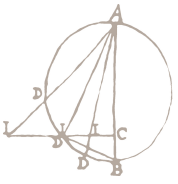

DA VINCI MEDAL ADDRESS

The Craft of Mud-making

Cropscapes, Time, and History

FRANCESCA BRAY

I am honored to receive this award, and most grateful to SHOT for this and the many other rewards and pleasures the society has given me, ever since the legendary Mel Kranzberg published my first-ever article, on Chinese plows, in Technology and Culture in 1978.[1] At that point I had been work-ing for five years on the history of agriculture in China, so I was already a historian of mud, and ever since I have remained fascinated by the mate-rial affordances and exigencies of mud-making, and by the place of this humble craft in history. This evening I would like to offer some reflections on mud as a useful medium for a historian of technology to think about the plural temporalities of the material practices we study, including how short-span technical processes and rhythms might be woven into the mesh of history.

I begin with some general remarks on materiality and temporality, and on mud-making as a practice of historical significance, in particular its role in shaping specific cropscapes (a term to which I return in a moment). I then offer a sequence of personal encounters with mud as a historical phe-nomenon that unfolded through my career as a historian of agriculture. I begin with the millet cropscapes that were the material foundation of the early Chinese state, and around which a sophisticated system of dry-farm-ing developed. Next I move to the rice cropscape of Kelantan, Malaysia, where I did a year's fieldwork just as the technological packages of the Green Revolution were being introduced in the mid-1970s; here I focus on timing to ask how the new cropping rhythms affected the transition. My third case is the rice cropscapes of southern China in the late imperial era, gendered landscapes in which women's rhythms of silk-making were given equal weight to the timing of rice-growing by men. In each case I outlin

Francesca Bray is professor emerita of social anthropology at the University of Edin-burgh.

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1. Francesca Bray, "Swords into Plowshares."

the multiple intermeshed temporalities that kept the cropscape working. I conclude my talk with a brief reflection on the longue durée of each of those cropscapes and on mud-making practices as an example of the evolv-ing materialities that attract so much attention from historians today.

1. Mud-making and Time

Charting temporalities and how they are interwoven, connecting micro- to macro-; short-term to long-term; lines, broken or unbroken, to cycles or loops, is obviously a central concern for historians. For historians of technology, interesting questions arise about how and whether longer-term trends or transitions connect to the shorter-span time-registers specific to particular technologies. Almost every technological change has a chronological impact: from time-saving machines to industrial plans or the logistics of just-in-time production; from the transformations of time-consciousness induced by the disciplines of factory time, railway time, or Taylorism, to the exhilaration of speed experienced in trains, cars, or ele-vators; or the sense of history shifting, the dread before-and-after of Hiroshima, or the half-forgotten pace of life before the internet.

One register of temporality that necessarily concerns historians of technology along with chemists, physicists, and biologists, farmers and cooks, artists and smiths, is the pace and rhythms of matter itself. How long does a particular ore take to melt, or a casting to cool? When should I start adding oil to the egg yolks, how fast, and at what point has the may-onnaise taken? Timing our interventions in such material processes is a basic skill prerequisite to all the transformations of our environment that nowadays we call technology.

As a historian of agriculture, one basic technique that has particularly captured my attention is mud-making. Mud-making, the controlled mar-rying of crumbs of soil with drops of water to achieve a desired consis-tency, is a technical process fundamental to building human worlds: farm-ing and pottery, building and painting, mayonnaise and calligraphy all involve mud-making. The importance of this transformative technique is honored in a profusion of creation myths in which a deity fashions the first humans from clay.[2]

Agriculture, along with ceramics, is the field of human activity that most obviously and literally depends on mud-making and mud-manage-ment. Farmers manipulate soil and water in a sequence of carefully timed procedures, adjusted to the contingencies of weather, pests, available labor

2. This origin myth is found across the Americas, Africa, and Eurasia; see David Adams Leeming, Creation Myths of the World, 312–13. In Chinese mythology, the mother goddess Nügua (or Nüwa) 女娲 is said to have molded the first humans out of clay or yellow earth that she kneaded with water; Charles Le Blanc, “L’invention du mythe de Fuxi et Nügua.”

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resources, and so on. From soil preparation through sowing, weeding, and harvest, their techniques, tools, field systems, and calendar will typically be organized around one principal crop-plant, its preferences and toler-ances—whether it is a staple like wheat or rice or a commodity like cotton, sugar, or soy. I refer to this articulated assemblage, organized around a spe-cific crop, in a specific place and time, as a cropscape.

Let me explain. One of SHOT's most exciting gifts to me has been the re-search project with which I am currently obsessed. For the last four years I have been engaged with three other SHOT historians of agriculture, Bar-bara Hahn, John Lourdusamy, and Tiago Saraiva, in a book project entitled Moving Crops and the Scales of History—most generously supported by Dag-mar Schäfer, director of Department III (Artifacts, Action, Knowledge) at the Max Planck Institute for the History of Science in Berlin, and enriched by much perceptive critical input from other colleagues, many of them SHOT-ers too, with whom we have built a network called Republic of Plants.[3]

Our goal in taking crop plants and their movements as our prism is to develop new and richer global histories. To challenge conventional peri-odizations and geographies, scales and values, we developed the concept of cropscape. The term cropscape denotes the ever-mutating assemblages of nonhumans and humans, material, social, and symbolic elements within which a particular crop in a particular place and time flourishes or fails. In-spired by the critical use of the landscape concept, as recently elaborated by archaeologists and geographers, for us the "scape" element in the term sig-nifies that any specific account of a cropscape is structured by the historian's choice of frame, scale, focus, and angle. An unconventional choice of scale or focus will likely challenge established understandings of that particular cropscape and suggest new ways to approach cropscapes in general.[4] Here, then, I propose mud-making as a focus that, I argue, can enrich our under-standing of the multiple, layered, and intermeshing temporalities that un-derpin the histories of agricultural and other socio-technical systems.

2. Millet Temporalities: The Dry-farming Cropscapes of Medieval Northern China

Contrary to popular belief, millet, not rice, was the staple grain upon which Chinese civilization was founded. According to Chinese legend it was Lord Millet (Hou Ji 后稷), a magical being conceived when his hith-erto barren mother stepped in a footprint left in the soil by the supreme deity, who taught the ancient Chinese how to grow grain. The grains in

3. Francesca Bray et al., Moving Crops. And see www.francescabray.co.uk/cropscapes and www.mpiwg-berlin.mpg.de/research/projects/moving-crops-and-scale-history.

4. For a more detailed outline of cropscape as concept and method, see Francesca Bray et al., "Cropscapes and History." Our book on cropscapes and global history, Mov-ing Crops, is forthcoming.

question were millets, spring-sown crops hardy enough to survive the semiarid climate of northern China.[5] From early Neolithic settlements dat-ing back to around 6,000 BCE, through the early empires and dynasties, and into the early modern period, millets were the dominant staple of most of northern China, shaping its cropscapes including its farming practices, cooking techniques and drinking habits, the tax system, and political ritu-als.[6] The millet belt remained China's political, cultural, and economic core, the site of its capital cities and its principal tax base, until 1127 CE when the Northern Song government was defeated by Jurchen armies and set up a new capital south of the Yangzi River—after which rice supplanted millet as China's iconic cereal and cropscape.[7]

This came as a surprise to me when in 1973, armed with no more than a newly minted BA in Chinese history, I was invited by Joseph Needham to start work on the agriculture volume for his monumental series Science and Civilisation in China.[8] I told Joseph that I knew nothing about agriculture, in China or anywhere else, but he said that didn't matter, I would soon learn. "Why don't you begin," he suggested, "by translating a wonderful old Chinese farming treatise called Qimin yaoshu." So I set to work. Dating from around 540 CE, Qimin yaoshu 齊民要術 (Essential techniques for the common people) was written by an official and estate-owner called Jia Sixie賈思勰.[9] After two years I had translated over half of this sixth-century masterpiece: the six volumes on tilling principles, millet and other cereals, oil and fiber crops, vegetables, fruit, and timber trees, including a delightful essay on the beauties of a good hedge and an essay on producing for the market as well as chapters on livestock from horses to fish. It was an en-thralling introduction to the sophistication of northern dry-land millet-based farming, at the core of which, as Jia Sixie insists, was timing.

If you follow heaven's seasons (shun tianshi 順天時) and accurately gauge the land's potential (liang dili 量地利), then you will reap large rewards for little labor, but if you are wilful and oppose heaven's way then however hard you work you will get no harvest. (If you dive into a spring for timber or climb into the mountains for fish you will al-ways return empty-handed. If you try to sprinkle water against the wind or to roll a ball uphill, then the circumstances are against you.)[10]

5. The Chinese domesticated both foxtail and broomcorn millet (Setaria italica and Panicum miliaceum).
6. See Francesca Bray, Technology, Gender and History, 59–65. On the domestica-tion and cultivation of millets in early northern China, see Francesca Bray, Agriculture, 434–52; and Chris J. Stevens et al., "Between China and South Asia," fig. 4, p. 1545. On their cultural significance and culinary uses, see Constance A. Cook, "Moonshine and Millet," and the other essays in Sterckx, Of Tripod and Palate.

7. Bray, "Instructive and Nourishing Landscapes," in Technology, Gender and History.
8. Bray, Agriculture.
9. Francesca Bray, "Qimin yaoshu"; Jia Sixie, Qimin yaoshu jiaoshi.
10. Jia, Qimin yaoshu, 43. All the translations, unless otherwise noted, are my own.

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Jia Sixie clearly laid out for his readers the multiple interwoven tempo-ralities that millet-scape farmers had to consider as they struggled to rec-oncile conflicting or competing rhythms and contingencies: the passing of the seasons, the vagaries of weather, the life cycles of different crops or crop varieties, competing labor demands, seasonal fluctuations in food supplies for humans and livestock, or changes in market prices. I was en-thralled above all by the niceness of timing that went into the craft and sci-ence of mud-making: the principles and practice of marrying soil and water to just the right degree so that the precious seed would germinate, the promising seedlings thrive, the grain swell to fill the ear. Jia's instruc-tions for mud-making bring together practical specifics and explanations of the natural principles or processes that they embody:

Spring sowing [of Setaria millet, gu 穀] should always be deep, so draw a bush harrow (ta 撻) over the seed.[11] Summer sowing should be shallow, so just sow the seed directly and leave it to sprout on its own. (In spring the soil is cold and germination slow. If you do not use the harrow the roots will spread into empty cracks [in the soil] and even though the plant germinates it will soon die. In summer the air is hot and germination rapid. If you use the harrow and then it rains the soil will become compacted.)[12]

At the heart of Jia's agronomy was the craft of keeping the soil "ripe" (shu 熟), at just the right tilth and degree of moisture and fertility for the demands of the moment.[13] As the staple food, Setaria millet was the crop that came first in Jia's treatise, and that clearly had priority when it came to labor, fertilizer, and planning of land use. Land was plowed and har-rowed, seed was sown in furrows with a drill, carefully spaced to reduce competition between plants for water and nourishment, and to facilitate weeding. Hoeing was repeated again and again, to get rid of weeds but above all to keep the surface soil in light crumbs, a mulch to protect the roots and conserve moisture. Animal manure and green manures were hoed in to improve soil structure and moisture retention in addition to providing nourishment to the plants. Repeated hoeing substituted for the gentle showers of rain that were so sadly lacking in the northern China growing season.

You should not mind how many times you hoe [millet]; once you have been right round the field start again, and do not stop even for

Text in parentheses or round brackets is the author's own commentary; texts in square brackets are my editorial clarifications.

11. For an explanation and illustration of the ta, see Bray, Agriculture, 272–73.

12. Jia, Qimin yaoshu, 43.

13. Shu denotes a processed state, something that from its original raw or natural (sheng 生) state has been worked on by time (ripened grain) or by human, technical in-tervention (tilled soil, smelted metal, cooked food).

a short time simply because there are no weeds. (Hoeing doesn't just get rid of weeds, it keeps the soil ripe and will give full ears, with thin husks, that do not shatter. If you hoe your field ten times you will get "eight-tenths grain" [the weight of the milled grain will be eight-tenths that of the grain in the ear].)[14]

Timing was crucial for every operation, but especially for sowing:

As a general principle sowing should be early, for early-sown crops yield much better than late. (Early crops are clean and easy to tend, but late crops are weedy and difficult to look after.) . . . The final choice, however, must always be dictated by the weather: grain is always best sown just after rain. If the rainfall is slight you should sow immediately while the soil is still damp; if it is heavy wait for the weeds to sprout first. (. . . If the rainfall is slight and you do not sow immediately there will be no moisture to make the seed sprout, but if you do not wait for the soil to turn pale after heavy rain then the dampness will be trapped in the soil and will make the roots sickly.)[15]

Here we see Jia balancing season with weather in tempering soil moisture to seed. The timing of seasons varied by region, so rather than specific dates, most agricultural texts indicated well-known natural signals for farming operations: the blooming of apricots, for example. Auspicious and inauspicious days also had to be taken into account, and Jia reflected a widespread belief in advocating that most crops were best sown as the moon was waxing. Such signals and calculations factored into the life cycle of any crop and as such were woven into the linear, step-by-step instruc-tions provided in each of Jia's chapters on field and garden crops. One tem-poral scale higher was the cyclical rhythm of crop rotations. Jia lays out a system of rotations to supply the estate with oils, fibers, pulses, and vege-tables as well as grain, while alternating between greedy and modest crops to keep the land in good heart long-term.

This was a dense, productive farming system whose successful execu-tion depended on scale. Only a large estate had sufficient land to practice rotations, enough workers to hoe the millet fields ten times in a season, enough draft animals and equipment to plow and harrow as needed. Peas-ant farmers had little land to spare from the millet needed for subsistence and tax payments, and often had to share animals and equipment. The meshed principles of timing I have just described, along with the ideals of mud-making for all seasons, were more easily accessible to the privileged than to the poor.[16]

14. Jia, Qimin yaoshu, 44.
15. Ibid.
16. Francesca Bray, "Agriculture," 368–70.

3. Green Revolution in Kelantan, Malaysia

In 1976 I set out to spend a year in Kelantan, a state on the east coast of Peninsular Malaysia, where—the latest literature assured me—wet rice was still grown without the use of modern machinery. In fact, the Green Revolution had just begun there.[17] Local farmers were struggling to come to terms with the famous GR package: high-yielding, quick-ripening rice varieties (HYV's) + irrigation + chemical fertilizers = double-cropping. They benefited from assiduous support from the agronomists at the local Kemubu Agricultural Development Authority (KADA), who worked in close consultation with farmers' associations both in developing infra-structure and in providing extension and support. The Malaysian govern-ment was determined that the new technology should be made accessible to smallholder peasant farmers, so the financial costs of adoption were very low, though not negligible. It was timing, however, that proved the main stumbling block.

Kelantan was a traditional rice-scape, in that rice was the staple food and the crop around which most farmers had organized their lives since precolonial times. However, rice was a monsoon-dependent crop, grown once a year in rain-fed fields. Before the Green Revolution, rice was just one of many sources of peasant smallholder livelihood. On land too high for water to accumulate, farmers grew rubber, fruits, and vegetables for market. Many worked in the off season as laborers, going to towns like Singapore for construction jobs or visiting west coast states like Kedah and Perak, rice-basket regions with a different monsoon season from the east coast, to work as paid laborers during harvest or transplanting.[18]

Back in Kelantan, as soon as the monsoon rains began, small nursery beds were tilled and seeded with rice, which grew for about six weeks be-fore transplanting. The main fields were meanwhile repeatedly plowed and harrowed, using water-buffalo, into smooth silky mud.[19] When the water had risen to about a foot deep in the fields, the rice seedlings were pulled up, sorted, trimmed and transplanted, then left to grow in the standing water, whose level steadily dropped once the rains ended, drying out com-pletely at the final stage of ripening, which is what the traditional rice vari-eties preferred. Once the harvest was in, the season for weddings and cir-

17. This section is based on Francesca Bray and A. F. Robertson, "Sharecropping in Kelantan, Malaysia"; Francesca Bray, The Rice Economies; and Francesca Bray, "Feeding the Farmers."

18. For the impact of the Green Revolution on the technologically more developed west coast rice-basket regions, see James C. Scott, Weapons of the Weak.

19. During my fieldwork I pestered farmers to teach me the basics of all their main tasks, including plowing and harrowing the rice paddies. I found that, notwithstanding my apprehension of hidden thorns and horror of leeches, the sensation of the silky mud oozing between my toes as I moved through a flooded paddy was a pleasure as sensuous as biting into a perfectly ripe rambutan.

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cumcisions, kite-flying and shadow theater began.[20] And after a month in celebratory mode, the farmers turned to their other jobs to earn cash.

Transplanting and harvesting were periods of intense labor demand, when everyone was out in the fields working from dawn to dusk.[21] In a re-gion consisting entirely of small peasant farms, there were various strate-gies to make this manageable. Individual farmers would grow several dif-ferent varieties of rice, with longer and shorter growth periods. But most important were the labor-sharing arrangements between relatives and neighbors. In berderau, a group shared the work on a rotational basis, moving from one field to another until all the work was done. In pinjaman, a farmer would provide a good meal to anybody for a day's work, and one bundle of cut rice out of twenty at harvesting time—this gave people with too little land for their own needs, or too old to farm, an opportunity to ac-quire extra rice.

Many Kelantan farmers found themselves unable to maintain the strict new forms of time discipline demanded by the Green Revolution regime. The Green Revolution's miracle rices, double-cropped and dependent on water supply from an irrigation scheme whose large scale offered little local flexibility, imposed rigorous time constraints that were often hard to meet and had significant knock-on effects. In order to keep up with schedules that typically required plowing for the new crop to begin just a few days after harvesting ended, farmers had to abandon buffalo-plows, sickles, and traditional labor-exchange in favor of hired tractors and reaping machines, which damaged the delicate soils of the rice paddies. Under the new time regime of double-cropping, it became impossible for most farmers to con-tinue combining rice production with alternative and often more prof-itable sources of income like market-gardening or construction work, which could have helped pay for inputs like the machine rentals needed to grow the miracle rices.

Irrigation had been expected to double the area under rice annually, by creating the equivalent of the monsoon in the off-season. But paradoxi-cally, by raising the water table, irrigation waterlogged the land that had previously been the best for rice, while transforming what had once been good dry land used for gardens or rubber groves into marginal rice land. The off-season was now better for growing rice than the main season, with more rice land left unfarmed during the monsoon. Yet although irrigation failed to produce a uniform or optimal terrain for rice farming, in response to the loss of much good dry land, the time constraints of the double-crop-ping calendar, and generous government incentives (motivated by the quest for national food security) to plant as much rice as possible, the

20. West Coast Malaysians regarded the Kelantanese as economically and socially backward, even primitive, yet cherished them as the custodians of authentic Malay cus-toms and cultural practices that had been displaced by development elsewhere.

21. Bray, The Rice Economies, fig. 4.2, p. 126.

Kelantan cropscape morphed steadily from mixed farming to rice mono-culture.
A number of farmers I interviewed in 1976–77 and on later visits said they were giving up rice-growing because the time constraints made their lives unmanageable. The Green Revolution package in Kelantan was care-fully designed to serve the interests of small farmers. Yet its time disci-plines, their negative impact on alternative earnings, and the transforma-tions the new technology imposed on mud-making and its costs triggered economic differentiation and a gradual exodus of poorer farmers to towns or development schemes. However, a long-standing legal prohibition on turning rice land to alternative use, coupled with continual and intensive state investment in schemes to improve rice-farmer productivity and liveli-hoods, has kept Kelantan rice farming alive today, albeit ailing.[22]

4. Rice and Silk, Male and Female Work in Southern China

As I mentioned earlier, when the Song government was driven south in 1127, losing control of the hitherto dominant millet lands of the North, the rice-scapes of southern China became the state's source of material sup-port. This was immediately reflected in a shift in agronomic attention: treatises now documented rice, not millet, cultivation, and a new iconog-raphy of southern rice-scapes was developed and disseminated.[23]
I had gone to Kelantan primarily because I wanted to understand the essential material aspects of rice farming in order to decipher the late im-perial treatises that were at the core of my Needham project. A year of ap-prenticeship in practical mud-making in Kelantan helped me understand the most obvious dimension of the late imperial rice-scapes as portrayed in Chinese sources: they were organized around the needs of rice, at the core of which was the control of water (mud!), and rice served as an anchor for many other activities. The productivity of rice-scapes was increased by multiple-cropping of paddy-fields; the use of dry land or hills to grow cot-ton, fruit, or tea; and household industries—all with labor demands fitted around the rhythms of rice. With intensive, interlocking labor demands, time-saving technologies like the chain-pump for irrigation, or water mills for processing grains and other materials, were highly valued.[24]

My move to UCLA in 1987, where women's studies and feminist history

22. Bray, "Feeding the Farmers."
23. Bray, Technology, Gender and History, 1–3, 219–52.
24. Bray, Agriculture, 597–616. The logic of time-saving inscribed in a system of mixed commodity production anchored in smallholder rice farming was, however, quite different from the time-saving logic of industrialization. The nature of this differ-ence, and how it played out over long-term historical change, has generated bitter argu-ments between historians arguing for or against Western exceptionalism; see Bray, Technology, Gender and History, 23–28.

were gathering strength, provided a new, vital optic: these rice-scapes were gendered. They were conceived as a landscape of mud for rice and mulber-ries for silk, embodying a neo-Confucian world order founded on the mate-rial, moral, and cosmic complementarity of men's and women's work.[25] "Men till, women weave" (nan geng nū zhi 男耕女織) , the Chinese saying goes—or in my terms here: "mud for men, worms for women." I now began to appreciate that, in late imperial terms, textile production too fell under the category of nong 農, agriculture, a reality that had largely eluded me in the context of the Science and Civilisation in China project, in which Need-ham had classified textiles in volume 5 under chemical technologies, for some obscure reason, and farming in volume 6 under biology.[26] Unlike the Qimin yaoshu, which had no special sections on textiles, most farming trea-tises written after 1000 CE contained ample sections devoted to silk and cot-ton and the equipment needed to process them. I now began to perceive just how tightly female and male work were intermeshed in the cropscape, even if women by definition worked inside, and men outside.

Mulberry trees were one bridge between the spheres of work. Silk-worms were fed on mulberry leaves; men tended the trees and harvested the leaves, which women fed to the worms at a rhythm determined by the worms' development. After hatching, silkworms eat voraciously, grow rap-idly, then sleep and moult; the process resumes two or three times depend-ing on the breed of silkworm. Finally, the worm begins spinning. Once it has spun its cocoon and pupated, the moth must be killed before it gnaws its way out. Then the silk is reeled as rapidly as possible (here too, time-sav-ing devices were enthusiastically welcomed).[27] The schedules of women's work were organized around the lives and needs of the worms as well as the lives and needs of their family—the images of sericulture almost always show women working with their infants in their arms or old folk minding their boisterous toddlers.[28] Meanwhile, the rhythms of the worms' hunger also shaped men's work schedules, while the mulberry trees themselves helped stabilize the mud system of the rice-scape, as we see in this advice given in a farm handbook written in 1149:

On high land identify the places where water accumulates and dig out tanks for water storage. . . . At the end of the spring when the rainy season begins, heighten the banks and deepen and widen the interior [of the tank] to give it the best capacity. Strengthen the banks with mulberries or silkworm-oaks to which water-buffalo

25. Francesca Bray, Technology and Gender.
26. Dieter Kuhn, Textile Technology.
27. Ibid., 289–434.
28. On how the "womanly work" (nügong 女功) of textile production was construed, represented, and experienced, see Bray, Technology and Gender, 183–205; and Roslyn L. Hammers, Pictures of Tilling and Weaving.

may be tethered in the shade, as their nature requires.[29] The buf-falo's trampling will strengthen the banks, the mulberries, being well-watered, will grow into fine trees. Even in the dry season there will be sufficient water for irrigation, yet in heavy rains the tank will not overflow and harm the crops.[30]

The tank waters the rice fields and sustains the mulberry trees, whose canopy of leaves not only feeds silkworms but also protects the precious water from evaporation and the buffalo (a surprisingly delicate animal) from heatstroke.[31]

5. The Longue Durée

I conclude with some brief reflections on how the local systems of mud-making I have just presented fit into longer historical trends. I'll be-gin with southern China and work my way back.

The late-imperial rice-scapes supported a regime of commercial crop-ping and small-scale manufacturing that famously made early modern China the world's biggest exporter of manufactured goods and importer of silver.[32] Between 1000 and 1900 these intensive rice-scapes steadily expand-ed from a small core in the Yangzi Delta to cover most of the South, thanks to a panoply of water-control devices (including tanks, canals, flumes, and pumps) and land-reclamation techniques (polders, terracing, etc.) that per-mitted all kinds of land to be converted into muddy rice-paddies.[33] Migrants helped carry the frontier forward. State officials also played a central role in promoting local projects to develop rice farming.[34] But it was not just rice cultivation; rather, it was the complete gendered cropscape that officials sought to reproduce, with projects to teach local women sericulture folded into their plans. While sericultural projects often failed, incorporation of the locality into rice-based networks of commerce usually ensured that women too could contribute to household earnings—and to tax payments.[35]

29. Cudrania tricuspidata belongs to the same family as the mulberry, and its leaves are also used to feed silkworms.

30. Chen Fu 陳旉, Nongshu, 2.

31. Water buffalo are extremely strong but tire easily and need frequent baths in mud wallows to rest and cool down. A buffalo or two, often mother and calf, snuggling into a murky wallow at the edge of a field was one delightful feature of the Kelantan rice-scape before tractors took over. Chen Fu devoted a whole section of his short treatise to praise of and proper care for the water buffalo, an indispensable partner in the mud-making for food production upon whom Chinese farming families and—by extension—the Chinese state depended for survival; Francesca Bray, "Where Did the Animals Go?" 131–35.

32. André Gunder Frank, ReOrient; Kenneth Pomeranz, The Great Divergence.

33. Bray, The Rice Economies, 28–42, 69–100.

34. Francesca Bray, "Science, Technique, Technology."

35. Bray, Technology and Gender, 226–36.

The dissemination of the rice-scape was conceived by government as a civilizing project: teaching local men and women to plow and weave the Chinese way would not only ensure that they could pay their taxes, it would also impart the material skills and moral mindset of proper Chi-nese subjects. The Green Revolution too was a civilizing project, intended to convert backward, inefficient peasants, vulnerable to Communist sub-version, into modern, entrepreneurial farmers.[36] This grand plan encoun-tered various challenges in different contexts. In Malaysia, one significant factor was the government's ethnic policies. In the simmering post-inde-pendence tensions between Malays and Chinese, the Malaysian govern-ment designated Malay farmers *bumiputra*, "sons of the soil," the truly au-thentic Malays who provided the nation with its staple food, rice, and therefore deserved all the support the nation could muster.[37]

Malay farmers originally had very diverse sources of livelihood, in which rice often played a minor role, but increasingly they were pressured into specializing in rice. National surveys classified them as rice-farmers, eligible for certain types of aid. Increasing levels of rice self-sufficiency be-came the national goal.

Meanwhile, Green Revolution technologies with their inflexible mud-making temporalities and topographies turned mixed farmlands into unbroken stretches of paddy-field. Since the 1960s, the Malaysian govern-ment has poured money into a series of policies for supporting rice pro-duction, yet it has never succeeded in dragging the majority of Malay rice farmers out of poverty.[38] Their absolute living standards have risen slowly but have never matched those of other occupations. Peasant rice farming simply doesn't pay, but as a national symbol, peasant rice farmers and their green, monocultural, and now supposedly "authentic" rice-scapes are still considered politically vital. Agronomists and economists desperately seek improved technical packages to modernize what they see as a stubbornly archaic sector.[39] One solution currently proposed is that rice farmers should pool their land and labor on "mini-estates" or "independence es-tates" (*ladang merdeka*) and simply be paid salaries for their work.[40]

Meanwhile, the ostensibly archaic and marginalized millet-scapes of northern China are experiencing an astonishing economic revival. As ex-plained earlier, the millet system was most productive when practiced at scale, on large and well-equipped estates. But imperial Chinese state policy always favored smallholder farming and a direct relation between peasant

36. Raj Patel, "The Long Green Revolution"; Madhumita Saha and Sigrid Schmal-zer, "Green-Revolution Epistemologies."
37. Bray, "Feeding the Farmers."
38. M. R. Rabu and M. D. Mohd Shah, "Food and Livelihood Security."
39. A classic example of the development of underdevelopment; André Gunder Frank, "The Development of Underdevelopment."
40. Ninth Malaysia Plan, 3.72; KADA, "Ladang Merdeka."

and state. This made it easier to levy taxes and exercise control, and re-duced the risk of power bids from feudal rivals. Between 100 BCE and 1000 CE there was continual tension: sometimes peasant farming predomi-nated, sometimes large estates took over.[41] But once the rice-scapes of the South were recognized as a more profitable investment, northern estates dwindled away and the region became one of predominantly peasant farms, poor by contrast to the South. Statesmen were wont to refer to the northern region as a feckless younger brother, dependent for sustenance on the bounty of the southern rice-scapes. Through the violent upheavals and titanic socialist development proj-ects of the twentieth century, many remote rural regions of China remain-ed desperately poor. One such was Wangjinzhuang 王金庄 in Hebei Prov-ince.[42] During the Maoist era, as in many other poor and environmentally fragile regions, the inhabitants mobilized the only resources they had—their own labor, soil, and stone—to extend existing terraces into a spectac-ular landscape of masonry-buttressed strip-fields covering the steep mountainsides from foot to peak. In the 1970s the village was honored as a model of socialist ingenuity and labor—but it remained economically isolated and poor, dependent on its harvests of millet and maize grown on the terraces using donkey-plows or mechanized hand-tillers.

Today China is a prosperous, technologically advanced nation with a highly developed internal tourist industry and an intensifying nostalgia for tradition. There are growing worries about threats to the environment and food safety, feeding into well-funded research on alternatives to produc-tivist agriculture. Wangjinzhuang has been designated a "Nationally Im-portant Agricultural Heritage System." Visitors flood in, clamoring to have their photos taken with the village's now-famous donkeys. They devour bowls of millet porridge, now regarded not as the coarse staple of the poor but as a super-healthy food with a millennial tradition. Wangjinzhuang farmers market their millet, maize, Sichuan pepper, and nuts across the country, through the internet. The labels declare that these foods are eco-crops, "peasant-grown and donkey-manured."[43]

In this era of Anthropocene fears for the environment, as zero-tillage farming methods challenge the orthodoxy of deep plowing and as a prolif-erating network of UN Food and Agriculture Organization "Globally Im-portant Agricultural Heritage Systems" serves to inspire new agronomic research agendas, past and future rationalities and assemblages of mud-making become intricately entwined.[44] I found it delightful that the donkey-

41. Bray, *Agriculture*, 587–97.

42. Sigrid Schmalzer, "Layer upon Layer."

43. See, for instance, China's largest web-sales site, Taobao: https://pikbest.com/e-commerce/foods-briefing-details-foods-millet-foods-details-taobao-details-simplicity-details-taobao-foods-sha_525166.html (accessed 22 November 2019).

44. The terraces of Shexian County, which include those of Wangjinzhuang, are

drawn harrow in one of the publicity photos for Wangjinzhuang's heritage terraces was exactly the same as those illustrated in centuries-old Chinese murals and farming treatises.[45] (I can't help wondering if perhaps it is copied from a famous illustrated treatise of 1313!)[46] Wangjinzhuang millet, a marginalized ancient staple rebranded as an ingredient of the middle-class Chinese diet of the future, has value added by being grown in mud made the ancient way, in a village coincidentally located in the very hills, locals claim, where the goddess Nügua created human beings from yellow earth at the beginning of time.[47] But the mud of today's Chinese millet-scape is fertilized not just by donkey droppings—but also by the internet.

I hope my presentation has convinced you that mud merits historical attention. My sincere thanks to SHOT for giving me the opportunity to make the argument here in Milan, in the shadow of the great Leonardo, just a stone's throw from Leonardo's own favorite mud-making project, his vineyard.[48]

currently a proposed FAO Globally Important Heritage Site: www.fao.org/giahs/giah-saroundtheworld/proposed-sites/asia-and-the-pacific/shexian-dryland-terraces/en (accessed 22 November 2019).45. www.takungpao.com/lens/235123/2019/0514/2754.html, photo 2 (accessed 7 September 2019)

46. The woodblock illustration of the harrow is reproduced in Bray, Agriculture, 232.

47. Phoenix Mountain, where Nügua is said to have been born, is also located in

Shexian County. Today the ancient temple in Nügua's honor attracts large numbers of tourists.

48. "Museo Vigna di Leonardo." The resurrection of the Vigna di Leonardo, like the reinvention of the millet fields of Wangjinzhuang, depended upon tourism and con-sumer sensibilities shaped by ecological concerns and the global heritage industry. The original plot of sixteen rows of vines was given to Leonardo by Ludovico Sforza, the duke of Milan, in 1498. The gift of this land, part of a much larger vineyard that Ludo-vico intended to develop into a residential neighborhood for loyal families, was allegedly a reward for painting the Last Supper in the nearby church of Santa Maria delle Grazie, which Ludovico was remodeling as the Sforza family mausoleum. When the French cap-tured Milan in 1499, the Sforzas and their supporters were driven out. But a few years later Leonardo successfully petitioned to buy back his vineyard, which his heirs kept up until 1943, when it was destroyed by Allied bombing. To mark the 2015 Milan Expo, in 2008 archaeologists began excavating the plot. From the buried rootstock, oenologists and geneticists were able to identify the original grape variety, a Malvasia di Candia Aro-matica typical of Piacenza, a hundred kilometers from Milan. Leonardo's vineyard is now replanted with the Malvasia grape; it was opened in 2015 for the Expo and pro-duced its first harvest in 2018. Just in time for the 500-year anniversary of Leonardo's death, and no doubt at commensurate prices, the 330 bottles of the first vintage of vino di Leonardo were auctioned in winter 2019 ("Leonardo da Vinci's Personal Vineyard")

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