The Great Warming

Climate Change and the Rise and Fall of Civilizations

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Disorder, like a swelling flood, spreads over the whole empire, and who is he that will change its state for you?

—Confucius, Analects

The Huang He basin, northern China, late winter, A.D. 950. The wind cuts through one’s clothing, chilling one to the bone and gumming up one’s eyes. Oblivious to the cold and the fine dust, the farmers toil over their arid plots of land, thick cloths sheltering their faces. They turn over the soil, breaking up sods of earth hour after hour with never a break. The men move slowly, deliberately, stoically, as if knowing that their efforts are in vain. Last year’s millet harvest was far less than usual after a hot, unusually arid summer. People have been dying of hunger and dysentery for months, but the winds never relent, the skies are gray, the endless dust accumulates pitilessly on the freshly turned, arid soil. One of the farmers looks wearily up at the gloom overhead, looking vainly for even a hint of spring rain. There is more hunger ahead.

They call the Huang He (Yellow River) “China’s Sorrow” because it has killed millions of people with its sudden floods and lengthy droughts. Few rivers are more prone to disaster than the Sorrow, at
3,395 miles (5,464 kilometers) China's second longest river after the Yangtze. The Huang He rises in the Kunlun Mountains south of the Gobi Desert, flows through some deep gorges, then across the Ordos Desert before emerging into a huge drainage basin carved out of extensive plains covered with the fine, windblown dust known to geologists as loess. Here the great river picks up a heavy load of fine silt which turns its water a distinctive yellow. Eighty-seven miles (150 kilometers) from the mazelike channels of the mouth, the silt load exceeds that of every river in the world except the Ganges-Brahmaputra and the Amazon. With irregular monsoon rainfall and savage droughts, the 334,000 square miles (865,000 square kilometers) of the Huang He basin have been a crucible for human misery for more than seven thousand years. Here, global climatic forces helped decide the fate of medieval Chinese societies.

In northern China, the monsoon and the forces that drove it shape the climate of the warm centuries. As always, the climatic record of the warm centuries comes, for the most part, from proxies. The documentary record is long. For more than a thousand years, Japanese and Korean officials have recorded the date of cherry trees' spring flowering, a historical record whose duration rivals the longest from Europe. By combining archives such as these with proxies, Chinese climatologists have developed a winter temperature curve for eastern China, which shows that readings were above the long-term mean from A.D. 950 to 1300. The Medieval Warm Period was reality here. But, as always in East Asia, the major climatic player during these four centuries was the monsoon, nurtured in the Pacific Hot Pool.

The East Asian monsoon has close links to the Southern Oscillation, El Niños, and La Niñas. A long-term research program led by Wang Shao-wu at Beijing University has shown that when an El Niño warms the eastern tropical Pacific in winter, the subtropical high intensifies and shifts westward the following summer. This movement blocks the
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The summer monsoon from moving as far north as usual, so the Huang He basin suffers from sparse rainfall or drought. Ever since 1870, weather observations from stations in northern China have shown a connection between El Niño events and widespread drought. The East Asian monsoon stalls over the middle and lower Yangtze. Heavy rain falls there in June and July, while the north suffers from intense drought. When the Southern Oscillation swings and a cool, dry La Niña sets in over the Pacific, the subtropical high no longer blocks the northward movement of the monsoon, so summer rain falls in the north and often brings widespread flooding, with drier conditions in the south. The climatic contrasts caused by the ENSO-connected monsoon are such that there were effectively two Chinas for over three thousand years, from before 1000 B.C. In the south, the visitor was struck by the bustling commerce of the Yangtze Valley. In the north, poverty-stricken subsistence farmers wrestled with uncertain rainfall. (One should caution that the links between ENSO and monsoons and between El Niños, La Niñas, and climatic conditions in China are, to put it mildly, complex and still little understood.)

Forty-five percent of China's population lives in the provinces north of the Yangtze, in regions where rainfall can vary by 30 percent from year to year. The Huang He Valley receives 70 percent of its 19.6-inch (500-millimeter) annual rainfall between May and September, during the hot summer. Severe, dry winters with blowing snow add another challenge for northern farmers. For thousands of years, they have harvested wheat in June, then millet and sorghum in September. If the irregular spring rains fail, there is a poor wheat crop. If the summer monsoon falters, then there is no harvest for the entire year. The critical month is June, with poor rains a high probability. For instance, in modern times, Beijing has received deficient June rainfall during twenty-one of fifty-five years. Five of those years saw virtually no rain at all. Uncertain rainfall and violent climatic extremes made the Huang He a risky environment for cereal farmers even in good years. Everyone lives at the mercy of the monsoon.

A thousand years ago, temperatures were somewhat warmer in the north, where the Medieval Warm Period was in full swing. The American geographer George Cressey wrote in 1934: "With more adequate rainfall, it [the loess soil region] might form one of the most productive soils in the world." For details, we have to rely on climatic proxies, which are still few and far between.

One such proxy comes from the other end of China, from Lake Huguangyan on the low-lying Leizhou Peninsula in the tropical south. The closed lake lies in a region where 90 percent of the annual rainfall falls between April and October, the amount being determined by the position and intensity of the subtropical high in the western Pacific. The carbonate concentrations in the lake sediments vary considerably over time, probably as a result of changing evaporation rates and rainfall fluctuations. High carbonate levels signifying dry conditions occur at Huguangyan between A.D. 880 to 1260, which coincides with a widespread low-moisture index recorded in eastern China and major lake level changes throughout the entire country.

The Chinese droughts even have a global connection. Thousands of miles to the northeast, the Ohio State University climatologist Lonnie Thompson, well known for his work on Andean glaciers (chapter 9), drilled a series of cores deep into the Guliya ice cap on the Qinghai-Tibetan Plateau, where glaciers cover an area of 22,000 square miles (57,000 square kilometers). Guliya is in the western Kunlun Mountains. Four hundred and thirty-three feet (132 meters) of one core cover the past two thousand years and reveal an extended dry period between A.D. 1075 and 1375, followed by a nearly four-century wetter interval. Thompson was fascinated to discover that the Guliya drought coincided almost exactly with a major drought of the twelfth and thirteenth centuries 12,400 miles (20,000 kilometers) away in the Quelccaya ice cap of the southern Andes.

While Guliya links South America and Asia, cores sunk into Lake Huguangyan in coastal southeastern China provide a high-resolution record of climatic change in the south and another global connection. The sequence goes back over sixteen thousand years, measured by studying changing magnetic properties and titanium content, the
latter a record of sediment deposition, in the lake deposits as proxies that measure the strength of dry winter winds.\textsuperscript{8} During periods of warming in the northern hemisphere, the summer monsoon was stronger and the winter monsoon was weak. When the ITCZ moved south, as it does during El Niño years, the summer monsoon was weak and there was less rainfall. The Huguangyan cores show a general shift toward drier, colder climate in about A.D. 750 to A.D. 900, with a series of three multiyear droughts within that generally dry period.

Remarkably, these droughts coincide with the dry cycles recorded in the Cariaco basin deep-sea cores off Venezuela, described in chapter 8. The Cariaco records chronicle multiyear droughts that began as early as A.D. 760 and recurred at about fifty-year intervals: 760, 820, 860, and 910. The Cariaco droughts occurred when the ITCZ moved southward, just as they did in China, at a time of prolonged La Niña conditions in the tenth-century eastern Pacific, known to us from the Palmyra Island corals. Cool La Niña conditions in the tropical Pacific usually mean that heavy monsoon rains fall in northern China, while the south is dry, exactly the pattern one sees in the few proxies there.

For the northern Chinese, the Medieval Warm Period may have been warmer, but it was a time of violent climatic swings nurtured thousands of miles away that brought either lengthy dry cycles or torrential rainfall that inundated thousands of acres of the Huang He basin.

**Medieval Agriculture** in the Huang He basin lived with sudden climatic twists and turns, and with the sins of earlier farmers. Loess forms a fine, soft-textured earth that is both homogeneous and porous, making it easy to cultivate with simple ox-shoulder-bone shovels and digging sticks. Cereal farming began here at least 7,500 years ago, in the midst of a verdant, forested landscape, where summer monsoon rains and a dry winter nourished small agricultural settlements. Rainfall was higher than it is today; droughts were but a sporadic problem for over three thousand years. Archaeological surveys have located dozens of prosperous villages across a densely populated landscape dating to before 2000 B.C.\textsuperscript{9} Then, suddenly, the number of archaeological sites shrinks dramatically between 2060 and 1600 B.C. as more arid conditions settled over the region. Population densities fell rapidly, less fertile areas were abandoned, and people retreated from higher elevations. Plant and tree pollens from the extensive clay silt layers in the valleys show that forests gave way to grasses and shrubs as a result of prolonged drought and perhaps some human clearance. For the next two thousand years, dry conditions persisted, making agriculture at best a marginal activity. The survivors of what must have been a major catastrophe turned to sheepherding in the now barren landscape. Only about two thousand years ago did wetter conditions once again prevail and agriculture on any scale resume.

The climate shift of four thousand years ago was an event on a millennial scale, but northern China has never been very wet, so what should have been a paradise for cereal farmers never realized its full potential. They were at the mercy of unpredictable summer monsoon rains and a capricious environment that drought, human deforestation, and sheep grazing had modified fundamentally. As farming populations rose during the second millennium and the primordial Shang civilization flourished along the Huang He and its Wei River tributary, much of the remaining forest vanished, with disastrous consequences. Heavy summer rains washed cultivated hillsides into the river and left a scarred and eroded landscape behind them. Over the centuries, river-borne silt accumulated rapidly, thereby accentuating summer flooding on the plain. The river channel itself was never stationary, shifting suddenly and arbitrarily. Even when the rains were plentiful, this was a high-risk neighborhood for village farmers, despite small-scale irrigation canals and numerous wells built and maintained by villages and households. Crop yields were low, reflected in thousands of years of a political economy that was based on small-scale peasant farming by villagers living in compact settlements located on higher ground.

The loess highlands and delta of the Yellow River are unique, not for the fertility of their soils, but because of the frequency of disastrous
floods and especially droughts. Historical floods and droughts make the point, for conditions had changed little a thousand years later, in the late nineteenth and early twentieth centuries. In A.D. 595, the emperor Yang-Kien was forced to move his court from Xi'an to Henan, as there was not enough food for his court. Nineteenth-century droughts were of epochal proportions and accentuated by political unrest. In 1877-79, a third of the population of Shaanxi Province died of hunger and famine-related diseases.

The years 1897-1901 brought another savage drought. More than 2 million out of a total population of about 8.5 million died. An American journalist, Francis Nichols, traveled to Xi'an, the ancient capital of China, as a special “famine commissioner” for the Christian Herald of New York in 1901. A prolonged drought lasting three years, combined with Shaanxi's isolation from the coast and with the fact that the region is surrounded by mountains, made it virtually impossible to bring food from outside. The loess soils had turned to a “dry, white powder, in which crops parch and wither and die.” No rain fell from the summer of 1898 until May 1901. The farmers’ small food reserves were soon exhausted. Wells and rivers dried up. The country became a vast desert. The price of a bushel of wheat rose fifteenfold in a few weeks.

As their fields dried out, so thousands of farmers moved into Xi'an, 300,000 of them during 1900-01 alone. The governor forbade them to come within the city walls, so they camped in caves dug into riverbanks and in the fields. They ate coarse grass and weeds. Nichols visited “grim, blackened caves” around Xi'an, nearly all of them empty, their inhabitants long dead. Dysentery and cholera followed in the wake of famine. At the height of the disaster, the governor’s officials were burying more than six hundred corpses a day. Nichols reports that cannibalism became inevitable. “A horrible kind of meat ball, made from the bodies of human beings who had died of hunger, became a staple article of food, that was sold for the equivalent of about four American cents a pound.”

The authorities received funds from Beijing and set up soup kitchens, but the main problem was a lack of food locally with which to feed the starving. Entire families subsisted on cats and dogs, also horse meat, then slowly starved to death. Nichols traveled through the countryside. “Every quarter of a mile, a village rose out of the white, treeless desert, which stretched away to the north, east and west like a treeless ocean. The vast plain was silent... No farmers were in the fields... The plain was silent because its inhabitants were dead.”

Floods also took their toll. Heavy monsoon rains pummeled the Huang He basin in early summer 1898. The river flooded and overflowed its bank in Shouzhang, then farther downstream. Over two thousand villages and 2,972 square miles (7,700 square kilometers) of farmland vanished under water. Millions fled, many stranded on dikes, where they lived off willow leaves, wheat gleanings, and cotton seed. Tens of thousands perished. Another catastrophic inundation, in August 1931, killed an estimated 3.7 million people.

These droughts and floods occurred when the Huang He was still effectively a preindustrial farming area. Much of the destruction resulted from inept irrigation works, poor water management, and corruption, but the potential for disaster was always there. It is even greater today, for the Huang He is an extreme example of hydrological crisis. The river is almost at the point where it cannot support any more water exploitation. In the early 1900s the low-flow period in the river was about forty days. Today, the low-flow period lasts two hundred days, which places severe stress on the more than 100 million people living in the Huang He basin and on their ability to grow crops, quite apart from reducing freshwater species and habitats.

A.D. 850, at the Chinese court. The long line of northern tribesmen, headed by a brightly caparisoned Mongolian khan, rides along a beaten-earth road to the emperor’s palace. Solemn Chinese officials surround the visiting leader. They have met the envoys at the border and accompanied them to the capital. The heavily laden column dismounts. The goods are unloaded and stored, as court officials coach the visitors in the proper etiquette for their appearance. When the day of the audience
comes, the khan and his leading henchmen are escorted into the imperial presence. With detached care, they perform the expected rituals and kowtow before the emperor in a symbolic gesture of inferiority. The visitors are permitted a brief conversation with the emperor; hides and horses, some falcons are presented as gifts. In return they receive lavish gifts from their royal host. The audience soon ends. The closely supervised envoys are now permitted to trade with Chinese merchants for three to five days.13

The Chinese emperor, who had a Mandate of Heaven to rule his domains, set an example of orderly government and society that would encourage foreigners to be “transformed.” His virtuous actions were thought to offer an irresistible attraction to the “barbarians,” who dwelled outside the realm of Chinese civilization.

Such was the idealized Chinese vision of a self-sufficient empire indifferent to foreign lands. Reality was, of course, far more complex and rooted in centuries of complex and often violent interaction between the Chinese of the settled lands and the nomadic peoples of the northern grasslands.

When the irregular dry cycles recorded in lake and ice cores descended over East Asia during the ninth century, T’ang emperors held sway over China.14 This three-century dynasty (A.D. 618–907) was a high point in Chinese civilization. Early T’ang lords, based at Ch’ang-an (present-day Xi’an), acquired their empire by conquest and maintained trading contacts by land and sea with India and southwestern Asia. The Silk Road across Eurasia enjoyed great prosperity. Thousands of foreigners lived in Ch’ang-an, at the time one of the great cosmopolitan cities of the world. Kashmir and Nepal, Vietnam, Japan, and Korea paid tribute to the T’ang, while nomadic Eurasian tribes called the emperor Tian Kehan (“Celestial Kaghan”). The T’ang emperors were remarkable for their religious tolerance during three centuries when Buddhism became part of Chinese culture, printing was invented, and both literature and art enjoyed a golden age. T’ang rule thrived because of a system of government that relied on trained career officials who had no territorial base or local loyalties. Many of them were scholar-bureaucrats, who acted as intermediaries between government and commoners.

By the middle of the eighth century, T’ang power was eroding, following a defeat by the Abbasid caliphs at Talas somewhere in Kazakhstan. They were struggling for control of key trade routes in central Asia. The T’ang were eventually driven out of central Asia, and China did not regain power there until Mongolian times. During the late ninth century, a series of persistent rebellions by powerful provincial lords weakened the central authority of the government. The last emperor was deposed in A.D. 907.

But the most powerful enemy of the T’ang dynasty may have been cold, dry conditions and strong winter monsoons with less summer rainfall. If later history is any guide, crop failures and hunger fostered social disorder and rebellion. The T’ang may have been powerless to maintain central control in a situation of persistent and widespread drought in the loess lands around Ch’ang-an, just as Maya civilization on the other side of the world collapsed over a wide area in a time of volatile droughts. The task of supplying food to millions of people may simply have been beyond the capability of the government of the day. As Francis Nicholson saw, the same sort of crisis brought this part of China to its knees even at the turn of the twentieth century.

After 900, China fragmented into five northern dynasties and ten southern kingdoms. With dizzying rapidity, ambitious lords rose to power and were just as promptly dethroned. Given the political vacuum, the political situation would have been difficult at the best of times. But, if the climatological sequences are to be believed, northern China was also plagued by unusually dry conditions, and by prolonged, often serious droughts. The crop losses and resulting famines must have added complex variables to an already volatile frontier between lands inhabited by settled farmers and nomadic herders.

We tend to think of the northern frontiers of China as a rigid entity, defined by the Great Wall. Reality was very different. The T’ang never presided over a clearly demarcated northern frontier, merely a scattering
of fortresses and military colonies and some fortified border prefectures. (The current Great Wall was built during the Ming dynasty, after 1449.) They had believed in defense in depth, backed by powerful armies in the provinces far from the border. They also maintained a complex set of agreements with the tribes in the border districts, whereby the tribal leaders maintained their independence, but were given Chinese titles and ranks. Large numbers of prominent tribespeople attended the T’ang court, but the constant intercourse did not make Han Chinese out of them. Instead, they acquired a firsthand knowledge of the court and of Chinese institutions and administrative methods, which was to stand them in good stead in later times. For centuries, the border was partly an ecological boundary between the landscape of settled farmers and environments where only herders could flourish. But the frontier was also a multilayered region where Han Chinese and nomad lived amicably alongside one another, while cultural and ethnic identities remained distinct. When the T’ang dynasty faltered, the borderlands still remained a permeable frontier, but now became a region where military leaders held sway.

The droughts of the warmer centuries lasted for long periods of time in western North America and the Andes, and, if the Guliya and Huguangyan cores are any guide, so did those in East Asia. The droughts were not continuous, but cyclical, which would have had dangerous shock effects in the loess lands where the northern borderlands lay. When a sudden wet year followed a long drought cycle, floods would have inundated the arid fields and disused irrigation works in short order. The centuries of the Medieval Warm Period were climatically extremely volatile in this region of dramatic rainfall shifts, perhaps even more so than almost anywhere else on earth. The vagaries of drought and flood must have rippled through the realms of politics and war, for both farmer and nomad lived at the subsistence level and at the mercy of the climate, whatever the deeds of great lords and warring armies.

The extreme cycles of medieval climate also affected the complex relationships between the nomadic peoples of eastern Eurasia and those who dwelled on the settled lands. The most powerful of these tribal groups were the Khitan, herders and horse people whose origins went back deep into the past. Like those of other nomadic peoples, their lives were governed in part by rainfall on the steppe, by the gyrations of the desert pump. In periods of drought, they pressed southward into better-watered and more settled lands. After the 840s, and as the T’ang hold on power weakened during drier cycles, the Khitan defeated their tribal neighbors, then turned their attention to the powerful states to the south. At first the Khitan contented themselves with raids and temporary incursions into more settled lands, after which they withdrew northward again. To what extent these movements were the consequence of drought on the steppe, we do not know, but, judging from centuries of nomad history, many of the most serious incursions certainly occurred during dry years when grazing was in short supply.

The collapse of T’ang power and increasing rivalry between different warlords operating in the borderlands led the Khitan to unite. With the accession of A-pao-chi as Great Khan in A.D. 906–07, the Khitan embarked on ambitious campaigns of conquest. Within twenty years, they had become masters of the nomadic peoples of Mongolia and Manchuria. Theirs was a well-organized kingdom, with cities for Chinese from the border regions, a diversity of industries and areas of settled farming, and a dual form of organization that accommodated both the Chinese and nomadic ways of life. The pattern of nomadic life was changing, as farmer and herder became increasingly interdependent, a useful form of insurance in climatically volatile times.

A-pao-chi died in 926, to be followed by the Liao, Hsia, and Chin states during a period of constant warfare and seething rivalries. But behind all these political and military events and a pastiche of rulers lay the harsh economic realities of subsistence agriculture on the settled lands. We know from Chin records that the state produced about 90 million shih (a shih is about 125.5 pints [59.4 liters]) of millet and rice annually. A tenth of that went to the government as land tax. The average grain consumption of an individual was about 6 shih annually, so a year of good rainfall produced just enough grain to feed the population...
adequately. But an average year left no surplus to build up reserves for
distribution during droughts. The food supply was never secure in the
north, as it was in the southern Sung kingdom in the rich environment
of the Yangtze Valley, which produced as many as two rice harvests a
year.16

Chin rulers were well aware of the precarious food situation and at-
ttempted to increase the acreage of land under cultivation by fostering ir-
rigation works. They also attempted to increase crop yields by terracing
hillsides. But both these measures had unforeseen consequences, espe-
cially terracing, which led to inexorable deforestation and rapid soil ero-
sion. The latter had a particularly serious effect in the Huang He basin.

Agricultural production was precarious, even during good years,
so the drought cycles of the warm centuries must have had a serious
impact on political events in the north. Contemporary records do not
dwell on droughts and other natural disasters—hardly surprising, for
the peasantry were illiterate, anonymous, and almost a “background
noise” to the goals of warlords, emperors, and ambitious officials. But
the vagaries of the summer monsoon made it imperative that northern
states import rice from their southern neighbors, the Sung. The need
had been there for centuries. Overland transport was slow and unreli-
able, so the logical way to transport grain was by water. Coastal routes
were unreliable and dangerous because of pirates and storms; inland
waterways linking the Yangtze and Huang He basin were the best solu-
tion, although punishingly expensive.

Efforts to construct a waterway had begun as early as 486 B.C. The Sui
rulers of the late sixth and early seventh centuries A.D. linked earlier sec-
tions, joining the rich agricultural regions of the lower Yangtze with their
western capital at Luayang. A patchwork of lakes and canals became the
Grand Canal, Da Yun He, the longest artificial waterway in the world, far
longer than Suez or Panama. By the tenth century, the system boasted
locks, feeder lakes, and lateral canals. At its peak during the fifteenth and
sixteenth centuries, the canal system extended over 1,553 miles (2,500
kilometers), ran through 24 locks and under about 60 bridges, and carried
about 441,000 tons (400,000 tonnes) of grain annually.

For centuries, northern China and its loess lands were dependent on
critical food supplies from the south. Not even the most organized
preindustrial state and effective administration could overcome the pro-
longed droughts and sudden floods that regularly devastated food
supplies and those who produced them. The north was profoundly vul-
nerable a thousand years ago. The Huang He basin is even more vulner-
able to catastrophe today.