groslier, *Indochina*, London, Frederick Muller, 1966, 195, 267, Plates 1, 10.

estimated to number “much less than one hundred.”[85] But the advent of the circular earthwork structures of eastern Cambodia, with their average diameter of 250 meters and relatively consistent internal area of 4 to 6 hectares, had now enabled communities to shelter individual households, house gardens, animal pens, and communal spaces – sufficient for perhaps 25 families, at least 125 people but possibly as many as “the upper hundreds to a thousand or more residents.”[86] Communities were becoming larger, more self-sustaining, and more complex.

Intriguingly, these were new communities that had come from elsewhere. Archaeologists have found no evidence that the sites of the circular earthwork structures or their proximate surroundings had been inhabited before the construction started.[87] On their arrival the newcomers often chose a site on the edge of a plateau overlooking the lowlands.[88] They began raising circular external walls from 700 to 900 meters in circumference, using earth just inside the circle by excavating a concentric internal depression which assumed the appearance of a “moat” but rarely retained water. The builders added height to the walls with more earth by levelling the center of the compound, but leaving inside it a large circular platform between 150 and 210 meters in diameter. The outer walls typically towered 1.5-2 meters above the external ground level, 4 meters above the concentric internal depression, and over 2 meters above the central platform, which formed a habitation area of around 2.4 hectares. Houses were grouped (and the greatest density of artifacts were found) toward the outer edges of this platform, with possible communal space in the center. One or sometimes two passageways led out across the

[85] Dega and Latinis, “Social and Ecological Trajectory,” 336.
[86] Dega, *Prehistoric Circular Earthworks*, 38; Dega and Latinis, “Social and Ecological Trajectory,” 334.
[87] Dega, *Prehistoric Circular Earthworks*, 40, 45.
[88] Louis Malleret, “Ouvrages Circulaires en Terre dans l’Indochine Méridionale,” *Bulletin de l’École Française d’Extrême-Orient* XLIX:2 (1959), 409-448, at 415, Fig. 7; Albrecht *et al.*, “Circular Earthwork Krek 52/62,” 24-25.

depression and through the outer wall giving access to perennial water sources and swidden farmland.[89]

Who were these people and where did they come from ? A Japanese-Cambodian archaeological team has compared the earthwork structures to those of the "round villages" of houses arranged in a circle around a central communal building that are still found mostly among small Mon-Khmer Austroasiatic groups in the uplands of northeastern Cambodia, southern Laos and central Viet Nam. Investigation of an earthwork structure at Krek in eastern Cambodia "strongly supported" this hypothesis that the original earthwork people may have been speakers of ancestral Mon-Khmer languages part of whose village culture is preserved today in the uplands to the north. This led the archaeologists to propose that further study of the origin of the circular earthworks may "provide us with clues as to the time depth of the Mon-Khmer occupation in mainland Southeast Asia."[90]

Before they arrived in the red soil region to build these circular earthworks, the immigrant communities already possessed a complete stone "toolkit," and also, had already mastered the manufacture of a variety of pottery vessel forms. Archaeologists have recovered many classes of stone tools from the circular earthwork sites, and have noted that although "lithic diversity" increased over time, "one set of tools did not replace another." There is also a geographic consistency, suggesting "a shared regional cultural adaptation" and perhaps, an "ethnic identity." Earthwork sites in both Bình Phước province of southwestern Viet Nam and 60 km. away in Cambodia yielded specimens thought to represent "a full range of lithic production

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[89] Dega, *Prehistoric Circular Earthworks*, 42-44, 38, 46, 73-74, 87, 89-90.
[90] Yasushi Kojo and Sytha Pheng, "A Preliminary Investigation of a Circular Earthwork at Krek, Southeastern Cambodia," *Anthropological Science* 106:3 (1998), 229-244, at 236-39.

and use."[91] Fragments of four lithophones (stone sound instruments) found in several of the earthwork sites are "the only lithophone fragments recovered in Southeast Asia that have been provenienced to a specific site."[92] A campaign of limited excavations at six Cambodian earthwork sites and surface collection at a seventh produced 1,800 lithic specimens in 16 tool classes. These ranged from "large cores and grinding stones" for tool-making, to no fewer than 177 stone chisels that point to "finer wood working and/or the manufacturing of bone and wooden ornaments," to small picks or awls for drilling ornamental pieces in wood or stone, to 28 polishing stones or whetstones. The earthwork community's toolkit thus included "a great proportion of the known Neolithic artifact range from Southeast Asia."[93]

The incised cord-impressed pottery decorations of the people who built and occupied the dozens of circular earthworks in eastern Cambodia and southern Vietnam confirm that they participated in the same culture. Yet their pottery also shared common attributes with that of the earliest known sedentary communities in the interior valleys of the Southeast Asian peninsula, from Thailand to north and central Vietnam, in the period from 3,000 to 500 BCE. Indeed from about 2,500 BCE, when the Cambodian circular earthworks began to be built, until the mid-first millennium BCE, decorations of incised lines "filled with impressed or incised motifs" such as "S-shaped meanders" are characteristic not only of the pottery of the Cambodian circular earthwork populations but of pottery contemporaneously manufactured "across the entirety of Mainland Southeast Asia."[94]

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[91] Dega, *Prehistoric Circular Earthworks*, 66, 74, 76, 78, 89, 64.
[92] Albrecht *et al.*, "Circular Earthwork Krek 52/62," 41-42; Dega, *Prehistoric Circular Earthworks*, 64; Malleret, "Ouvrages Circulaires," 428-29, and Planche XXXIX (photo).
[93] Dega, *Prehistoric Circular Earthworks*, 65-66.
[94] Dega, *Prehistoric Circular Earthworks*, 89, 92.

As for the economy of the earthwork communities, the stone tools found at each site suggest “a heavy emphasis on woodworking and/or clearing tools, tools used as hoes, and cutting tools” used for butchering animals and harvesting plants. Stone butchering tools “far outnumber projectile points,” indicating that hunting was less important than stock-raising, possibly of cattle and pigs. Also important were agriculture and horticulture, with the hoes used for gardening and stone flakes for cutting grass or reaping rice stalks.[95] These tools appears to have been used for swidden agriculture only. There is no sign of landscape modifications or any pollen, macrobotanical or faunal data that would suggest the existence of a wet-rice economy or related ecosystems such as fishing or other exploitation of water resources.[96] Nevertheless one team of archaeologists has described the earthworks system as “homogeneously constructed rice-farming villages” that by the first millennium BCE appear to have formed “an economical, social, cultural, and therefore even political entity.”[97] Memotian circular earthworks communities, first established during Cambodia’s Neolithic era, seem to have lasted through its Bronze Age and probably even into the Iron Age in the second half of the first millennium BCE.[98]

Cambodia’s Bronze Age

Study of the prehistory of Indochina began in 1877 with two French publications based on commander Jean Moura’s findings at Samrong Sen in central Cambodia the previous year.[99]

[95] Dega, *Prehistoric Circular Earthworks*, 77, 71, 69-71.
[96] Dega and Latinis, “Social and Ecological Trajectory,” 343.
[97] Albrecht *et al.*, “Circular Earthwork Krek 52/62,” 43.
[98] Miriam Noël Haidle, “Fragments of Glass Bangles from Krek 52/62 and Their Implications for the Dating of the Mimotien Culture,” *Asian Perspectives* 40:2 (2001), 195-208, at 195-96, 204-5.
[99] E. Saurin, “Les Recherches préhistoriques au Cambodge, Laos et Viet Nam (1877-1966),” *Asian Perspectives* XII (1969), 27-41, at 27, 34. The two publications were Jean-Baptiste Noulet, *L'âge de la pierre polie au Cambodge, d'après les découvertes de M. Moura*, Toulouse, Impr. Louis et Jean-Matthieu Douladoure, 1877, and Émile Cartailhac, “L'âge de la pierre dans l'Indochine,” *Mat. pour l’hist. primitive et nat. de l'homme*, 1877, 97-101.

In notes of his visit there, Moura had described the site: "The heap of shells is below the soil at depths varying from 3 to 4 meters. Its extent is immense, and the Cambodians have dug shafts kilometers apart to remove shells of which they make a fine lime, very white, used in the mastication of areca and betel nut." The shells, mostly of ancient mollusc species still present in Cambodian lakes and streams today, were found in sedimentary layers 40-50 centimeters thick, interspersed with clay beds of similar depth. Strewn among the shells were "human heads and bones, as well as elephant skulls," pottery, in particular some very thick jars, stone tools, and importantly, two pieces of "worked copper" in the form of "links of piping, with auricles."[100] This was the first revelation of the Bronze Age in Indochina.[101]

Near the mouth of the Chinit River as it flows into the eastern side of the Tonle Sap lake, the Samrong Sen site is difficult to study and has never been professionally surveyed. As Moura pointed out, its surface is merely "6 to 7 meters above the the lake's lowest water level." In modern times the lake's annual levels rise and fall by as much as 8 meters. "When the Mekong overflows [into the Tonle Sap] in October every year, these areas are completely covered," Moura wrote in 1876. Shells, skulls, stone tools, and bronze artifacts are all washed together. Because of the havoc wreaked by this rising and falling of the waters, the Samrong Sen site has proved notoriously difficult to date. However a similar metallurgical site at Xuân Lộc in southern Viet Nam has been radiocarbon dated at 2000 BCE, and the contemporaneity of the two sites has

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[100] Jean Moura, manuscript notes provided to Jean-Baptiste Noulet in 1876, quoted in J.-B. Noulet, *L'Âge de la pierre polie et du bronze au Cambodge d'après les découvertes de M. J. Moura*, Toulouse, Édouard Privat, 1879, 8.
[101] Saurin, "Recherches préhistoriques au Cambodge," 34.

been strengthened by the radiocarbon dating of a potsherd, excavated in 2001 at Samrong Sen (as noted above) at 2050 BCE.[102]

In place almost certainly as early as the mid-first millennium BCE, it was the reductions in rainfall and increased seasonality following the Early Holocene that had brought this greater variability to the water levels of the Tonle Sap lake and these central Cambodian lowlands. Today, as then, the lake expands more than five-fold during the rainy season, flooding up to 16,000 square kilometers of the surrounding alluvial plain.[103] This seasonal pattern may have inspired lowland farmers in the first millennium BCE to replicate the lakeside process through wet-rice agriculture, far more productive in the lowlands than the swidden practices employed in the uplands, including among the circular earthwork communities.[104] This agrarian transformation involved the construction of low earthen walls or bunds to trap and contain rainwater or especially receding floodwaters, creating an "aquarium" of water-fed nutrients in flat paddy fields in which the rice plant flourishes.[105]

Iron Age Cambodia

Further inland, farmers may have taken a different path to wet-rice agriculture than White has proposed. In the lowlands of the Sakon Nakhon Basin in northeast Thailand they switched directly from "slash-and-burn" or "shifting" agriculture to permanent cultivation. There, from

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[102] Saurin, "Recherches préhistoriques au Cambodge," 35; Ly Vanna, "Rice Remains," 25-27.
[103] Penny, "Holocene history and development of the Tonle Sap," 317, 319, 310.
[104] Penny et al., "Holocene Palaeoenvironmental Reconstruction," 224, citing White, "Modeling the Development of Early Rice Agriculture," 37-68.
[105] Clifford Geertz, *Agricultural Involution: The Process of Agricultural Change in Indonesia,* Berkeley: University of California Press, 1963, 31.

890 BCE the lake sediment record reveals both a decline in charcoal particles and the appearance of pollens that show a re-establishment of "dry/mixed deciduous forests." Penny considers these to be indicators not only of reduced burning but of a change from swidden agriculture to a more restrictive land-use, "most probably associated with the intensification of inundated rice cultivation." Chronologically, he adds, this accords well with local archaeological evidence of the use of iron and water buffalo, suggesting the plowing of permanent bunded rice fields.[106]

To the south and closer to modern Cambodia, "perhaps as early as 1000 B.C.," writes archaeologist David J. Welch, agricultural villages appeared on the broad alluvial plain of the upper Mun River valley, one of northeast Thailand's "largest continuous stretches of land well suited for wet rice agriculture." From about 600 BCE, these farmers, too, adopted the use of iron, and a new style of pottery appeared, known as the Phimai tradition, after the region's largest settlement. At the same time, these villages began to increase in number and their populations began to rise rapidly. The staple food, Welch argues, was "almost certainly" rice, and it was probably grown "using transplanting in diked and plowed fields."[107]

From the ninth to the fourteenth centuries CE, Cambodia's Classic Khmer civilization dominated mainland Southeast Asia. It built an extensive range of stone monuments such as those at Angkor, an urban complex estimated to cover 1,000 sq. km. As Michael Coe and Damian Evans write, "There is nothing else to equal it in the archaeological world."[108] Yet, they add, this civilization "arose and flourished in tropical lowlands with strongly marked rainy and

[106] Penny, "Palaeoenvironmental Analysis of the Sakon Nakhon Basin," 146.
[107] David J. Welch, "Late Prehistoric and Early Historic Exchange Patterns in the Phimai Region, Thailand," *Journal of Southeast Asian Studies* XX:1 (March 1989), 11-26, at 17.
[108] Michael D. Coe and Damian Evans, *Angkor and the Khmer Civilization*, Second Edition, London, Thames and Hudson, 2018, 11.

dry seasons, and middling to poor soils – in fact, areas that were not exactly optimum" for the staple crop of rice on which its economy was based.[109] That wet rice cultivation provided the foundation for such a powerful and long-lasting empire is a testament to thousands of years of human adaptation in the face of significant geophysical, climatic, and ecological transformation.

[109] Coe and Evans, *Angkor and the Khmer Civilization*, 12.