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From Wetland to Farmland: How Humans Transformed the Central Yangzi Basin

ABSTRACT:
From the Three Gorges down to the delta, the Yangzi River lowlands were once among the largest wetland systems in the world, but they have mostly been turned into farmland and settlements. This paper outlines how this process occurred in the Central Yangzi basin of Hubei and Hunan from the Neolithic domestication of rice to the Three Gorges Dam. These lowlands were seasonal wetlands dominated by the annual floods of the summer monsoons, and the key to transforming them into farmland was to build dikes. Over the past two millennia people have gradually rebuilt the region's waterways and landscape, transforming a massive wetland system into both productive farmland and the economic and demographic core of central China. By tracing the human transformation of the region from prehistory to the industrial present, this article reveals long-term trends that may not be apparent from a conventional historical timescale, and evaluates the changing impact of technology, demography, and political organization.

KEYWORDS:
Yangzi River, water control, wetlands, environmental history, Hubei, Hunan

INTRODUCTION

If you could visit China 5,000 years ago and sail down the Yangzi River from the Three Gorges to its mouth a thousand miles to the east, you would pass dolphins, plenty of fish, and huge flocks of waterfowl. On the shores you might see elephants, basking alligators, herds of deer, and perhaps the occasional leopard. If you took the same trip today you would travel along a river filled with industrial river traffic and one of the densest populations of human beings on earth. This paper will explore how humans transformed the western part of this region over the past 10,000 years, an eternity in human time but a mere instant in the 500-million-year history of the South China Plate on which it sits. The goal is both to understand the environmental history of one of China's core economic regions and to contribute to a

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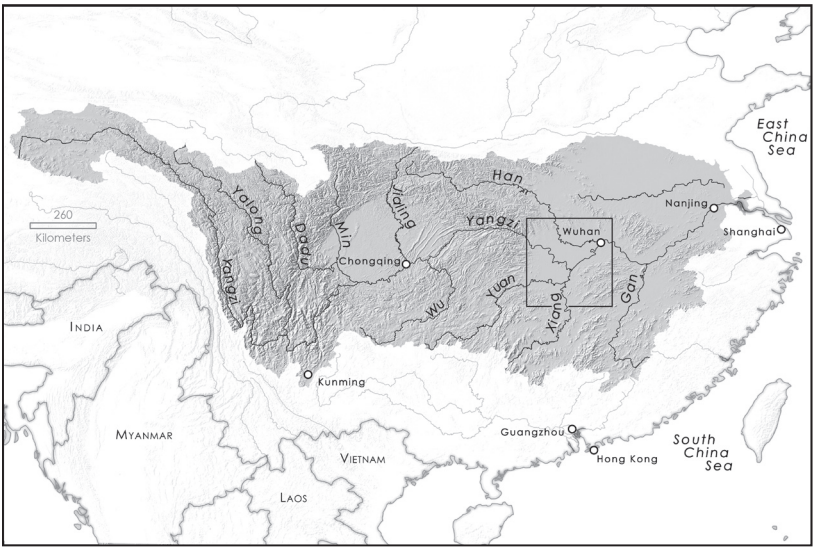
global environmental history of wetlands, which have been destroyed at an alarming rate because they make good farmland.

Before people reengineered the region's hydrology, its ecology was dominated by the seasonal rhythm of dry winters and highly variable summer rains. The seasonal cycle is caused by the alternation between summer monsoons that blow humid air off the ocean and rain it down inland, and winter monsoons that carry cold winds from arid Inner Asia. The summer melting of glaciers on the Tibetan Plateau further adds to the summer flow. The Yangzi River, one of the world's largest, flows right across the plain, where several large rivers and many small ones feed into it. To colonize these subtropical lowlands, people have rebuilt their hydrology with an increasingly integrated system of dikes, dams, and other infrastructure.[1] This process was driven by farmers seeking greater yields and reduced risks, and by states and wealthy families seeking to increase the number of farmers who paid them tax and rent.

This paper focuses on the 60,000 sq. km basin known as the Lianghu Plain 兩湖平原, henceforth called "the region" (see maps 1 and 2). Lianghu means "two lakes," a name that derives from the way the plain is split between the two "lake" provinces of Hubei ("north of the lakes") and Hunan ("south of the lakes"). The northern half, which is in Hubei, is called the Jianghan 江漢 Plain because it lies between the Yangzi (*Jiang* 江) and Han rivers, while the southern half is the Dongting 洞庭 Plain. The plain is divided by the Yangzi River, which flows through it in an eastward direction, and mostly divides the modern provinces. In general, the Jianghan Plain was colonized earlier and more intensively than the Dongting Plain, where the remaining fragments of Dongting Lake are some of the most important wetlands in East Asia. The basin is now home to tens of millions of people, including several cities, most notably Jingzhou 荊州 and Changde 常德 along its western edges, Changsha 長沙 to the south, and Wuhan 武漢 on the east. Wuhan has been the region's most important city for most of the past mil-

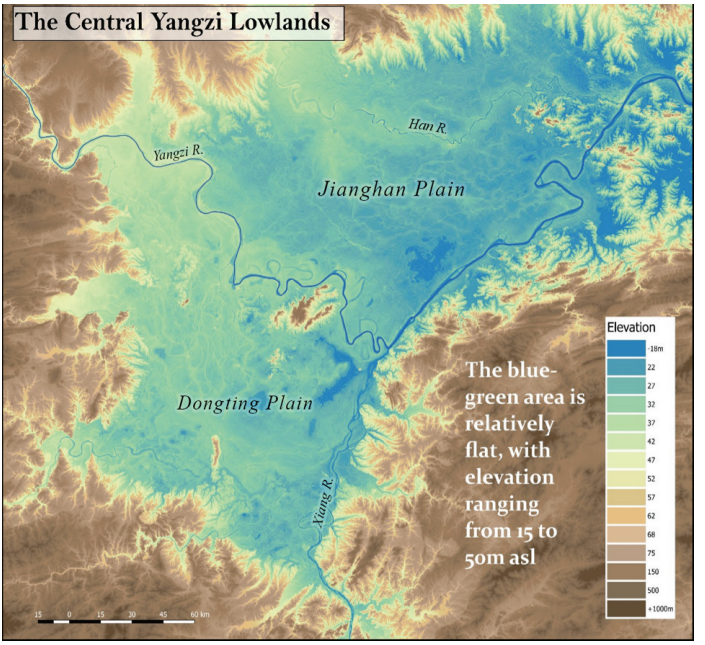
1 DRAFTED this paper while a fellow at the Harvard University Center for the Environment and revised it during a year in which I held a Luce/ACLS Early Career Fellowship in China Studies. I am grateful for their support. It benefited from the comments of participants at the China Environment Writing Workshop organized by Ling Zhang. I would like to thank Lynn Carlson for her work on the maps.

[1] I will use the term "natural" in its conventional sense of "that which came to exist without human intervention," with an understanding of "naturalness" as a spectrum rather than an either/or. The wide range of meanings of the word "nature" creates a paradox in that human society is fundamentally inseparable from "nature," and yet "nature" is commonly used to refer to what is *outside* of human society. On "nature," see Raymond Williams, "Ideas of Nature," in idem, *Culture and Materialism* (London: Verso, 2005), pp. 67–85.



Map 1. The Yangzi River Drainage Basin

The square indicates the region discussed in this study. Created by Lynn Carlson.



Map 2. The Lianghu Plain and Its Two Main Areas, the Jianghan and Dongting Plains

Base map by Lynn Carlson.

lennium because its location at the confluence of the Yangzi and Han rivers situates it at a key intersection of navigable waterways, namely the east-west Yangzi River, the Han River route to North China, and Hunan's Xiang River, the only navigable route between the Yangzi and the Pearl River, which flows down to the sea at Hong Kong.

This paper outlines the human colonization of the region, meaning how humans became the dominant force in the region's ecology. This use of the word colonization plays on the way that it is used by naturalists to refer to the movement of a species into new land, which itself derives from the earlier meaning of humans moving into a new area, often by subjugating its previous human inhabitants.[2] If there was ever a process of outside people conquering and colonizing people of different ethnicities in the Lianghu Plain it occurred during the southward expansion of the state of Chu in the first millennium BC, a history that is poorly documented. Under the early empires the population of the lowlands became culturally quite homogeneous, and the subsequent conflicts between the empires and non-Han peoples were restricted to neighboring mountains.[3] For most of the period for which we have written evidence the region's population were Han: it was they who gradually colonized the wetlands and turned them into agricultural ecosystems.

The Lianghu Plain is now the demographic, political and economic core of central China. For that reason, it has received considerable attention from historians, especially from those who have lived in the region. For obvious reasons, people tend to think of floods as a problem and to consider the history of dike building to be one of progress towards making the region habitable. In contrast, this paper treats the floods as the defining characteristic of the region's natural ecology, and the building of flood prevention dikes as the disruption of that system. By showing how humans have turned some of East Asia's largest wetlands into farmland, this paper is a contribution both to the global history of wetland loss, and more generally to the history of how

2 On the history of the term, see Michael Dietler, *Archaeologies of Colonialism: Consumption, Entanglement, and Violence in Ancient Mediterranean France* (Berkeley: U. California P., 2010), pp. 15–20.

3 On the Qin and Han imperial conquest and colonization of this region, see Maxim Korolkov, *The Imperial Network in Ancient China: The Foundation of Sinitic Empire in Southern East Asia* (New York: Routledge, 2022); on conflict between subsequent empires and mountain peoples, see Richard von Glahn, "The Country of Streams and Grottoes: Geography, Settlement, and the Civilizing of China's Southwestern Frontier, 1000–1250," Ph.D. diss. (Harvard University, 1987), chap. 7; Peter Perdue, *Exhausting the Earth: State and Peasant in Hunan 1500–1850* (Cambridge: Harvard University Council on East Asian Studies, 1987).

humans have come to dominate the earth's surface.[4] This process has been ongoing and generally accelerating for millennia, so understanding it requires multidisciplinary research on timescales much longer than human lifespans.

The story of human colonization in the region begins with rice, a grass adapted to the summer flood pulses of the Yangzi River. Neolithic people learned to cultivate rice, and gradually domesticated it, providing the fuel for the rise of civilization in this region. The agricultural system expanded over time, incorporating an increasing variety of cultivated plants and animals, each of which increased the ability of humans to build their own ecosystems. These were usually consumed alongside the natural resources of the area, most notably fish, which have been central to people's diets and to the regional economy for millennia.

The key technology for colonizing wetlands over the past two to three millennia has been dikes (or, levees), long earthen embankments built to keep flood waters out of a given area. Dikes are ideally built with impermeable materials like clay and protected with flow-resistant materials, but most dikes in history were relatively simple – long embankments built with whatever dirt was available and sometimes also with timber, branches, or reeds. The first colonists would have farmed only the highest edges of the wetlands, where they needed only small dikes to protect against occasional floods. But as people moved deeper into the lowlands, they had to entirely encircle their settlements with dikes, forming self-contained enclosures that in English are called polders and in Chinese called *wei tian* (圩田 or 圍田) if small and *yuan* (垸) if larger (see figure 1, overleaf).[5] During floods, polders are islands of farmland surrounded by water. The dikes keep outside water from flowing in but also make it difficult to get rainwater out, which can create problems of waterlogging inside polders.

[4] Patrick Dugan, *Wetlands in Danger: A World Conservation Atlas* (New York: Oxford U.P., 1993); Vaclav Smil, *Harvesting the Biosphere: What We Have Taken from Nature* (Cambridge, Mass.: MIT P., 2013).

[5] The image in fig. 1 is not a particularly accurate one, unfortunately: the artist has clearly shown how polders are like islands during floods, but does not seem to have understood that the dikes go all the way around to entirely separate the inside of the polder from the surrounding waters. I first saw this image when reading Francesca Bray's description of polders in *Science and Civilisation in China 6.2: Agriculture* (Cambridge: Cambridge U.P., 1984), pp. 113–19.

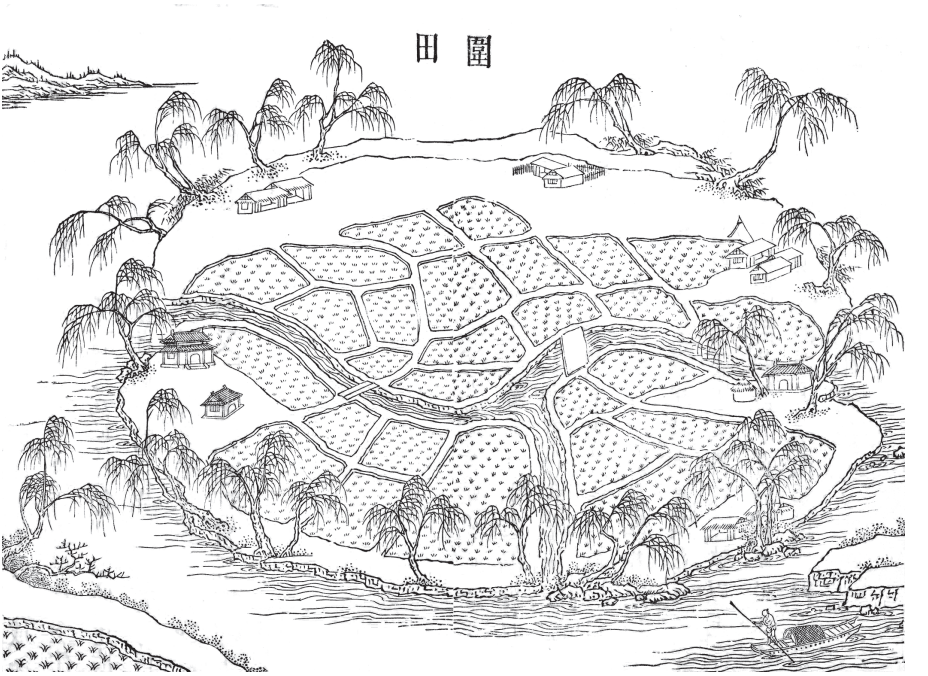


Figure 1. Simplified Depiction of a Polder, Called a Weitian

From the 1742 palace edition of Qin ding shou shi tong kao 欽定授時通考, *j. 14, pp. 5b-6a. I am grateful to <https://new.shuge.org> for putting it online in the public domain. Edited for clarity.*

The transformation of the Yangzi wetlands over such a long stretch of time has tended to involve both private families building small dikes and governments building large river-dikes. Individual polders were the smallest units in the water control system. The largest were the main dikes along the banks of the Yangzi River. They were essential for preventing the Yangzi from flooding certain areas, but were so large that only states could mobilize the large labor force necessary to build and maintain them. But while states could mobilize thousands of workers for short term projects, they could not make individuals colonize low-lying wetlands. Humans lived along the edges of the lowlands for millennia and although they had the technology to colonize them, they had no reason to engage in such labor-intensive work. It was only in recent centuries when population growth left no other land available that people began to farm the deeper parts of the wetlands.

Because of the central importance of the main river-dikes to agriculture in the lowlands, the ebb and flow of political power has been a key determinate of the region's environmental history.[6] Powerful states facilitated population growth, but they periodically collapsed into warfare that made dike maintenance difficult and often caused population decline. There was thus a "hydraulic cycle," corresponding to the dynastic cycle, in which hydraulic infrastructure neglected during warfare was rehabilitated by massive investment from the newly established dynasty, which later neglected the water control system even as population growth increased the importance of dike maintenance.[7] Of course this worked differently across time, and the correlation between politics and dike maintenance is more a general trend than a solid fact. The central Yangzi region was usually regarded as something of a backwater by political elites of the dynastic capitals in North China and the lower Yangzi, but they were aware that the region's farmers provided them with grain tax so they put significant resources into preventing floods. In other words, the transformation of the region's ecology has been premised on the desire of government officials to tax the people who lived there.

This paper will begin by outlining the region's natural ecology and will then proceed chronologically through the Neolithic (8000–1600 BC), Bronze Age (1600–300 BC), Early Imperial (300 BC–1000 AD), Late Imperial (1000–1900), and Modern (since 1900) periods. For most of the past 8,000 years humans lived along the edges of the wetlands, foraging in the bountiful flood-prone areas without building their houses there. Sometime after 500 BC, people began to build dikes and extend farmland into the edges of the floodplain. The gradual construction and enlargement of large dikes along the north bank of the Yangzi River over centuries opened up the Jianghan Plain to farming and forced floodwaters southwards into Dongting Lake (see map 4, further down). The colonization of the wetlands accelerated after 1300 AD as population growth drove people to enter ever-deeper land, a process that occurred in several cycles of abandonment and reconquest. The long-term trend was a gradual replacement of natural hydrological and ecological systems with anthropogenic hydraulic and agricultural ones,

6 On political organizations and environmental change, see Brian Lander, *The King's Harvest: A Political Ecology of Early China from First Farmers to First Empire* (New Haven: Yale U.P., 2021).

7 Pierre-Étienne Will, "Un cycle hydraulique en Chine: la province du Hubei du XVI^{e} au XIX^{e} siècles," *BEFEO* 68 (1980), pp. 261–87. Will makes his argument for the Ming and Qing dynasties, but it is clearly relevant much earlier.

a process that now has become amplified by the construction of the Three Gorges Dam.

On the surface this would seem to be a simple story of humans conquering nature and reorganizing ecosystems for their own benefit, but this paper will suggest that the destruction of the wetlands did not necessarily benefit humans. Although the colonization of the Yangzi is usually described in positive terms, I would suggest that this view reflects the opinions of the government officials who have written our histories and eaten the region's surplus rice. In earlier times the region's abundant natural resources probably allowed its inhabitants to find food without going to the trouble of building dikes and worrying about floods, but in recent centuries population growth has forced people to work very hard while suffering from the constant danger of flooding. The replacement of a highly productive natural environment with labor-intensive polders and fish farms is a classic example of diminishing marginal returns to labor because of population pressure.

NATURAL ECOLOGY

Dikes now divide the region into land and water, but its natural state is one of constant fluctuations between dry winters and highly variable monsoons and floods. The combination of very flat topography and highly seasonal precipitation meant that much of the lowlands were dry during part of the year but underwater during large floods.[8] Because floods bring nutrients, large river floodplains are extremely biologically productive areas: when inundated they are important feeding areas for aquatic life, and as the waters recede they leave a fertile layer of silt where plants grow and attract terrestrial wildlife.[9] Such seasonal flood zones provided the setting for the rise of complex civilizations in various other river valleys, including the Nile, Mekong, and Mississippi.[10]

8 Zhongyuan Chen, Kaiqin Xu, and Wasataka Watanabe, "Dynamic Hydrology and Geomorphology of the Yangtze River," in A. Gupta, ed., *Large Rivers: Geomorphology and Management* (New York: John Wiley & Sons, 2007), pp. 457–69; Tong Jiang, "Changes in Monthly Precipitation and Flood Hazard in the Yangtze River Basin, China," *International Journal of Climatology* 28 (2008), pp. 1471–81.

9 Peter B. Bayley, "Understanding Large River Floodplain Ecosystems," *BioScience* 45.3 (1995), pp. 153–58.

10 Bruce D. Smith, "Agricultural Chiefdoms of the Eastern Woodlands," in Bruce G. Trigger and Wilcomb E. Washburn, eds., *The Cambridge History of the Native Peoples of the Americas* (Cambridge: Cambridge U.P., 1996), pp. 272–77; Karl Butzer, *Early Hydraulic Civilization in Egypt: A Study in Cultural Ecology* (Chicago: U. Chicago P., 1976).

Areas situated above the flood levels were home to subtropical forests. Lower-lying areas were characterized by a mosaic of ecosystems whose main determinant was how often, and for how long, they flooded. Between areas that were always underwater and those that never flooded lay a variety of habitats ranging from land that was underwater all but the driest years to forest edges that flooded only during the largest floods. Because the difference between the high and low water marks was usually over ten meters, huge areas of the lowlands lay in the dynamic zone that was sometimes flooded and sometimes dry.

Before humans became the main factor in transforming the region's landscape, it was rivers that occupied that role, especially the mighty Yangzi. Before the dams and dikes were built, the Yangzi's floodwaters churned through the Three Gorges and then spread out across the broad floodplain, cutting channels and dropping sediments. The other rivers did the same, on a smaller scale. Over the past 10,000 years rivers have deposited sediments tens of meters thick in some parts of the plain, a process that accelerated after 5000 BC, when the ocean rose to its modern level and slowed the flow of the river. Ten thousand years ago much of the Jianghan Plain contained a lake that has been named Paleo Lake Yunmeng 雲夢; it was the main receptacle for Yangzi sediments.[11] As the sediment accumulated, the lake became a mosaic of lakes and lowlands that flooded in summer but contained large amounts of dry land during the rest of the year, much like remaining areas of Dongting Lake. This was the Yunmeng Marsh that was famous for its wildlife in ancient times.[12]

The region's remaining wetlands and lakes provide our best indication of its ancient ecology. Although they contain only the lowest-lying areas, and are generally quite degraded, they remain among the most important wetlands in East Asia. The soils are mostly alluvial, ranging from sand to silt to clay and often mixtures of these. A recent survey in West Dongting Lake Nature Reserve found 414 species of plants, 205 species of birds, 111 species of fish, 13 species of amphibian, 20 species of reptiles and 26 species of mammals.[13] Although these num-

[11] This paragraph is based on Hongfu Yin et al., "On the River–Lake Relationship of the Middle Yangtze Reaches," *Geomorphology* 85 (2007), pp. 197–99; Shi-bao Dai et al., "The Role of Lake Dongting in Regulating the Sediment Budget of the Yangtze River," *Hydrology and Earth System Sciences* 9.6 (2005), pp. 692–98; Tao Liu et al., "Migration of Neolithic Settlements in the Dongting Lake Area of the Middle Yangtze River Basin, China: Lake-Level and Monsoon Climate Responses," *The Holocene* 22.6 (2011), p. 652.

[12] Yuxin Zhu, Sumin Wang, and Ruijin Wu, "Sedimentologic Evidence for Date of Southward Moving of the Yangzi River in the Jianghan Plain since the Holocene," *Chinese Science Bulletin* 23.8 (1998), pp. 659–62.

[13] Huanan binwei dongwu yanjiusuo 華南瀕危動物研究所, Beijing linye daxue 北京林業

bers are impressive, many native species are no longer found in the area, especially larger animals. The list also includes species imported from elsewhere over the past century. The most common plants in West Dongting Lake Nature Reserve are grasses and sedges (75 species) and non-grassy herbaceous plants (around 200 species). Native tree species include mulberry, paper mulberry, poplar, and several kinds of willows.

To understand fauna that once inhabited the region, we can combine our knowledge of remaining wildlife with zooarcheological and textual evidence to gain a general idea of the various animals that inhabited the area. Along with Poyang 鄱陽 Lake, Dongting's lakes are among the few remaining large wetland areas in East Asia and are thus visited by tens of thousands of migratory birds every year. Given that Dongting is a mere fraction of its former size, and most of the subcontinent has been converted to human use, we can be sure that the bird life the region would have been far more abundant in earlier times.

The land was home to a variety of herbivorous mammals, such as Asian elephants, Asian two-horned rhinoceros, boar, as well as muntjac, sika, sambar, musk, elaphure, and water deer.[14] Macaques would have been common throughout the region, and forests would probably have been home to other kinds of monkeys as well as gibbons. Carnivores included civets, mongooses, badgers, wolves, raccoon dogs, red foxes, black bears, Asian golden cats, leopard cats, clouded leopards, leopards, and tigers. The floodplain would have been extremely fertile grazing land in the months after the subsidence of the summer floods and would have had large numbers of wetland specialists such as elaphures, water deer, and wild water buffalo.

This abundance of life above the water was more than matched by the life in the water. The Yangzi River and Dongting Lake are still home to a variety of fish, and we can be sure that the fish would have been larger and more plentiful before there were millions of people eating them. As for reptiles, there were several kinds of turtles as well as the fearsome Chinese alligator. And there were frogs, salamanders

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大學, *Hunan Xi Dongting hu ziran baohu qu zonghe kexue kaocha baogao* 湖南西洞庭湖自然保護區綜合科學考察報告 (internal publication, 2011).

14 On the elimination of large mammals from most of China, see Brian Lander and Katherine Brunson, "Wild Mammals of Ancient North China," *The Journal of Chinese History* 2.2 (2018), pp. 291–312; Samuel T. Turvey et al., "Long-Term Archives Reveal Shifting Extinction Selectivity in China's Postglacial Mammal Fauna," *Proceedings of the Royal Society B* 284 (2017), 20171979 (as with here and below, scientific publications increasingly replace page numbers with article numbers).

and other amphibians. There were also semi-aquatic mammals like otters and fully aquatic ones like the Yangzi dolphin. This abundance made it a very attractive place for humans.

At present we have enough evidence to reconstruct the ecosystems of the region before it was dominated by humans, but only a vague sense of how it has changed since then. We have little idea when each of the larger animals disappeared from the region, for example. We can simply deduce that the expansion of human societies gradually eliminated most of these animals from the lowlands.

THE FIRST SETTLEMENTS (CA. 8000–1600 BC)

The origins of farming are often called "the agricultural revolution," as though it was a single event. In fact, it was a very gradual process of experimentation with plants and animals, a process that continues today. Each new domesticated plant or animal improved the ability of humans to create their own ecosystems. The most important domesticate in the Yangzi River valley was rice, but people there also domesticated pigs, chickens, and a wide variety of vegetables and fruits. The combination of domesticated and wild foods helped the human population grow during the Neolithic, which is most noticeable in the walled towns whose remains are still visible in the landscape. But the societies of the region declined around 2000 BC, for reasons yet unknown.

Rice is a grass that evolved in seasonal wetlands where it adapted to floods by initially growing in shallow water and then ripening on dry land after the floods subsided.[15] The initial stages of domestication consisted of nothing more than people scattering rice seeds in wetlands and perhaps weeding out some other plants. The next step was to modify the hydrology of small plots to create the ideal conditions for rice growth, something that is already apparent at the 7,000-year-old site at Chengtoushan, in the Liyang area west of Dongting Lake.[16] This is the earliest rice paddy yet discovered in the world. It has been suggested that the prehistoric spread of wet rice cultivation in East Asia caused an increase in methane, a powerful greenhouse gas, beginning around 5,000 years ago.[17] This is a plausible argument, but we would

[15] Gary W. Crawford, "Early Rice Exploitation in the Lower Yangzi Valley: What Are We Missing?" *The Holocene* 22.6 (2012), pp. 613–21.

[16] Hunan sheng wenwu kaogu yanjiusuo 湖南省文物考古研究所, *Lixian Chengtoushan: xinshiqi shidai yizhi fajue baogao* 澧縣城頭山, 新石器時代遺址發掘報告 (Beijing: Wenwu, 2007).

[17] William F. Ruddiman et al., "Early Rice Farming and Anomalous Methane Trends," *Quaternary Science Reviews* 27 (2008), pp. 1291–95.

need much more research in agricultural archeology to prove that large numbers of rice paddies were being built beyond their natural habitat at this time.

While it is difficult to overstate the importance of rice in the region's long-term environmental history, it did not necessarily play as central a role in prehistoric diets as it has in more recent history because there was such a wide variety of plants and animals available. Archeobotanical research in neighboring Jiangxi province showed that in addition to rice people cultivated millet and also consumed kiwi, peach, plum, and berries of the raspberry/blackberry type (the *Rubus* genus).[18] We know that people were domesticating peaches around this time, and we can assume that people also grew various vegetables that do not preserve archeologically.[19] South China is also where oranges and pomelos were first domesticated, and we can assume that their cultivation also has a long prehistory.[20]

In the fifth millennium BC, the people of the region began to build moats and walls around settlements, and by the third millennium they were building very large ones. The most populous period in the Neolithic was that of the Qujialing 屈家岭 – Shijiahe 史家河 archeological cultures, which flourished roughly 3,400–2,000 BC. There were at least fifteen walled settlements in the region during this period, and the population grew considerably.[21] The purpose of these walls has been debated, but several of them were built on higher land along the edge of the lowlands, which means that they were not built for flood prevention, as has been argued. One purpose of these moats and walls was probably to keep large animals, such as elephants, rhinos, and buffalo from destroying the crops grown within, and perhaps to keep tigers and leopards from eating people. They may also have been built to defend from human enemies, though there is little evidence of warfare.

Some of these sites, most notably Shijiahe, are large enough to suggest some degree of political centralization.[22] We can expect that

[18] Chen Xuexiang 陳雪香, Zhou Guangming 周廣明, and Gong Wei 宮瑋, "Jiangxi Xin'gan Niucheng 2006–2008 niandu fuxuan zhiwu yicun chubu fenxi" 江西新干牛城2006~2008 年度浮選植物遺存初步分析, *Jianghan kaogu* 2015.3, pp. 100–8.

[19] On peaches, see Yunfei Zheng, Gary W. Crawford, and Xugao Chen, "Archaeological Evidence for Peach (*Prunus persica*) Cultivation and Domestication in China," *PLOS ONE* 9.9 (2014), pp. 1–9.

[20] Joseph Needham, Lu Gwei-djen, and Huang Hsing-tsung, *Science and Civilisation in China 6.1: Botany* (Cambridge: Cambridge U.P., 1986), pp. 363–77.

[21] Pei Anping 裴安平, "Juluo qunju xingtai shiyexia de Changjiang zhongyou shiqian chengzhi fenlei yanjiu" 聚落群聚形態視野下的長江中游史前城址分類研究, *KG* 2011.4, pp. 50–60.

[22] In particular, the walls of the Shijiahe site contained over 600,000 cubic meters of earth, which would have taken a large work force to build: Rowan K. Flad and Pochan Chen, *An-*

sites of this size would have had a significant population and corresponding impact on surrounding areas. However, for some unknown reason the cultures of the Yangzi lowlands all declined or, in the case of the Liangzhu culture of the lower Yangzi, mostly disappeared at the end of the second millennium BC, and for several centuries the region seems to have had no large towns. The only conceivable causes of such a widespread phenomenon would be pestilence or extreme drought, and there is evidence of floods and drought at this time, as well as of climatic fluctuations.[23] Climate changes may have played a role, but it will take considerably more research to prove it.

THE RISE OF STATE POWER: THE BRONZE AGE (CA. 1600–300 BC)

Human settlements were relatively scarce in the Yangzi valley after 2000 BC, but large ones did form in the Yellow River valley and by the mid-second millennium their influence extended into the central Yangzi region. Despite this, humans only really began to affect the region's environments after 700 BC, when the powerful state of Chu moved into the region and came to dominate it until conquered by the expanding Qin kingdom in 278 BC.

The earliest Bronze Age site in the region is remarkable for having no neighbors within hundreds of kilometers. Located in the northern suburbs of today's Wuhan, the walled settlement of Panlongcheng 盤龍城 was founded around 1500 BC and may have been an outpost for people sent to the south by the people of Erligang (modern Zhengzhou, Henan) in order to ensure the supply of copper from the Yangzi valley mines.[24] In subsequent centuries there were people living all around the basin, some of whom mastered bronze casting.[25] After the Zhou dynasty conquered the Yellow River valley in the mid-eleventh cen-

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cient Central China: Centers and Peripheries along the Yangzi River (Cambridge: Cambridge U.P., 2013), p. 121; Bing Li et al., "Linking the Vicissitude of Neolithic Cities with Mid Holocene Environment and Climate Changes in the Middle Yangtze River, China," *Quaternary International* 321 (2014), pp. 22–28.

23 Li Wu et al., "Mid-Holocene Palaeoflood Events Recorded at the Zhongqiao Neolithic Cultural Site in the Jianghan Plain, Middle Yangtze River Valley, China," *Quaternary Science Reviews* 173 (2017), pp. 145–60; Xiao Hong Zhu et al., "Late Neolithic Phytolith and Charcoal Records of Human Activities and Vegetation Change in Shijiahe Culture, Tanjialing Site, China," *PLOS ONE* 12.5 (2017), e0177287; Haiwei Zhang et al., "Collapse of the Liangzhu and Other Neolithic Cultures in the Lower Yangtze Region in Response to Climate Change," *Science Advances* 7.48 (2021), eabi9275.

24 Li Liu and Xingcan Chen, *State Formation in Early China* (London: Duckworth, 2003), pp. 75–79, 116–26.

25 Flad and Chen, *Ancient Central China*, chap. 5; Zhongguo wenwuju 中國文物局, *Zhongguo wenwu dituji: Hubei fence* 中國文物地圖集, 湖北分冊 (Xi'an: Xi'an ditu, 2002).

tury BC, they launched an unsuccessful invasion of the south, but did eventually colonize the Nanyang Basin, and settle near Wuhan.[26] There are scattered sites around the Lianghu Plain dating to the following five centuries, but the human population seems to have been low.

The post-Neolithic colonization of the region began in earnest in the seventh century BC, when Chu moved its capital southwards to Ji'nancheng 紀南城, on the western edge of the Jianghan Plain just north of modern Jingzhou 荊州. This came to be among the largest cities in ancient China, with rammed earth walls fifteen kilometers in circumference that still stand well above the surrounding land.[27] Chu was one of the most powerful states in the world at the time, and we can be sure that its capital drew heavily on the resources of the surrounding lands, though we have few records of it. This was the only period in which the Lianghu Plain was the capital of any state for more than a few decades, and we can be sure that Chu devoted considerable efforts to increasing the population and economic productivity of the region and to colonizing the Dongting Lake area, which is surrounded by Chu archeological sites.[28] In the mid-sixth century BC Chu carried out a survey of the resources in its domain, including "wetlands and marshes" and "reservoirs and weirs," the first evidence of state control over the region's resources.[29] Chu must have conquered and assimilated the peoples of the Lianghu region, but I have not found any archeological research on this process. In subsequent periods the lowlands were dominated by Han people while the mountains were home to other peoples.[30]

Despite the size of its capital, the population density in Chu was much lower than the overcrowded north China plain, and it was known as a land of abundant resources. Most famous were the extensive Yunmeng wetlands in the eastern Jianghan Plain, which were renowned for

[26] Li Feng, *Landscape and Power in Early China: The Crisis and Fall of the Western Zhou, 1045–771 BC* (Cambridge: Cambridge U.P., 2006), pp. 93–95, 322–32.

[27] Zhongguo shehuikexueyuan kaogu yanjiusuo 中國社會科學院考古研究所, *Zhongguo kaoguxue: liang Zhou juan* 中國考古學, 兩周卷 (Beijing: Zhongguo shehui kexue, 2004), pp. 259–63.

[28] Zhongguo wenwuju, *Zhongguo wenwu dituji: Hunan fence* 中國文物地圖集: 湖南分冊 (Changsha: Hunan ditu chubanshe, 1997).

[29] The former is a translation of *sou ze* 藪澤, the latter of *yan zhu* 偃豬 (堰瀦). Yang Bojun 楊伯峻, *Chunqiu Zuo zhuan zhu* 春秋左傳注 (Beijing: Zhonghua, 1990), pp. 1106–8 (Xiang 25); Stephen Durrant, Wai-yee Li, and David Schaberg, trans., *Zuo Tradition, Zuozhuan: Commentary on the "Spring and Autumn Annals"* (Seattle: U. Washington P., 2016), pp. 1154–55.

[30] On these relations, see Alexis Lycas, "Représenter l'espace dans les textes du haut Moyen Âge chinois: Géographie politique, humaine et culturelle de la région du Jingzhou," Ph.D. diss. (Paris: l'École pratique des hautes études, 2015); idem, "The Southern Man People as a Political and Fiscal Problem in Han Times," *MS* 67.1 (2019), pp. 145–64.

their abundant wildlife. Their wealth of natural resources was emphasized by Mozi when he tried to convince the ruler of Chu (which was also called Jing) that it was not worth conquering the North Chinese state of Song: "Jing has Yunmeng, filled with buffalo, rhinoceros, buffalo, elaphures, and deer, and the Yangzi and Han Rivers are full of fish, tortoise, giant turtles, and alligators – enough to feed the empire. Song, on the other hand, is known as a land that even lacks pheasants, rabbits, and foxes."[31] Although Mozi may have exaggerated the difference between the regions for rhetorical purposes, it fits with other evidence that suggests that the North China plain was already deforested and overpopulated, whereas the south had a low population density.[32]

We have little evidence of water control in the Yangzi River lowlands before the second century BC. The early history of water control in the region probably resembled in some respects that of the river edges in the well-studied Netherlands, another lowland that was colonized over many centuries.[33] There settlers first occupied relatively high land along the rivers that rarely flooded and thus required only small dikes. But when they built dikes along the river to protect themselves from occasional high water, they blocked the drainage of water flowing from inland areas to the river, so they often had to build small dikes all around their farms, effectively forming polders even at this early stage. As settlements expanded, they extended the dikes until they stretched all along the rivers, and these were gradually improved. As more and more land came to be protected by dikes, there was less area for floodwaters to accumulate, so large floods rose higher than they had before. This in turn led people towards larger-scale solutions, such as redirecting river courses with dams and canals. The result in both places were increasingly anthropogenic landscapes whose maintenance required constant labor and vigilance.

Given the long history of rice cultivation in the Yangzi valley there is no doubt that farmers in Chu territory modified waterways to grow

31 荆有雲夢, 犀兕麋鹿滿之, 江漢之魚鼈黿爲天下富. 宋所爲無雉兔狐狸者也. This passage is found in both *Mozi* and *Zhanguo ce*. Trans. James Crump, *Chan-Kuo Ts'e* (Oxford: Clarendon P., 1970), p. 563; Liu Xiang 劉向, ed., *Zhanguo ce* 戰國策 (Shanghai: Shanghai guji, 1985), *j.* 32, p. 1148; Ian Johnston, *The Mozi: A Complete Translation* (New York: Columbia U.P., 2010), *j.* 50, pp. 726–27. I have modified Crump's translation.

32 Brian Lander, "Deforestation in Early China: How People Adapted to Wood Scarcity," in Ian M. Miller et al., *The Cultivated Forest: People and Woodlands in Asian History* (Seattle: U. Washington P., 2022).

33 G.P. van de Ven, ed., *Man-Made Lowlands: History of Water Management and Land Reclamation in the Netherlands*, 4th edn. (Utrecht: Uitgeverij Matrijs, 2004), pp. 72–73. Peat subsidence, arguably the most important factor in Dutch environmental history, has no parallel in the central Yangzi.

crops.[34] Dikes, sluice gates, and other water infrastructure were well known in the Yellow River valley in this period, and were surely used in the Yangzi valley as well even though our earliest clear evidence dates to the subsequent Han period.[35] The early classical texts that mention water control were all written in the Yellow River valley and rarely mention the Yangzi region. They do mention that Chu built a canal between the Han River and Yunmeng – probably a modification of existing waterways rather than an entirely artificial canal – which shows that the Chu state was active in modifying the region's hydrology.[36] It is very likely that the state of Chu built dikes along the Yangzi to protect the farmland lying in the low-lying area between its capital at Ji'nancheng and the Yangzi River, and that the current dikes along the northern bank of the Yangzi are the result of around 2,500 years of gradual expansion and modification.

RULED FROM AFAR: THE EARLY EMPIRES, CA. 300 BC-1000 AD

Qin captured the central Yangzi from Chu in 278 BC and made it into its "Southern Commandery" (*Nan jun* 南郡), an administrative status it would retain for centuries as it became merely one of many commanderies set up by the Qin and Han states. From that date until now the region has usually been ruled from afar, and has received considerably less attention from imperial courts, and their historians, than the centers of political and economic power in North China and the lower Yangzi. Nonetheless, successive states appreciated its tax payments and encouraged the expansion of rice farming.

Tens of thousands of people can have a significant impact on the environment, but as far as North Chinese people were concerned, this was a sparsely populated and backwards region. Second century BC historian Sima Qian contrasted it with the crowded Yellow and Huai river regions, where people had to work hard to prosper. He described the Chu-Yue (Yangzi) region as being so fertile that the people could live easily without commerce:

[34] Liu Yutang 劉玉堂 and Yuan Chunfu 袁純富, *Chu guo shuili yanjiu* 楚國水利研究 (Wuhan: Hubei jiaoyu, 2012), pp. 230–46.

[35] Joseph Needham, Ling Wang, and Gwei-djen Lu, *Science and Civilisation in China 4.3: Civil Engineering and Nautics* (Cambridge: Cambridge U.P., 1971), pp. 344–50; Brian Lander, "State Management of River Dikes in Early China: New Sources on the Environmental History of the Central Yangzi Region," *TP* 100.4–5 (2014), pp. 325–62.

[36] Burton Watson, *Records of the Grand Historian: Han Dynasty, Vol. 2* (Hong Kong and New York: Renditions – Columbia U.P., 1993), p. 54.

> Since the land is so rich in edible products, there is no fear of famine, and therefore the people are content to live along from day to day; they do not lay away stores of goods, and many of them are poor. As a result, in the region south of the Yangtze and Huai rivers no one ever freezes or starves to death, but on the other hand there are no very wealthy families."[37]

He preferred the industrious laborers of his native Yellow River valley to the southerners who enjoyed an easy life by exploiting the region's natural abundance, a disdain reminiscent of that held by modern Europeans towards their colonized subjects who were hopelessly uninterested in accumulating wealth.[38] Sima described regions further south as humid and unhealthy, which was probably due to malaria and other illnesses that northerners were not adapted to.[39] He contrasted this with Jingzhou (the Jianghan Plain region) which enjoyed the "wealth of Yunmeng." This passage suggests that people in the region did not necessarily have to work very hard to stay alive, as one might expect in a fertile region with a low population.[40]

The Chu, Qin, and possibly Han states kept hunting reserves at Yunmeng to take advantage of its abundant wildlife.[41] Qin laws stated that poachers caught hunting boar, dogs, or three kinds of deer in the park were to be sentenced to hard labor, while those caught with dhole, wolf, raccoon-dog, porcupine, fox, pheasant, or rabbit were not to be punished.[42] In other words, people were allowed to hunt for smaller animals, but the larger ones were reserved for the royal elite. These hunting reserves are significant because they represent the only time before the 1970s that any part of the Lianghu region was set aside to protect its non-human inhabitants. Unlike South Asia, where large forests were preserved for war elephants, the Chinese empires had no

37 地埶饒食, 無飢饉之患, 以故呰窳偷生, 無積聚而多貧. 是故江淮以南, 無凍餓之人, 亦無千金之家. Sima Qian 司馬遷, *Shi ji* 史記 (Beijing: Zhonghua, 1959) 129, p. 3263–70; trans. Watson, *Records of the Grand Historian: Han Vol. 2*, p. 446; Nancy Lee Swann, *Food & Money in Ancient China: The Earliest Economic History of China to A.D. 25* (New York: Octagon Books, 1974), p. 447.

38 Max Weber, *The Protestant Ethic and the Spirit of Capitalism* (London: Routledge, 1992), pp. 53–67.

39 He described the Xiang 湘 and Gan 贛 river basins as humid and unhealthy; *Shi ji* 129, p. 3268; Qian Mu 錢穆, *Shi ji diming kao* 史記地名考 (Beijing: Shangwu, 2001), p. 200.

40 On subsistence strategies that emphasize low labor inputs, see Marshall Sahlins, *Stone Age Economics* (Chicago: Aldine, 1972).

41 For a poetic evocation of this wealth, see David R. Knechtges, *Wen Xuan, or Selections of Refined Literature Vol. 2: Rhapsodies on Sacrifices, Hunting, Travel, Sightseeing, Palaces and Halls, Rivers and Seas* (Princeton: Princeton U.P., 1987), pp. 53–71.

42 Liang Zhu 梁柱 and Liu Xinfang 劉信芳, *Yunmeng Longgang Qin jian* 雲夢龍崗秦簡 (Beijing: Kexue chubanshe, 1997), slips 278, 279, 258 and 254.

incentive to preserve large tracts of non-agricultural land and instead consistently emphasized agricultural expansion.[43]

Although the first dikes in the region were probably built at the time of Chu, our earliest evidence comes from administrative documents from the second century BC in which the early-Han state surveyed broken dikes in order to repair them and expand farmland.[44] This shows that the state was involved in dike repair much earlier than previously known. But not all dike building was state led; private groups drained land for profit in Nanyang, Henan, during the Warring States period and built polders along the Yellow River during the Han.[45] It was probably quite common for wealthy families to convert wetlands to farmland for profit, but this is not the type of activity that interested the political elites who wrote our historical sources. Nonetheless, later history suggests that elite families were often the main forces in wetland colonization, which is not surprising because they were often much more powerful than the state at the local level.

The Han is the earliest period for which we have population records, though they are difficult to use for this region because administrative boundaries had no relation with physical geography. The region's population has been estimated at 68,000 in 2 AD, 115,000 in 130 AD, and 100,000 during the Tang (618–907).[46] The population thus grew substantially during the Eastern Han dynasty (roughly the first two centuries AD). Records from the third to sixth centuries range from 30 to 60 thousand, but this probably reflects reduced state capacity to register people as much as actual population. Still, it would not be surprising if the population did drop substantially in the warfare during the fall of the Han (which overlaps with the tumultuous Three Kingdoms Period), when the Yangzi region was frequently a battleground. It was under the control of the state of Eastern Wu 吳 for much of the third century. Wu, and several of the subsequent Southern Dynasties, established agricultural colonies in the Lianghu plain which settled people displaced by wars on abandoned land in order to guarantee a supply of taxes and labor for the state.[47] Wu also carried out surveys of damaged waterworks

[43] Thomas R. Trautmann, *Elephants and Kings: An Environmental History* (Chicago: U. Chicago P., 2015).

[44] Lander, "State Management of River Dikes."

[45] Sima, *Shi ji* 129, p. 3278; Swann, *Food & Money in Ancient China*, p. 454; Wang Xianqian 王先謙, *Han shu buzhu* 漢書補注 (Shanghai: Shanghai guji, 2012), *j.* 29, p. 2890.

[46] Mei Li 梅莉, Zhang Guoxiong 張國雄, and Yan Changgui 晏昌貴, *Lianghu pingyuan kaifa tanyuan* 兩湖平原開發探源 (Nanchang: Jiangxi jiaoyu, 1995), p. 25.

[47] Ibid., p. 40; Jiang Fuya 蔣福亞, *Zoumalou Wu jian jingji wenshu yanjiu* 走馬樓吳簡經濟文書研究 (Beijing: Guojia tushuguan, 2012), pp. 144–231.

similar to the early-Han surveys mentioned above, but in this case they surveyed not river dikes but irrigation reservoirs around Changsha.[48]

The region was under the control of states based in the lower Yangzi valley for most of the period from the 230s to the 580s. They could easily float the region's tax payments down the Yangzi to their capitals at Nanjing. In the late-fifth century, these included rice, silk and hemp cloth, large and small beans, barley, sesame, and dried meat.[49] This was an important period in the colonization and economic development of South China more generally because these states lacked access to the densely populated north, and thus actively engaged in conquest and state building south of the Yangzi.[50] Nonetheless, the population figures suggest that the Lianghu Plain's population did not grow during these centuries, even though the population of South China as a whole increased substantially due to both immigration from the North and natural population growth. Records from the Jin period (280–420) suggest that the Lianghu Plain was not a popular area for northern migrants to settle.[51] It may be the case that 100,000 was an appropriate population for the region as long as people only farmed the best land around the edges of the wetlands. Only by building dikes could people expand farmland into lower-lying areas.

The earliest textual records of the large dikes on the north bank of the Yangzi at Jingzhou date to the fourth century AD, though, as noted above, they were probably first built centuries earlier.[52] Later on, during the Tang (618–907), those dikes were improved, a variety of waterworks were built west of the Dongting area, near modern Changde, and later records suggest that many other works were carried out.[53] The region's infrastructure was probably allowed to decay during the warfare that accompanied the fall of the Tang, but the states that took over the region after that promoted irrigation projects and consolidated the dikes along the northern bank of the Yangzi.[54]

48 Ling Wenchao 凌文超, "Zoumalou Wu jian 'yinhe botian bu' fuyuan zhengli yu yanjiu" 走馬樓吳簡"隱核波田簿"復原整理與研究, *Zhonghua wenshi luncong* 中華文史論叢 2012.1, pp. 107–45.

49 Mei, Zhang, and Yan, *Lianghu pingyuan kaifa*, p. 41.

50 Rafe de Crespigny, *Generals of the South: The Foundation and Early History of the Three Kingdoms State of Wu* (Canberra: Australian National University, 1990).

51 Connie Chin, "Climate Change and the Migrations of People during the Jin Dynasty," *Early Medieval China* 13–14.2 (2008), pp. 49–78.

52 Yang Shoujing 楊守敬 and Xiong Huizhen 熊會貞, *Shuijing zhu shu* 水經注疏 (Nanjing: Jiangsu guji, 1989), *j.* 34, p. 2863.

53 Mei, Zhang, and Yan, *Lianghu pingyuan kaifa*, pp. 46–47.

54 Hugh R. Clark, "The Southern Kingdoms between the T'ang and the Sung, 907–979,"

MORE AND MORE PEOPLE, CA. 1000–1900

The scale and pace of the human impact on the wetlands in the Yangzi River valley increased substantially over the course of the second millennium. The lower Yangzi became the economic powerhouse of East Asia, exporting textiles and other manufactures around the world. The central Yangzi exported rice to feed the people of the delta, whose farmers increasingly grew cash crops. Wuhan became one of the most important cities in the empire, the marketing center from which rice and other commodities were gathered from around the central Yangzi region to ship downstream to the delta.[55] Early in the millennium fast-ripening varieties of rice spread through south China, allowing for double-cropping with wheat and other crops.[56] These were later followed by New World crops like maize and sweet potatoes that greatly increased people's ability to exploit marginal land (as well as chili peppers for which the region's cuisine is now famous).[57] These crops made possible both agricultural intensification and the extensive clearance of marginal land for farming, key drivers of China's enormous demographic growth after 1600.

Our scanty records indicate that the region's populated fluctuated considerably over the first millennium, but in the second millennium it far outstripped all previous levels.[58] The region's population increased from 100,000 during the Tang, to 490,000 in the Song (tenth to thirteenth centuries), to 1,160,000 in mid-Ming (late-sixteenth century), then 15,000,000 in mid-Qing (early-nineteenth century).[59] While the eighteenth century was a period of rapid population growth across China, the Lianghu region's population grew particularly fast. Population growth in the most fertile agricultural regions pushed people into less desirable areas such as mountains and wetlands, where they cleared

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in Denis Twitchett and Paul J. Smith, eds., *The Cambridge History of China Vol. 5.1: The Sung Dynasty and Its Precursors, 907–1279* (Cambridge: Cambridge U.P., 2009), p. 173.

[55] During the Song the main city was Ezhou 鄂州 (now Wuchang 武昌), while by the Qing the center of commerce had moved across the river to Hankou 漢口: William T. Rowe, *Hankow: Commerce and Society in a Chinese City, 1796–1889* (Stanford: Stanford U.P., 1984), pp. 17–29; Yoshinobu Shiba, *Commerce and Society in Sung China*, trans. Mark Elvin (Ann Arbor: University of Michigan, Center for Chinese Studies, 1970), pp. 52–53, 66; Twitchett and Smith, eds., *Cambridge History of China Vol. 5.1*, p. 702.

[56] Bray, *Science and Civilisation in China 6.2*, pp. 491–95, 597–610.

[57] Ping-ti Ho, *Studies on the Population of China, 1368–1953* (Cambridge, Mass.: Harvard U.P., 1959), pp. 183–94.

[58] On Hunan's population in the Tang and Song periods, see Glahn, "Country of Streams and Grottoes," pp. 370–82.

[59] Mei, Zhang, and Yan, *Lianghu pingyuan kaifa*, pp. 25, 261.

increasingly marginal land.[60] Where people in earlier time lived along the edges of the wetlands and thus minimized the wearisome labor of building and maintaining polders, it became unavoidable as population growth reduced the supply of arable land and forced people deeper into the wetlands.[61]

Wars also played a role in the region's environmental history. The Lianghu region became a military frontier when the Song was driven from the north in 1127. Warfare and banditry depopulated the Lianghu Plain, but its proximity to the frontier of the new Southern Song state made it a strategic agricultural area and so the Song began a colonization project.[62] Colonies were established in the Jianghan Plain and farther up the Han River valley.[63] The Southern Song also built waterworks designed to link the Yangzi and Han Rivers and flood a belt of land in the north part of the plain to block the movements of Mongol cavalry.[64]

The Han River valley was a key battleground in the late-thirteenth-century Mongol conquest of the Southern Song, when protracted warfare in the upper valley drove refugees southwards so that the region's population rose to 838,000 by around 1290. The region's population declined in the mid-fourteenth century, as the Mongol Yuan dynasty collapsed and the Ming arose through protracted wars (and probably pestilence),[65] which included the Red Turban uprising in the Lianghu area. The founding Ming emperor established his capital at Nanjing

60 Martin Heijdra, "The Socio-Economic Development of Rural China during the Ming," in Denis Twitchett and F.W. Mote, eds., *The Cambridge History of China. Vol. 8, The Ming Dynasty, 1368–1644. Part 2* (Cambridge: Cambridge U.P., 2008), p. 420; Eduard B. Vermeer, "Population and Ecology along the Frontier in Qing China," in Mark Elvin and Ts'ui-jung Liu, eds., *Sediments of Time: Environment and Society in Chinese History* (Cambridge: Cambridge U.P., 1998), pp. 235–82; Zhuang Huafeng 莊華峰, "Gudai Jiangnan diqu weitian kafa ji qi dui shengtai huanjing de yingxiang" 古代江南地區圩田開發及其對生態環境的影響, *Zhongguo lishi dili luncong* 中國歷史地理論叢 20.3 (2005), pp. 87–94.

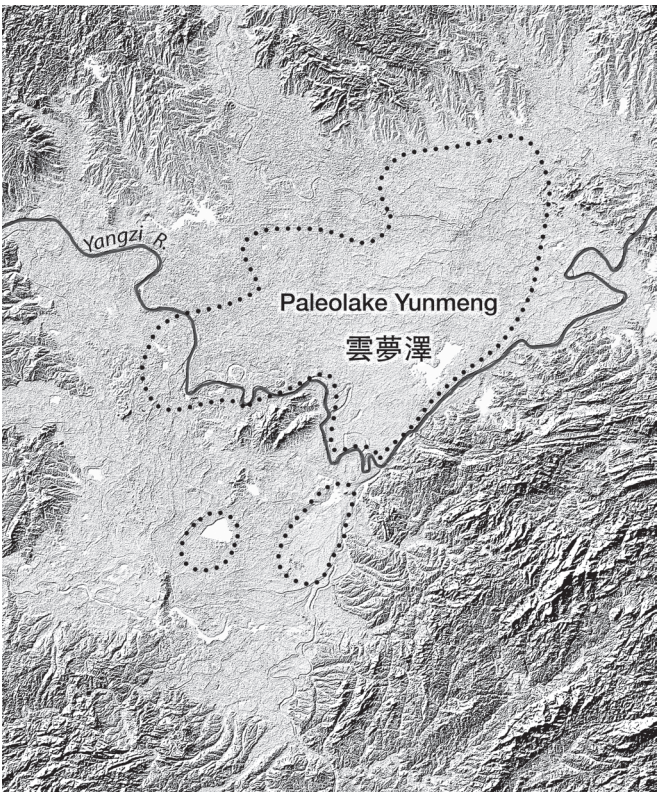
61 On the relationship between population and agricultural colonization, see Gong Shengsheng 龔勝生, "Qing dai Lianghu diqu renkou yali xia de shengtai huanjing ehua ji qi duice" 清代两湖地區人口壓力下的生態環境惡化及其對策, *Zhongguo lishi dili luncong* 1993.1, pp. 69–94; Shi Quan 石泉 and Zhang Guoxiong 張國雄, "Jianghan pingyuan de yuantian xingqi yu heshi" 江漢平原的垸田興起于何時, *Zhongguo lishi dili luncong* 1988.1, pp. 131–40; Chen Xi 陳曦 and Yang Guo 楊果, *Jingji kaifa yu huanjing bianqian yanjiu: Song, Yuan, Ming, Qing shiqi de Jianghan Pingyuan* 經濟開發與環境變遷研究, 宋、元、明、清時期的江漢平原 (Wuhan: Wuhan daxue, 2008), pp. 145–90.

62 Twitchett and Smith, *Cambridge History of China Vol. 5.1*, pp. 665, 699–700, 733.

63 Fang Jian 方健, *Nan Song nongye shi* 南宋農業史 (Beijing: Renmin, 2010), pp. 144–55.

64 Pierre-Étienne Will, "State Intervention in the Administration of a Hydraulic Infrastructure: The Example of Hubei Province in Late Imperial Times," in Stuart R Schram, ed., *The Scope of State Power in China* (London: School of Oriental and African Studies, 1985), pp. 300–1.

65 Robert Hymes, "Epilogue: A Hypothesis on the East Asian Beginnings of the *Yersinia pestis* Polytomy," *The Medieval Globe* 1 (2014), pp. 285–308.



Map 3. Schematic Depiction of Floodwater Accumulation before Dike Construction

Dotted lines indicate where water accumulated. It mostly accumulated in the Jianghan plain before people built dikes along the northern bank of the Yangzi, which they began to do in the mid-late first millennium BC.

on the lower Yangzi and sent people across the empire to supervise the repair and construction of various kinds of water works. He encouraged local inhabitants to suggest improvements to the hydraulic infrastructure, and had local people conscripted to build such works.[66] These state-sponsored hydraulic works were essential to making the plain arable again, and thus led to the extraordinary levels of immigration into the plain in the first decades of the Ming from other parts of Hunan and Hubei, as well as Jiangxi.[67] After this period the Ming

66 Will, "State Intervention," pp. 308–9.

67 Perdue, *Exhausting the Earth*, pp. 101–13; Jiayan Zhang, *Coping with Calamity: Environmental Change and Peasant Response in Central China, 1736–1949* (Vancouver, B.C.: UBC P., 2014), p. 34; Mei, Zhang, and Yan, *Lianghu pingyuan kaifa*, p. 25.

Map 4. Schematic Depiction of Floodwater Accumulation after Dike Construction

As the Yangzi R. dikes were expanded, they pushed floodwaters south; and by the second millennium AD much of the floodwater accumulated in Dongting Lake. Base map by Lynn Carlson.

state tended to mitigate problems occurring within existing water infrastructure rather than actively encourage more intensive waterworks, though private actors continued to build dikes.

Various technologies that could lift water were invented and came into widespread use in this period.[68] Both human and buffalo muscles were used to turn water wheels that picked up water and dumped it higher up, essentially the opposite of labor-saving water-powered wheels. Similarly, human labor also was used to turn chains of small buckets for the same purpose. However, unlike the powerful water-lifting windmills that were used to drain polders in the Netherlands, the

[68] Joseph Needham and Ling Wang, *Science and Civilisation in China 4.2: Mechanical Engineering* (Cambridge: Cambridge U.P., 1965), pp. 337–62.

amount of water that could be moved with these technologies was limited. They worked well for lifting irrigation water into fields but were not much use for draining flooded polders. Their widespread adoption exemplifies the intensification of land use.

The empires of this period spent most of their funds for water control in the Lianghu region on the large dikes along the north banks of the river that protected the Jianghan Plain.[69] While that plain had originally been the main destination for the floodwaters of the Yangzi, over the centuries the people of the region gradually expanded and connected the dikes that stretched along the north of the Yangzi river, keeping floodwaters from flowing north. At the same time, they made sure to maintain some of the waterways that led southwards to Dongting Lake so that it would absorb the floodwaters and sediment of the Yangzi floods. The result was that floodwaters accumulated in Dongting Lake, making it much bigger than it had been before, and the Jianghan Plain became separated from the Yangzi floodwaters (see maps 3–4, preceding).[70] This had the benefit of protecting the Jianghan Plain from the Yangzi; but the significant downside of preventing its floodwaters from draining out into the Yangzi was that it formed large permanent lakes within the plain. This then forced people to build dikes and canals within the plain to keep the lake-water from flooding their fields.[71]

The wars of the Ming-Qing dynastic transition in the mid- to late-seventeenth century again degraded hydraulic infrastructure and forced people to flee the flooded region. Many settled in Sichuan. After the Qing state consolidated its rule around 1680 it devoted considerable resources to dikes, which expanded arable land and encouraged immigration.[72] While the eighteenth-century government encouraged polder building, by the nineteenth it became a problem as people illegally colonized land in low-lying areas of Dongting Lake and in the lands beside the Yangzi River that were outside of the dikes.[73] This further reduced the flood catchment area, increasing flood severity. Many farmers would have preferred to grow two crops a year, including high-yield rice varieties, but their land was waterlogged and flood-prone, so they had to make do with low-yielding crops that could withstand

69 Will, "State Intervention," 317–18; Xiao Qirong 肖啓榮, "Ming Qing shiqi Han shui xiayou diqu de dili huanjing yi difang guanli zhidu 明清時期漢水下游地區的地理環境與堤防管理制度, *Zhongguo lishi dili luncong* 23.1 (2008), pp. 34–43.

70 The location of flooded areas is based on Hongfu Yin et al., "River–Lake Relationship of the Middle Yangtze Reaches," pp. 197–207.

71 Chen and Yang, *Jingji kaifa yu huanjing bianqian yanjiu*, pp. 49–134.

72 Will, "State Intervention," pp. 314–20.

73 Perdue, *Exhausting the Earth*, pp. 164–233.

waterlogging.[74] Because so many people built polders that they could not adequately drain, a significant percentage of the population lived precariously even before the mid-nineteenth-century Taiping uprising, which damaged the region's water control system, and the ability of the Qing state to repair it, without halting the long-term trend of population growth.[75]

While people could keep river waters out of their land with dikes, there was not much they could do about rain, which tended to arrive precisely when the waters outside of the dikes were higher than the water inside. The only solution was to create space for water within the dikes, dividing the land into fields, ponds, and lakes.[76] Up to 55% of the Jianghan Plain was under water as of 1995, probably a lower figure than during the Qing.[77] In contrast to the constantly fluctuating division between wet and dry in the natural wetlands, people strove to create permanent divides between land and water within the dikes by fixing the locations of lakes and pond. This also made the water bodies subject to the same rules of ownership and control as land, also with the same disputes.

The destruction of wetlands after 1700 significantly reduced the comparative importance of fishing in the region's economy, and in its tax payments. But fishing has remained important both in people's diets and in the cash economy. During the Qing, many people fished professionally in the agricultural off-season. Fish caught in the region included sturgeon, shad, anchovies (*Colilia*), oriental puffer, freshwater eel, grass carp, black carp, silver carp, bighead carp, noodlefish (related to smelt), black Amur bream, Chinese perch, Amur catfish, snakehead (*Channa*), culter, and common carp. The fish sold in Dongting fish markets now tend to be quite small, probably because overfishing has eliminated larger and longer-lived fish, leaving only smaller fish that are more resilient to constant fishing pressure. The reduction in the size of wild fish was surely one factor that led people to begin farming fish, which has become increasingly common since 1949.

[74] Zhang, *Coping with Calamity*, pp. 101–29; Perdue, *Exhausting the Earth*, pp. 113–35.

[75] Yan Gao, "Transformation of the Water Regime: State, Society and Ecology of the Jianghan Plain in Late Imperial and Modern China," Ph.D. diss. (Carnegie Mellon, 2012), pp. 210–71.

[76] The following two paragraphs are mostly based on Zhang, *Coping with Calamity*, pp. 155–80; Yin Lingling 尹玲玲, *Ming Qing lianghu pingyuan de huanjing bianqian yu shehui yingdui* 明、清兩湖平原的環境變遷與社會應對 (Shanghai: Shanghai renmin, 2008), pp. 15–63.

[77] Zhongguo linyeju 中國林業局, *Zhongguo shidi ziyuan: Hubei juan* 中國濕地資源, 湖北卷 (Beijing: Zhongguo linye chubanshe, 2015), p. 38.

CONCRETE AND COAL: SINCE 1900

As in most other parts of the world, China's environment has been transformed at an increasing pace over the past century. The population grew dramatically in the three decades following the communist revolution of 1949. In the same period, a powerful centralized state and modern technology combined to build far more effective water control structures than had ever existed before, consolidating and rebuilding the system of dikes and polders that had been built in previous centuries. The construction of the Three Gorges Dam upstream on the Yangzi has reduced the seasonal variability in water levels, seriously affecting the remaining wetlands.

In the 1920s and 30s The Republican government reorganized the national water control administration and hired Western water-control experts, but it lacked the power to implement an effective system.[78] The floods of 1931 devastated the region, and demonstrated the inability of the government to either control floods or organize an effective relief effort.[79] Like its imperial predecessors, the Republican state was not powerful enough to impose its will on those who stood to lose from the establishment of a basin-wide hydraulic management strategy. In particular, wealthy families and government clerks had enormous power to block central government initiatives. The success of the Communists in establishing effective rural administration in the 1950s was due in no small part to their success in destroying the local gentry.[80] The Communist state was thus vastly more powerful than any of its predecessors and was dedicated to a thoroughly modernist and technocratic approach to water control in the interests of expanding agriculture.[81]

In the polder areas, this entailed replacing traditional water management organizations with production teams and rebuilding the landscape according to hydraulic engineering principles.[82] They mustered huge numbers of laborers to improve water control infrastructure, especially on the very labor-intensive work of enlarging dams and dikes. The older systems tended to be designed not around the shape of the

78 Gao, "Transformation of the Water Regime," pp. 307–15.

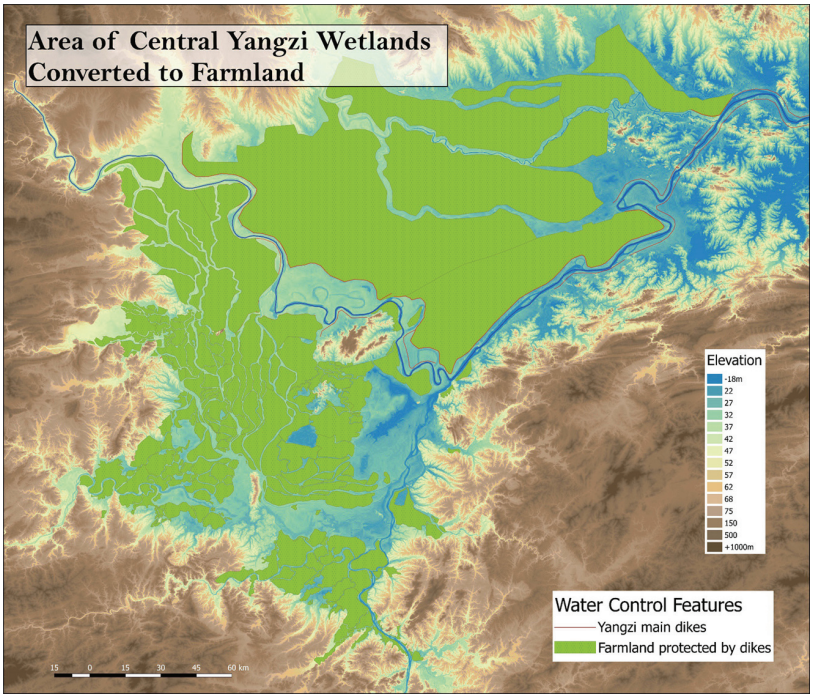
79 Chris Courtney, *The Nature of Disaster in China: The 1931 Yangzi River Flood* (Cambridge: Cambridge U.P., 2018).

80 Philip A. Kuhn, chap. "Maoist Agriculture and the Old Regime," in idem, *Origins of the Modern Chinese State* (Stanford: Stanford U.P., 2002), pp. 80–113.

81 David A. Pietz, *The Yellow River: The Problem of Water in Modern China* (Cambridge, Mass.: Harvard U.P., 2015), p. 130.

82 Gao, "Transformation of the Water Regime," p. 334.

land and waterways, as an engineer might have done, but rather according to the complex history of each polder's creation and ownership. The Communist local governments reorganized them entirely, often combining smaller polders into larger ones, but the state's failure to control the disastrous 1954 flood, or mitigate its consequences, revealed the limits of these campaigns.[83] It should be noted that this project was promoted not only for increasing agricultural yields, but it was also included in the national campaign for the elimination of the parasitic disease schistosomiasis, a campaign that was not entirely effective (see map 5).[84]



Map 5. Area of Central Yangzi Wetlands Converted to Farmland and Fish Ponds

Map by author based on information from Hunan sheng guotu ziyuan ting 湖南省國土資源廳, Dongting hu lishi bianqian ditu ji 洞庭湖歷史變遷地圖集 (*also titled:* Atlas of Historical Vicissitude in Dongting Lake) *(Changsha: Hunan ditu chubanshe, 2011); and Hubei sheng shuili zhi bianzuan weiyuanhui* 湖北省水利志編纂委員會, Hubei shui li zhi 湖北水利志 *(Beijing: Zhongguo shuili shuidian chubanshe, 2000).*

83 Chris Courtney, "At War with Water: The Maoist State and the 1954 Yangzi Floods," *Modern Asian Studies* 52.6 (2018), pp. 1807–36.

84 Gao, "Transformation of the Water Regime," pp. 335–41; Zhong Sheng 鐘聲 and Yang Qiao 楊橋, *Dongting hu qu shengtai huanjing bianqian shi* 洞庭湖區生態環境變遷史 (Changsha: Hunan daxue, 2014), p. 13.

These campaigns greatly increased the amount of arable land in both the Jianghan Plain and Dongting Lake.[85] The widespread waterlogging that had plagued Qing-era farmers was mitigated by dike improvements and a system-wide planning strategy. The creation of new land substantially reduced the size of Dongting Lake, which fell from 4,530 sq. km in 1949 to 2,740 in 1977, with most of the work being done in the 1950s.[86] Of course, much of this land had already been poldered in the late Qing and then abandoned during the second world war, but the polders were much more robust now.

While the scientific rebuilding of the dikes and waterways could not have occurred without mass labor, modern technology played a decisive role. Fossil-fuel-powered pumps regulated the movement of water into and out of polders and made it possible for low-lying polders to regulate their water levels effectively, ensuring both proper drainage in the rainy season and irrigation water when the rains failed. The whole region is now a managed hydrological system based on fossil-fuel power, since even electric pumps are mostly powered by coal.

The destruction of so many wetlands greatly reduced the habitat, and number of wild animals of various kinds.[87] The most obvious repercussion of this for humans was the decreased availability of wild fish, whose total catch in the Dongting area dropped from 330,000 tons per year in 1949 to 110,000 tons per year in the early-twenty-first century. The lack of wild fish prompted people to raise fish themselves, which was an obvious way to use the large amount of open water that remains within the dikes. Fish farming is now a common occupation in the area, and its breeding and feeding technologies increasingly resemble those of terrestrial industrial meat production.[88] The shift from wild to farmed fish is a classic example of how increasing human population density increases the amount of labor required to obtain food. It is also an adaptation to the fact that even modern water control systems did not manage to eliminate water from within the polders, but did allow people to neatly divide them into rice paddies and fish ponds. Ponds are also used to grow crops like water caltrop and lotus.

85 The number of lakes over 100 *mu* (16 acres) in Hubei declined from 1,332 in the early 1950s to 843 in the mid-1980s; Zhang, *Coping with Calamity*, p. 157.

86 In more detail (all in square kilometers): 4,530 in 1949; 3,915 in 1954; 3,141 in 1958; 2,740 in 1977. Zhong and Yang, *Dongting hu qu*, p. 11.

87 This paragraph based on ibid., pp. 15–17, 91–99.

88 Fangzhou Hu et al., "Development of Fisheries in China," *Reproduction and Breeding* 1.1 (2021), pp. 64–79.

While much of the region has been encompassed within polders, until recently the natural flood regime still dominated the areas outside of them. This changed with the construction of the Three Gorges dam, which has replaced the monsoon cycles with the logic of electricity generation and flood reduction, a further disruption to the remaining wetlands.[89] Retention of water in the dam reservoir during the low water period lowers the level of the Yangzi and the lakes that drain into it (Dongting and Poyang).[90] This has generally reduced the water levels in Dongting Lake, sometimes to the extent that there is not enough to irrigate the surrounding areas. It has altered the compositions of the fish populations in the river, and probably contributed to the recent extinction of the Yangzi River dolphin.[91] The decrease in water also exacerbates the pollution problem by reducing the ability of Dongting Lake to flush out pollutants. Hunan is one of the most polluted provinces in China and the Xiang River has the highest levels of heavy metal pollution of any river in China. Its Zhuzhou 株洲 municipality, just south of Changsha, has the highest levels of cadmium pollution in all of China.[92] A significant amount of Hunan's rice is polluted with cadmium. Soil pollution is difficult and expensive to clean, so we can expect that much of this land will remain polluted indefinitely.

Another force driving change has been the growth in cities.[93] This has been particularly obvious in Wuhan, the region's largest city, which has expanded by filling in 156 square kilometers of lakes and wetlands per year in the three decades after 1978.[94] This is probably also the case in other lowland cities like Changde and Jingzhou and can be expected to continue. Much of the sand used to fill in the lakes–and to make

89 Xuefei Mei et al., "Linkage between Three Gorges Dam Impacts and the Dramatic Recessions in China's Largest Freshwater Lake, Poyang Lake," *Scientific Reports* 5 (2015), 18197; Xiao Zhang et al., "Impact of the Three Gorges Dam on the Hydrology and Ecology of the Yangtze River," *Water* 8.12 (2016), p. 590.

90 Q. Zhang et al., "Has the Three-Gorges Dam Made the Poyang Lake Wetlands Wetter and Drier?" *Geophysical Research Letters* 39.20 (2012), L20402.

91 Samuel T. Turvey, *Witness to Extinction: How We Failed to Save the Yangtze River Dolphin* (Oxford: Oxford U.P., 2008); Xin Gao et al., "Regime Shift in Fish Assemblage Structure in the Yangtze River Following Construction of the Three Gorges Dam," *Scientific Reports* 9.1 (2019), 4212.

92 Isabel Hilton, ed., *Polluting and Health in China: Confronting the Human Crisis* (London: China Dialogue, 2014), p. 21; Zhong and Yang, *Dongting hu qu*, pp. 14–15.

93 Cong Xie et al., "Impacts of Land-Use Changes on the Lakes across the Yangtze Floodplain in China," *Environmental Science & Technology* 51.7 (2017), pp. 3669–77.

94 Zheng Zhongming 鄭忠明 et al., "Chengshihua beijing xia jin 30 nian Wuhan shi shidi de jingguan bianhua" 城市化背景下近30年武漢市濕地的景觀變化, *Shengtaixue zazhi* 生態學雜誌 28.8 (2009), pp. 1619–23.

concrete–has been dredged from the bottom of the lakes and rivers of the region, transforming their hydrology and ecology.[95]

On a more positive note, the provincial government declared 190,000 hectares of East Dongting Lake a nature reserve in 1982, and in 1994 that status became nationally authorized.[96] The 25,000 hectare South Dongting Lake was declared a provincial level reserve in 1997, and the 35,000 hectare West Dongting Lake Nature Reserve was declared a Nationally Important Nature Reserve in 2014. The two national-level reserves are guaranteed central government protection, which is very significant in terms of actual protection. All three are included on the Ramsar List of Wetlands of International Importance.[97]

CONCLUSION

This paper has recounted how humans colonized some of East Asia's largest wetlands. In order to transform dynamic and diverse ecosystems into rice monocultures, fish ponds, and gardens they had to completely rebuild the region's hydrology, a project that took millennia, but has gradually accelerated over time. There has been a general trend towards the building of increasingly labor and energy intensive water-control systems, and each innovation has tended to create new problems that can only be solved with further control measures. The process continues, as the building of the Three Gorges dam has dramatically transformed the hydrology of the entire lower Yangzi system, with effects that are only beginning to be understood.

Although each modification in the region's environment was intended to improve conditions for people living there, the expansion of farmland has not made life more pleasant for local residents, because each increase in the amount of food that can be produced on any given area has simply promoted population growth. The end result is massive overpopulation and highly labor- and energy-intensive agriculture, in which people have to work much harder to achieve yields that could have been achieved with much less work on the much larger farm plots of earlier times.[98]

[95] Xingliang Meng et al., "Responses of Macroinvertebrates and Local Environment to Short-Term Commercial Sand Dredging Practices in a Flood-Plain Lake," *Science of The Total Environment* 631–632 (2018), pp. 1350–59. Thanks to an anonymous reviewer for pointing out the importance of sand mining, which I had neglected despite seeing it many times.

[96] Zhong and Yang, *Dongting hu qu*, pp. 106–7.

[97] On the wildlife in the remaining natural areas in the region, see Zhao Qihong 趙啓鴻, *Tianxia Dongting* 天下洞庭 (Yueyang: Hunan Dong Dongtinghu guojiaji ziranbaohuqu guanliju, 2012).

[98] Rice yields can be increased through increasing labor inputs more than any other major

The trend of increasing population leading to diminishing quality of life has seemingly halted with China's entry into the global capitalist system over the past four decades, which has seen substantial increases in the quality of life for most people in the region. This mainly reflects the fact that Chinese shoppers have joined the wealthy world in affecting the entire globe through their consumption. However, the price of this new-found wealth has been severe pollution and further degradation of ecological systems both locally and globally. The Chinese government remains committed to increasing per capita consumption and to dealing with environmental problems through modernist technological fixes, so we can expect that the same trends will continue in coming decades. On the positive side, for the first time in many centuries, the government is firmly committed to maintaining certain areas for the benefit of their non-human inhabitants, and the remaining sections of Dongting Lake are among the most important bird habitats in East Asia. But the huge numbers of birds that gather on those lakes remind us that they have very few other places to go in a subcontinent whose land and water is almost entirely devoted to producing materials for human consumption.

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grain crop; Francesca Bray, *The Rice Economies: Technology and Development in Asian Societies* (Berkeley: U. California P., 1994).