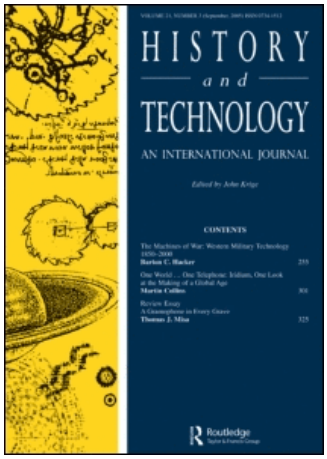

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Europe, Technology, and Colonialism in the 20th Century

David Arnold

The purpose of this paper is twofold. It aims first to provide a critical overview of the literature on the history of technology as it relates to colonialism, decolonization and development in the extra-European world during the 20th century. Second, it seeks to identify changing perspectives and emerging research issues in the history of technology in the European colonies and ex-colonies of Asia and Africa, and thus to trace a move away from earlier 'diffusionist' arguments and discussion of polarization and conflict between 'Western' and 'indigenous' technologies, toward a more interactive, culturally-nuanced, multi-sited debate about how technology functions within specific parameters of time, place and culture. Body, land and state are identified as major 'triangulation' points for the critical investigation and contextualization of these issues.

Keywords: Technology; Colonialism; Decolonization; Development; Diffusionism; Body; Land; State

Decentering the History of Technology

The literature on the history of technology in the colonial and ex-colonial world of the 20th century, already vast, has lately grown in both volume and complexity. This essay does not aspire to cover the entire colonial and ex-colonial world. Instead, following the lead of the collaborative project on the 'Tensions of Europe' from which it derives,[1] it concentrates on the colonies and ex-colonies of Europe. It focuses on territories in Africa, Asia and, to a lesser extent, the Caribbean, thus excluding those American colonies that attained independence in the 18th and early 19th centuries and 'white settler' colonies, like Australia and New Zealand, which had a substantially different technological (as well as social and political) history: South Africa, though, which to some extent straddles those two categories, is included in the discussion. This selectivity, regrettable in some ways, allows the paper to concentrate thematically on a particular

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trajectory in the historiography of colonial and postcolonial technology and its critical relationship with issues of 'diffusion' and 'development.'

Although this paper refers to the history of technology, much of the scholarship discussed here is not, in fact, located in work specifically addressed to the history of technology. As far as the colonial/postcolonial world is concerned, histories of technology have until recently been few in number and often analytically weak. Though we may balk at the trumphalist values and teleological assumptions such works espouse, some of the most empirically useful and technically informed studies remain those of the colonial era itself.[2] In terms of recent scholarship, much relevant subject matter and interpretive analysis is to be found in work emanating from other historical sub-disciplines—economic history, agrarian history, environmental history and the history of medicine—which have brought their own methodologies and agenda to the discussion of technology. In part this is because fields like medical and environmental history have been better funded than the history of technology, have attracted greater academic and public interest, and have accordingly made the intellectual running. Medical and environmental history have had a particularly seminal role in identifying and investigating technology-related issues, and their importance is registered in this paper through an emphasis upon body and land as exemplary sites for the understanding of colonial and postcolonial technologies.[3] Engagement with the history of technology has also been an offshoot of ongoing investigation into imperial policies and colonial practices, and the role of the colonial and postcolonial state thus forms a third main element in this discussion.

Furthermore, to an extent surely unmatched in Europe, much insightful work on technology in Africa and Asia has been done not by historians but by anthropologists,[4] or by historians who recognize the importance of situating technology within parameters of culture and place as well as time.[5] This has often meant moving technology away from laboratories, foundries and factories and into villages, towns and everyday lives. The significance of this anthropological infusion has been diverse, but includes a less teleological and judgmental approach to technologies that lie outside the norms of Western modernity, a greater concern with technology's local context and signification, and an analytical interest in the interactive (not merely causal) relationship between innovation and practice. At times appreciation of this anthropologically-minded approach has given rise to the perhaps over-zealous complaint that, by comparison with Asia and Africa, the history of technology in its Euro-American heartlands has failed to engage with questions of culture and even to regard technology as somehow above culture.[6]

In order to make the broad parameters of this discussion clear it is necessary at the outset to identify, however schematically, how the history of technology as it relates to Africa and Asia has developed over the past half-century. Since the mid-1960s there have, broadly speaking, been three main approaches: these can be presented as a series of historiographical stages though they might better be understood as cumulative rather than merely sequential, each adding additional layers to existing interpretative schema rather than erasing all that went before. The first of these, equating technology with industrial technology as evolved in Europe and North America, saw the establishment of modern technology in Africa and Asia as primarily a legacy of colonial intervention,

a boon bestowed by technologically advanced civilizations on societies considered 'backward,' even 'primitive.' Conceived and created in Europe, such technologies were diffused to the rest of the world almost entirely through European agency and without significant local input. These technologies were seen to modern, progressive and largely benevolent: they constituted a supposedly objective rationale, if not for a dying colonialism, then for the intervention of a superior civilization. If such technologies failed, it was because local populations, stubborn or misguided, were unable to appreciate their benefits or local physical conditions militated against their effective use.

In an age of assertive Third World nationalism and of growing technological skepticism within the West itself, this diffusionist understanding of technology was soon eclipsed, its very presumptiveness helping to provoke an alternative, adversarial understanding of Western technology's historical role. It was pointed out that many extra-European societies had long and noteworthy histories of technology of their own, some of which predated (even contributed to) those acclaimed for Europe, but which had been forcibly superseded by colonialism and international capitalism.[7] In this 'indigenist' understanding,[8] European (and, as the last century unfolded, American) technological intervention was characterized by violence—a physical and epistemological violence directed against past practices and outmoded technics; but also a current violence expressed through technologies of warfare and policing, of rapacious land appropriation and mineral extraction, of intrusive medicine and coercive public health.[9] In place of progress and benevolence, aggression, arrogance and greed were seen in this critical riposte as the hallmarks of Western technological ascendancy. A further aspect of this interpretation was the uncovering of ways in which indigenous technologies and accompanying beliefs had provided a site for resistance to colonizing technologies and to wider systems of colonial and postcolonial hegemony.[10]

If it is possible to characterize a still incipient third approach it might be described as 'postcolonial'—in looking temporally beyond the colonial moment to its aftermath and enduring effects and in drawing interpretive inspiration from the contemporary movement of postcolonial criticism.[11] In this emerging discourse metaphors of space and travel appear more apposite than parables of dissemination; fluidity, plurality and circularity sideline old rigidities and stark dichotomies. There has been a growing distrust of sweeping generalities across time and place, of earlier, seemingly simplistic, typologies, with their unsubtle (or worse, unfounded) distinctions between 'colonial' and 'indigenous,' their tendency to treat colonialism as an undifferentiated whole, and their disposition to see technology as an instrument of power relations rather than as a cultural space in which various forms of interaction and exchange, of mimesis and reversal, became historically possible. The history of technology thus becomes less an investigation of origins and inventions (a history that has long privileged Europe) than an enquiry into uses, meanings, effects.

The Insufficiency of Europe

One of the fundamental issues to emerge still unresolved from these diverse approaches is how we situate the history of technology relative to both the history of Europe and

the inner histories of colonial and postcolonial societies. Despite the substantial shift of emphasis and understanding that has occurred in the regionally grounded scholarship of Africa and Asia in recent times, many historians in Europe continue to regard the history of the extra-European regions, *especially* with respect to technology, as essentially a projection of European history. They seem to see it still as the dissemination of those technological achievements (and the intellectual currents and human agencies identified with them) that characterized that continent's technological advance. It cannot be denied that there were some respects in which this was the case, but it need not be the sole or necessary concern.

One way of responding to the Euro-centric assumption is to reverse the paradigm and to argue, *au contraire*, that the history of Europe and of its technology cannot adequately be understood except by reference to the world outside Europe. The case for contextualizing—even 'provincializing'[12]—Europe rests on several interlocking arguments, each of which might call for further investigation by both European and extra-European specialists. First, let us look at the idea of 'Europe' itself. There is a growing body of literature stressing the ways in which the concept of Europe and of Europeans was shaped in relation to the extra-European world. As Catherine Hall has observed in the British context, 'the colonies provided the many benchmarks which allowed the English to determine what they did not want to be and who they were.'[13] Questions of culture and identity appear equally central to the discussion of what 'technology' and 'Europe' meant. To take one simple illustration, the term 'European' was widely employed outside that continent to describe people who were seen to share a common origin and identity, regardless of their national affiliations, and in contradistinction to other races and cultures. In India as early as the 18th century it was customary for the British to speak of themselves as 'Europeans' (at a time when they would seldom have so designated themselves at home): this usage, common to other parts of Asia and Africa, persisted into the era of mid-20th-century decolonization. Seen from this external perspective, Europeans possessed a basic commonality of ethnicity and culture. The term 'European' was similarly applied to technology, science and medicine as well and bore similar connotations of origin, form and intent. It is perhaps easier for many of us who work on Africa and Asia to think of pairing such generalities as 'Europe' and 'technology' than for many of those historians whose purview is restricted to a single nation or a single branch of technology.

Second, much of what is still thought of as innately 'European' was to varying degrees made in, or influenced by, the world beyond Europe. The extent to which developments like Britain's industrial revolution were fuelled by the profits and technological incentives of the Atlantic slave trade, overseas plantation economies, and the plundering of India might remain contested ground, but it would be reckless to deny that external factors had some influence. The port cities (from Liverpool to Amsterdam, Hamburg to Marseilles) that loomed so prominently in Europe's economy and urban geography in 1900 owed much to the legacies of overseas trade and finance. The story of European emigration in the 19th and 20th centuries is familiar enough, but historically Europe has repeatedly drawn upon the labor power of extra-European slaves, migrant workers and recruits to maintain its agrarian economy, run its cities,

service its industries, and supplement its armies. Similarly, in matters of consumption and taste the produce of the extra-European world has for centuries fed the continent's near-insatiable appetite for foodstuffs and beverages that could not be produced in Europe itself. It also supplied the carpets, wallpaper and textiles, china, dyestuffs and drugs that became the templates for Europe's own industrial emulation.

Third, although the direct technological impact of the lands outside Europe might be less evident for the 20th century than for almost any preceding century, extra-European societies were, and to a degree remain, important sources of new or alternative technologies. This might be dismissed as the technology of nostalgia—Europe looking backwards to crafts and skills (as in the handmade, hand-worked textiles of India, Indonesia, and China) that have been lost or become too costly in Europe, or which echo the atavistic aesthetics of 'arts and crafts' revivalism. For all its technological progress, Europe continues to crave what other societies produce or arises from their very different cultural and technological traditions. Just as it is possible to imagine 'alternative modernities' coexisting in the modern world,[14] so is it necessary to think of alternative technologies helping to sustain modernity's plural forms and fashions. It is surely one of the paradoxes of globalization that it has allowed alternative technologies of the body such as acupuncture, or the use of Ayurveda and Traditional Chinese Medicine, to gather new adherents in Europe at a time when Western medicine seemed otherwise close to global dominance. Envy and desire require a place in the history of 20th-century technology, for in terms of taste and aesthetics, and how these stimulate trade and technics, there has been a persistent sense of Europe's insufficiency.

Fourth, Europe has long looked overseas for opportunities for technological experimentation and development that were not feasible in Europe itself. Colonies (and their successor states) in Africa, Asia and the Americas provided career openings for engineers, agronomists, doctors and technicians, for well-qualified women as well as men, opportunities that were often lacking or very restricted in Europe. Colonial expertise might have been derided in some circles as crude and second-best, but it gave professional expertise to many individuals who in turn made significant contributions to European (and North American) technology—in such fields as mining, bridge-building, water-management and medicine.[15] Even at the humbler technological level represented by the miner, the train driver, and the factory foreman, the colonial world might have a domestic function in representing a heroic image of European technology overseas, reinforcing images of white masculinity and racial superiority.[16]

Fifth, while colonies and ex-colonies might sometimes be the dumping ground for Europe's unwanted goods and obsolete technologies, they might also be favored sites for the development of the most modern technologies. In the 19th century, colonial India was technically not far behind Britain and the rest of Europe in map-making and surveying, and that on a subcontinental scale, even if other parts of the British Empire in Southeast Asia and Africa lagged far behind.[17] In most recent times, colonies and ex-colonies provided overseas laboratories and testing-grounds, places where dangerous experiments could be conducted or ambitious schemes alike of social and physical engineering enacted, without the public scrutiny and political constraints that might inhibit—even prohibit—such ventures in Europe itself. Similarly, technological

projects sited in the colonial and ex-colonial world might serve to realize the domestic ambitions or enhance the international reputation of Europe's nation states—to demonstrate that they, too, could build transcontinental railroads, conduct nuclear weapons tests, erect big dams and gleaming airports.[18] For smaller states like Belgium and Portugal, this extra-European presence (a task for which Africa acquired a singular utility) was especially significant. Even today the European states still look to the ex-colonial world to boost their standing nearer home.

Finally, it was in many of these overseas territories that the equation of Europe with technology was most effectively—and presciently—challenged. In Asia and the Pacific in the 1930s Japanese competition was the most significant regionally generated threat to European technological dominance, foreshadowing that of the East Asian economies generally in the latter part of the century. Further, it was evident in many colonies and ex-colonies even before the 1960s that this was in many technological respects not Europe's century, but America's. As colonial newspaper advertisements show, by the 1920s and 1930s it was often the USA that set the pace in technological fashion—from automobiles to matinee idols—just as techniques of dam construction and factory organization increasingly reflected US innovation and prestige. In the eyes of the colonized (and even of the colonizers themselves) Europe's technology was beginning to appear shabby and second best by comparison. The technological decline of Europe relative to the USA was arguably even more dramatic in the colonial and ex-colonial world than it was in Europe itself: well before the end of the century narratives of technology as progress had ceased to be exclusively narratives of European-ness. The linking of Europe's identity to its technological achievements, so marked at the start of the century, had partly unraveled by its end.

Locating Technology in Time

The question of chronology besets all historians. We are as aware of continuities as we are of disjunctures, but the tension between what persists and what changes has a particular significance with respect to extra-European societies. Does all history march to Europe's time? Is it satisfactory to start a history of technology with the advent of European colonialism, as if this automatically signaled a moment of profound technological (as well as cultural, economic and political) change? Or should we look instead to long-term patterns of technological evolution and exchange that predate colonialism and take us back hundred, even thousands, of years?

In this one might recall agricultural technologies, especially those of rice cultivation, fundamental to the subsistence and employment of millions of people in East, South and Southeast Asia. It is essential to recognize the very extended period of time over which such technologies (and associated land- and water-management systems) evolved, and to set this alongside the late arrival of colonialism (and then only in some of Asia's many rice-growing regions). One can further reflect on the changes brought about in postcolonial times by the adoption of new, high-yielding varieties of rice: these have had many far reaching effects, but, in many instances, have failed to displace pre-existing (and often highly labor-intensive) techniques of terracing, plowing,

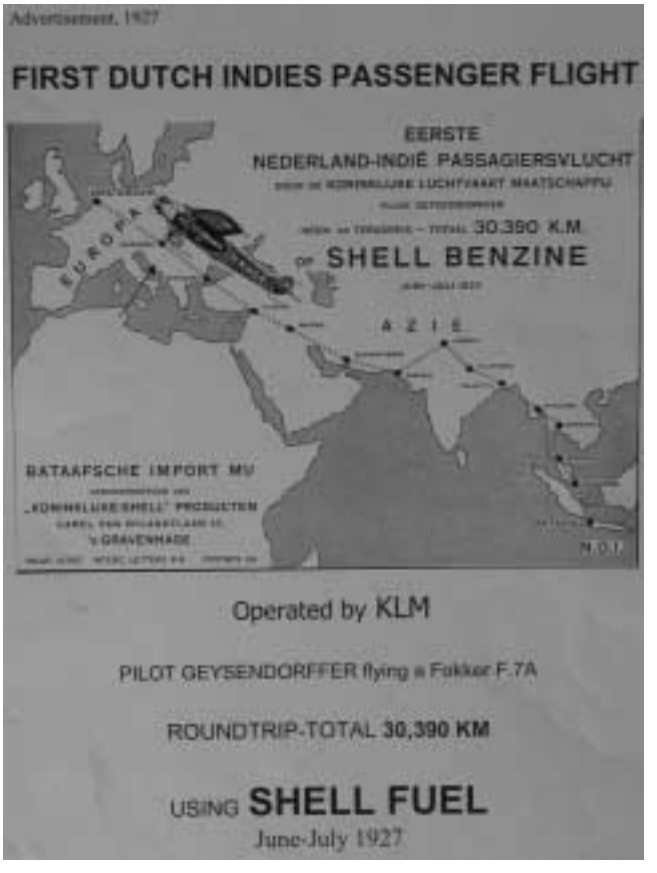

Figure 1 From the mid 19th century onwards, a host of new transnational transport infrastructures heavily influenced the flow of people, information, energy, goods, and services between European nation-states and their colonies. Airline infrastructures exemplify the importance of the colonial connection for Europe.
Source: Advertisement from 1927 provided by Donna Mehos.

transplanting and harvesting.[19] Alongside this land-based technology, one can also think of technologies of the body. Longevity has been a hallmark of several non-Western medical traditions, notably Ayurveda and Traditional Chinese Medicine, which have long histories, independent of, and prior to, Europe. They have evolved over two millennia (or more) and yet have also been subject, over the past century or two, to the profound institutional and conceptual influences of 'cosmopolitan' medicine.[20]

Aside from technology's *longue durée*, there appear to be two crucial moments in the modern history of technology in the non-European world. The first occurred in the mid to late 19th century and was associated with the advent (in some areas, consolidation) of European empires and the arrival of modern industrial technology. For writers such as Headrick,[21] this was the real foundational moment, the point at which Western technology provided the 'tools,' first for the creation of overseas empires, and second for their management and exploitation. The first of these tasks was largely complete by World War I as the last echoes of the technologically one-sided battle of Omdurman

(1898) died away and as medical science (and the accompanying technologies of public health and sanitation) began to remove the threat of malaria and yellow fever. The second set of technologies (including railroads, steamships and telegraphs) fed into a process of (seemingly) unidirectional technology flows from Europe to the colonies that lasted until World War II, or as long as the empires themselves. This diffusionist chronology embodies the idea of technology as historical grand narrative, as a primary determinant of history itself. It is hard, especially in the older versions of this story, not to see this as a triumphalist narrative, the victory march of Western civilization.[22] Taking a longer-term, less partisan, perspective, we may wish to dissent from this celebratory vision of technology's intimate relationship with empire. It should be noted, though, in passing, how a similarly one-sided and selective use of technological examples to illustrate the exceptionalism of the West can be found in recent works like those of Landes and Diamond,[23] in which the role of technology is often combined with bland assumptions about the inhibiting influence of non-European cultures and environments.

It is clearly important not to underestimate the physical clout and ideological force of late 19th- and early 20th-century technology in the service of imperialism, a concern that continues to preoccupy many historians as they search for new forms of its influence and expression. Many of the new industrial technologies of the high imperial era not only had the capacity to help create and sustain European empires where none had previously existed (as in parts of Africa and Southeast Asia) but also greatly to strengthen and extend European control in regions like India, Indonesia and the Caribbean where empires boasted longer lineages. Along with the material impact of these new, often highly visible, technologies came their ideological impact, proclaiming the technological and hence civilizational superiority of the West and differentiating between colonizers and colonized, between 'advanced' and 'backward' races. Even societies like India and China, which had once commanded European approbation, were now ranked among the most lowly and technologically impoverished. Machines thus became the universal 'measure of men,'[24] and historians have become as much interested in the ideological uses of imperial technology as in its material effects.[25]

Two qualifying issues might, however, be raised here. The first is how far these 'big'—one might say 'heroic'—technologies (railways, Gatling guns, telegraph systems, irrigation works and so forth), so emblematic to the imperial eye and so often commanding state resources and prestige, actually mattered to local populations. Did they have a greater cultural impact and practical significance than the humbler technologies of the sewing machine, typewriter or bicycle?[26] And how far were these new technologies, large and small, able to displace the technologies by which most people had hitherto lived and worked? All was not sudden change. While some pre-existing technologies clearly were rapidly displaced, many older ones quietly continued or evolved symbiotically. Well into the era of Nehruvian Five Year Plans, a survey of agricultural implements in India in 1960 showed the persistence of many ancient or hybrid plows, harrows and harvesting tools.[27] Water management, too, suggests complex processes of technological change. While some systems of water storage and irrigation disappeared, others, given conducive circumstances, could, like the ancient tank-fed

irrigation systems of southeastern India, survive the advent of colonial irrigation works and even continue to function effectively into the post-colonial era of tube-well technology.[28]

A second, related, issue harks back to the point made at the start of this section. This is the question of how far the history of technology in Africa, Asia and the Caribbean can be understood as essentially an aspect of the history of technology in Europe, the mere extension of steamships and railroads into the non-European sphere, the simple imposition or transfer of modern technologies of warfare, transport and communications, in ways which yet again make Europe the dynamic center of all things and the rest of the world its periphery. It is remarkable how many histories of technology blatantly ignore the non-European world or confine its role to remote antiquity.[29] It may never be entirely possible to 'provincialize Europe,' nor should its very real impact be overlooked in attempting to do so; but it is imperative to see the history of technology in the non-European world as representing more than a single (Western) logic and a single (living) tradition.

The events and epistemologies of this first foundational moment in the history of technological change, situated in the mid to late 19th century though having consequences that reverberated well into the 20th century, have become increasingly integrated into the study of colonial and imperial history: indeed, they have helped propel it in previously unexplored directions. However, a second moment of change has as yet been much less the province of the historian (who has often been chary of venturing beyond the apparent watershed of mid-century decolonization) and rather more that of the development-focused anthropologist or political scientist. Looking at technology from an extra-European perspective, the 20th century appears a deeply divided century. This had much to do with the world wars,[30] especially the second whose technological impact was enormous. This was obviously and especially so in relation to technologies directly related to the conduct of war, but also those technologies of labor mobilization, agricultural control, resource extraction and disease eradication which colonial regimes and their successors deployed with exceptional energy and interventionist force under the pressure of global warfare and in its immediate aftermath.[31]

Further making the 20th century such a divided one were two other developments that converged around the middle decades. The first, and arguably greatest, of these was decolonization. Foreshadowed earlier in Egypt and the Philippines, this gathered momentum in the late 1940s with the independence of India (and, through Partition, Pakistan), Ceylon and the Dutch East Indies, and in the 1950s and 1960s with the independence of most remaining African, Asian and Caribbean colonies (those held by Portugal, however, remaining into the 1970s). How far decolonization in itself signified either technological liberation (as might be argued in the case of India) or, conversely, a new era of exploitation and extraction (as in many parts of tropical Africa) is an issue historians have too little examined. Anthropologists have been more adventurous.[32] In some instances, in breaking the shackles of formal political control, decolonization allowed Africans and Asians to take control of technologies previously monopolized by whites, or, as doctors, engineers and technicians, to move into positions of political power and professional authority within the new nation states. To the

effects of decolonization were quickly added the political, economic and technological pressures generated by the Cold War, which intensified the drive (especially by the USA) to speed up certain kinds of development and introduce technologies (such as those of disease-control and the 'green revolution') that might allay poverty and pre-empt unrest.[33]

Second, overlapping with the onset of political independence and the Cold War, the middle decades of the century were marked by a series of technological innovations that were in their way as important, and arguably even more momentous, as those of the imperial era. Some of these were wholly new; others represented the popularization of technologies that had hitherto enjoyed only restricted use. They ranged from cars, buses, trucks and tractors, along with burgeoning air transport, to new medical and public health technologies (embodied in new drugs, insecticides, mass vaccination programs and contraceptives), innovative agricultural technologies (hydroelectric schemes and irrigation dams, tube-wells, chemical fertilizers, and the Green Revolution technologies centered on high-yielding varieties of wheat, rice and maize), to new communications technologies (from telephones and radios to photography, cinema and television).[34] We lack a collective name for this technological great leap forward, but the signs of it were widely visible across the non-European world. Perhaps it was only then, in the middle of the 20th century, that technological change really impacted on the lives of the great mass of Africans, Asians and West Indians.

Possibly because they relate to more recent events than the 'big' technologies of the high imperial era, or because their impact has been so extensive, or are closely identified with latter-day capitalism and imperialism, the technologies of this second period have attracted a fierce response, especially from within the Third World itself. This has especially been so for India, where the anti-industrial (and, in part anti-state) tradition pioneered by Gandhi during the nationalist movement has remained resilient. The critical assault comes particularly from those who see modern technology as innately violent—against villagers displaced by dam projects, against landless laborers worsted by the impact of Green Revolution technologies, or against women's bodies (as in programs of enforced birth control). Modern technology is seen as alien and, as in the colonial period, associated with state power rather than public need. It is seen to threaten biodiversity and eco-friendly indigenous traditions.[35]

The question has been asked, most critically through the anthropology of development,[36] whether this apparent double turn—political independence plus technological change—really brought about revolutionary change. It is argued instead that, at a discursive level, the ideology of development as it emerged in the 1950s and 1960s simply strengthened preexisting (colonial) power relations and even heightened the technological disparities between Europe and the Third World. This argument might seem to reinforce the idea that the history of technology in Africa and Asia was indeed driven by technological change elsewhere—initially Europe, increasingly the USA—and that colonies and ex-colonies were relatively powerless to control their own technological destinies. At another level it confirms the view that what happened outside Europe, in the Third World, was seldom a simple repetition of what had happened in Europe, but followed a different technological path.

Locating Technology in Space

Does place matter to the history of technology? It surely does, especially in trying to connect the history of technology in the non-European world with that of Europe. First, there is the physical environment. One of the characteristic features of Europe's technology in the 19th and 20th centuries (along with science and medicine) was its claim to universality. The significance of the Earth's different climatic and geographical regions was immense and technology was no freer than science and medicine from the appreciation (involving degrees of subjectivity) that certain kinds of places, such as the arid and semi-arid 'Orient' or the hot, wet 'tropics' (in which so many colonies were located), were in some way different from Europe. Technology was sited in a space called 'nature.'

As the scientific and technological ambitions of Europe increased, so the physical limitations of Europe became evident. Just as in the 18th century science had to travel to observe the transit of Venus or establish the dimensions of the Earth, so in the 19th century European astronomers had to travel to India and elsewhere to observe and record solar eclipses.[37] The accurate delineation of time as well as space in the modern age was reliant upon a new 'global grid' of technology and knowledge.[38] The whole specialty of tropical medicine (and the attendant fields of tropical agriculture, botany, forestry, and veterinary science) which came to maturity in the 1890s and 1900s exemplified this sense of difference, articulated through differences in climate, in the nature of disease vectors, in plant ecology and soils, and even (perhaps especially) in perceived racial differences.[39] Epidemiologists might now doubt that 'tropical medicine' really deserves to be distinguished as a separate disciplinary field, but historically this branch of medicine was extremely successful, politically and professionally, in creating a niche for itself both in the colonial sphere and in the metropolitan centers that serviced it.[40]

European engineers overseas were forced to recognize that railway construction and bridge-building in 'tropical' India or Africa presented rather different problems and called for somewhat different solutions than in Europe, as did large-scale irrigation works in South Asia and Indonesia. It might be deemed physically and politically desirable to locate penal settlements and the accompanying technologies of the criminalized body in remote (or labor-scarce) tropical colonies, or, as in the case of French Guiana, where one tropical function superseded another, to build space stations near the site of old penal settlements and as close to the Equator as possible.[41] The apparent ineluctability of 'nature' gave rise to repeated tensions within the colonial medical, scientific and technical services, or proved, as in the case of agriculture and forestry, that what was standard practice in Europe was neither feasible nor desirable in a very different African, Asian or Caribbean environment.

The forests of the tropics and monsoon Asia, with their great variety of tree species and diverse ecologies, could not be managed in the way French and German foresters managed the smaller number of temperate species in European forests.[42] Soil erosion and conservation—issues that assumed increasingly importance from the early 20th century onward—presented different technical challenges in many parts of the tropical world than they did in Europe. Schemes, often in the state-managed colonial tropics,

to introduce unmodified European methods were doomed to failure or encountered local resistance based upon different customary practices evolved within physical and social environments markedly different from Europe's own.[43] As the examples of state-managed forests in Asia suggests, even what might be technically feasible was not necessarily socially or culturally acceptable locally. Technology was sited in different cultural as well as 'natural' spaces. Whether new forestry techniques were successful or not (in commercial and environmental terms), the denial of access to the 'political forest,' by those traditionally most accustomed to use them might lead to local resistance and force at least a partial reconsideration of how environmental resources might be harvested and what the technologies most appropriate to their exploitation might be.[44]

Thus, the environment, though frequently invoked as a self-explanatory and scientifically legitimating factor, does not stand alone in marking and effecting difference between technology in Europe and technology in the colonial/postcolonial world: the role of the environment, real or perceived, was influenced and supported by a range of cultural, economic and political considerations. Technology, in the colonies and ex-colonies, no less than in Europe (and perhaps to a more extreme degree) functioned within a politically configured and culturally differentiated space and was profoundly shaped by that context. In retrospect, it might be argued that the gap between 'indigenous' and 'scientific' (or Western) knowledge has been exaggerated and is a largely artificial dichotomy. These were not separate, watertight systems but, even under colonialism, evolving epistemologies and practices that borrowed extensively and pragmatically from one another.[45] However, it was precisely one of the self-legitimizing mechanisms of colonial regimes and many of their postcolonial successors to make a distinction between indigenous technologies (as for instance, shifting cultivation) that were condemned as being primitive, wasteful or environmentally destructive and those (like 'scientific forestry') that were validated by modern science and sanctioned by the imperatives of productivity and profitability. Even if popular knowledge was eclectic, states (colonial or postcolonial) tended to see things differently.[46] Equally, one of the effects of colonialism, especially in Africa, was to partition the land spatially and functionally between technologically differentiated sectors—the plantation, the factory, the forest, the labor or game reserve—and to seek to order society accordingly.[47]

While Europe often saw itself as the originator and exemplar of big technologies—the steamship and railroad, the steel mill and nuclear power plant—what it often fostered and sustained in the colonies and ex-colonies were basic technologies that were obsolete or increasingly marginal in Europe itself. These were essentially technologies that relied upon an abundance of cheap manual or semi-skilled labor rather than advanced mechanical technology—such as the vast numbers of laborers, including women and children, and not infrequently in the 19th century convicts and famine refugees, armed only with picks and baskets who dug irrigation canals or built railroad embankments in South and Southeast Asia; or those men, women and children who worked with outmoded machinery in the jute and cotton textile mills of late colonial Calcutta and Bombay; or those, again, who equipped only with hoes, machetes and pruning knives labored on sugar plantations or on tea estates in postcolonial Sri Lanka.[48] The site of the 'high' technology—the place where the railroad locomotives

were made and the textile machinery was manufactured, or where the primary produce of the colonial empire and Third World was processed, refined, spun, woven or cured—was likely to be elsewhere, in overseas technological enclaves under direct European management or in the ports and factories of Europe itself. This, then, was a technology of spatial segregation—within the colonies, but more especially between 'high-tech' Europe and its 'low-tech' satellites overseas.

It might be argued that the advent of steamships and railroads in the 19th century, and even the new technologies of the mid 20th century, did not fundamentally change cultures. Hindus might travel by rail without their religious beliefs being undermined—indeed, they might find the railroad a convenient means of visiting pilgrimage sites (and thereby, to the chagrin of colonialists who equated technological change with cultural transformation, strengthen their religious beliefs).[49] However, it is precisely with respect to what indigenes, rather than colonizers, made of new technologies that we are, as yet, little informed. In some cases new technologies were undoubtedly a basis for resentment and resistance, but not in others. In trying to assess the 'social life of things,'[50] and how new technologies were locally received and adapted, it might be observed that certain technologies moved easily and relatively rapidly between one section of society and another, even in a seemingly polarized colonial world. Photography in India, for instance, was not only taken up by the colonial state for its own

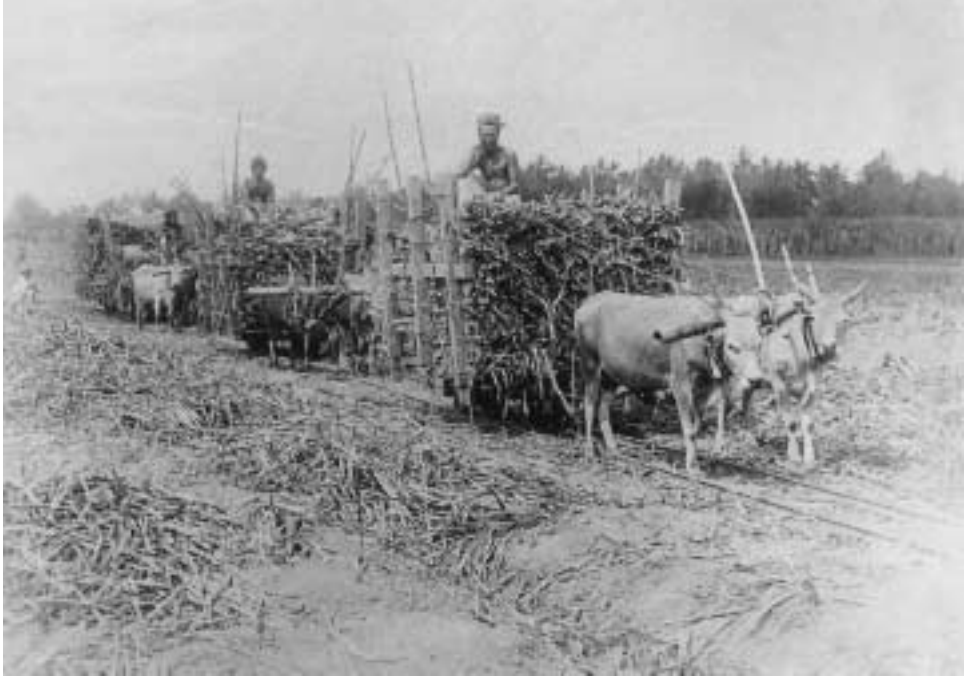

Figure 2 Western technologies were often mixed with local technologies to create new hybrid systems. In the early 20th century, the transport of sugar cane in the Dutch Indies was done combining domestic means with a rail track.
Source: Special Collections from Wageningen University Library, The Netherlands.

Foucaldian purposes, but also, almost from the outset, had a wide appeal to Indians, spreading from its initial base among the Westernized middle classes to almost all sections of society, and acquiring meanings, uses and conventions that derived from indigenous, rather than European, cultural contexts.[51] Likewise, the appeal of automobiles, the radio and cinema, of modern architecture, fashionable clothes, and air travel in late-colonial Indonesia appears to have readily transcended the European elite and become lodged in the lifestyles and expectations of the indigenous population as well.[52]

Diffusion, Circulation, Exchange

Questions of networks, linkages, and circularity constitute an increasingly salient set of issues relating to the spatial dimension of colonial and Third World technologies. As indicated earlier, models of dissemination and diffusion remain strongly entrenched in much writing about colonial and ex-colonial technology. There is sometimes understood as a dual process—in the first instance, from metropolis to colony, and then, secondarily, from the leading centers of administration, science and industry within the colonies to smaller towns and ultimately villages, or perhaps more directly to specialist sites like mines, plantations, mission stations, and agricultural research stations. The return flow is conventionally conceived in terms of raw materials—fibers, minerals, foodstuffs—or perhaps as fragments of basic knowledge (items of practical 'information' rather than entire epistemologies) about what grows where, or how local climate, geology, labor conditions, etc., favor or impede the process of production and extraction. The classic diffusionist model was that devised by Basalla in 1967 to explain the spread of Western science: it has been much criticized, but, as a Euro-centric typology, is as applicable to technology as science and has often been used—and critiqued—in that light.[53]

Although the diffusionist model is still widely invoked, many scholars now regard it as an unsatisfactory basis on which to approach the technology of the non-European world. What are the alternatives to Euro-centric diffusionism? For a start, if we take a long-term view, patterns of technological diffusion have clearly not been from Europe alone. As Needham and his associates long ago showed,[54] substituting a Sino-centric model for a Euro-centric one, China was an important and longstanding source of new technologies: other scholars have highlighted the role of India, the Muslim world or maritime regions like the Indian Ocean in the creation and spread of new technologies, including agricultural ones.[55] Historically, technologies have traveled in a number of different directions, across several continents, and not simply outward from Europe.

Even if we concentrate on the late 19th and early 20th centuries, the age in which Europe was rampant, it is not difficult to see something more complex than a simple diffusionist model at work.[56] The colonies were themselves significant sites of technological innovation. This might be through direct borrowing and adaptation from indigenous practices (such as the well-sinking technique used in constructing the foundations for bridge piers in 19th-century India) and local knowledge (such as the indigenous knowledge of medicinal plants, analgesics, and narcotics taken from the native Americans from the early 16th century onwards and gradually refined and redeployed

by European science and technology across the world). At other times, Europeans in the colonies, acting out of scientific curiosity as much as from economic incentives, experimented with new techniques—for refining and processing minerals and raw materials, for example, or for introducing, modifying and hybridizing locally grown crops—as in experimental work conducted by British researchers on Indian wheat varieties between 1905 and 1925.[57] This new knowledge, appropriated, hybridized, or empirically arrived at, then became part of Europe's store of technical know-how (with its colonial origins often quickly forgotten). Some technologies developed first in the colonies for reasons that had much to do with local environmental and social conditions or economic and political circumstances, and then were brought back to Europe, often by the individuals who had helped to pioneer them. The case of fingerprinting, developed first by British officials and police officers in late 19th-century India, and then rapidly disseminated across Europe and worldwide as a forensic tool, is a case in point.[58]

If we are to adopt a model based on a complex web of exchanges and interconnectedness, we need also to recognize that many technological innovations and knowledge flows were not simply between a single metropole and its colony or ex-colony. There was significant inter- and intra-regional movement, between colonies (or even non-colonial territories): examples include water management and irrigation technology in arid lands, passed between India, Australia and the southwestern USA, but largely bypassing Europe, and the circular flow of agricultural and medical expertise between colonial India and British possessions in eastern and southern Africa. Although it has been customary to think of European empires as virtually self-contained systems, even as mutually antagonistic enterprises, there was considerable intra-regional traffic in ideas and practices, as, for instance, between British India and the Dutch East Indies (with a mutual interest in the 1920s and 1930s in discovering the causes of beriberi and tackling the nutritional deficiencies caused by heavily milled rice).

There were, too, important territory-to-territory exchanges within regions like the Caribbean or Southeast Asia where, despite the existence of several different, often fiercely defended, imperial and national sovereignties, there were frequent occasions for local collaboration or for an informal contraband trade in useful technologies (such as those relating to sugar cultivation and refining). To cite one early 20th-century public health example of the regional pooling of expertise, the Far Eastern Association of Tropical Medicine, which first met in Manila in 1910 (under American auspices), held subsequent biennial meetings at, among other places, Hong Kong, Batavia, Singapore, Tokyo, Calcutta, Bangkok, and Hanoi, before disappearing with the coming of World War II. As suggested by this example and by the movement of cinchona, rubber, sisal, tea, and other commercial crops in which tropical empires took a particular interest, these lateral movements and regional exchanges were particularly associated with technical fields like tropical agriculture and medicine, where metropolitan expertise was necessarily limited or secondhand. This is not to deny, though, the role that metropolitan-based imperial institutions like Kew Gardens (or its public health counterpart, the London School of Hygiene and Tropical Medicine) might play in directing or overseeing such exchanges.[59]

Rather than seeing a single trajectory to technology in the colonies and ex-colonies we might look instead to a series of alternating trends. At some periods of time, as in the high imperial era between the 1870s and World War I, European science, medicine, and technology seemed particularly buoyed up by the requirements of imperial prestige, as by new scientific discoveries and industrial processes and correspondingly intolerant of indigenous epistemologies, practices and responses. This phase seems to have waned with the onset of the Great War and European reactions against the destructiveness of mechanized warfare.[60] In the interwar period in Africa and Asia colonial experts seemed rather more willing to recognize the limitations of imported technologies and to accept the need to understand and utilize local conditions (of soil, crops, water resources etc) and to secure local cooperation, even by incorporating indigenous traditions and practices. To a degree, technology and science were informed by a dialogue between cultures rather than imposed by European diktat or hailed as a Promethean gift.[61] This was perhaps a phenomenon most marked with respect to African agriculture, but in India, where there had been a comparable period of relative openness before the 1830s, there was a renewed interest in the 'traditional knowledge' stored up in indigenous agriculture (as shown by the Howards' investigation of Indian cropping techniques and wheat varieties),[62] and, to some degree, in indigenous systems of medicine. In part, though, this late-colonial responsiveness in India was prompted more by the challenge of the nationalist movement (which brought indigenous medicine to greater prominence) and by the revival of traditional crafts and opposition to modern industries spearheaded by Gandhi. The technological, economic and political pressures of World War II and its aftermath, and the accompanying revival of confidence in 'big' technologies and technological solutions to issues of Third World poverty, disease and deprivation (such as the wholesale use of DDT to tackle malaria),[63] saw a swing back to a more authoritarian approach and a diminished willingness to look for technical solutions based on local knowledge and consent. Even this extreme phase was to some degree modified by a late 1960s' and 1970s' reaction and renewed quest for 'appropriate' technologies.

Conclusion

The point of this paper has been to suggest some of the lines on which the history of technology in the colonial and postcolonial world has been unfolding. In particular, it has sought to recognize the connectedness of this extra-European history to that of technology in Europe, while making the point that the history of technology in Africa, Asia and elsewhere cannot be seen as an unproblematic extension of the history of Europe's own technology. There cannot be a worthwhile history even of technology in 20th-century Europe without this wider dimension being taken into consideration: without the rest of the world that history would be insufficient. What we mean by Europe and the privileged place it continues to retain for itself in relation to technology needs to be radically rethought.

Although the diffusionist model still holds sway in many quarters, it is increasingly seen as a legacy of empire itself, and there is a growing scholarly recognition, in the

history of technology as in other fields, of a dynamic and ongoing interconnectedness between Europe and the rest of the world. Even in the 20th century, which might superficially seem unpromising ground for such an argument, there was repeated recourse to the non-European world, not merely for raw materials to feed Europe's industrial technology or consumer needs, but also for the very things that fashioned or facilitated the technologies of modern Europe. More than this, we can see in the history of technology outside Europe the value of learning from anthropology as well as from such other historical sub-disciplines as the history of medicine and environment. We can see in the colonial and postcolonial era the value of looking beyond individual technologies to those technologies that cluster around body, land and state as both core historical sites and as a heuristic device for assessing the wider meaning and context of modern technology. Do those technologies reveal a history of growing exploitation and dwindling diversity, or a history of plurality, of fruitful ongoing exchanges and conversations between different cultures and technologies? That issue is still far from resolved. Indeed, it is so fundamental it may never be.

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Notes

[1] See www.histech.nl/tensions for details.
[2] See Sandes, *The Military Engineer*, and, for an African example, Weinthal, *The Story*.
[3] For the impact of environmental issues on recent African history, see Beinart and McGregor, 'Introduction.'
[4] E.g., Lemonnier, *Technological Choices*.
[5] A fine example of this, especially with respect to medical technologies, is Hunt, *A Colonial Lexicon*.
[6] Bray, 'Technics,' 12–14.
[7] Joseph Needham's work on science and civilization in China was an exemplar here, but so too were works like Alvares, *Homo Faber*.
[8] To be 'indigenist' the exponents of this approach did not need to be indigenous to the societies they described (they often were not) but to identitfy with its traditions and to see Europe as an external, intrusive and coercive force.
[9] If a single episode could encapsulate this postcolonial violence it might be the gas leak at the Union Carbide Plant at Bhopal in 1984: see Nandy, *Science*, 1.
[10] For this view the present author should take some responsibility: see Arnold, *Colonizing the Body*, ch. 3; cf. Beinart, 'Introduction: The Politics of Colonial Conservation.'
[11] Anderson, 'Introduction,' 651–2; Langfort, *Fluent Bodies*, ch. 1; Beinart and McGregor, 'Introduction,' 17; MacLeod, 'Introduction,' 8–9.

[12] Chakrabarty, *Provincializing Europe*. For the significance of this idea, see Anderson, 'Introduction,' 645–6; Burton, 'Introduction,' 1–2.
[13] Hall, 'Rethinking Imperial Histories,' 10.
[14] Appadurai, 'Global Ethnoscapes.'
[15] Irrigation technology provides an important illustration of this, especially in the movement of hydraulic engineers and their expertise in the late 19th and early 20th centuries from India to Australia and the USA as well as Europe: Worster, *Rivers of Empire*, 143–56.
[16] The ambivalence of this situation cries out for further research. In the self-representations of Europe, train-drivers, miners, mechanics, and others might appear heroic pioneers, but in representations of the indigenous population, and even of the colonial administrative and military elites, they might be seen fare more negatively.
[17] Edney, *Mapping*; Barrow, *Making History*.
[18] For an illustration of the connection between ideas of technology-based progress at home and in French West Africa under the Third Republic, see Conklin, *A Mission*, ch. 2.
[19] Bray, *Rice Economies*.
[20] Leslie, *Asian Medical Systems*. For a helpful introduction to long-term trends in Africa, see Austen and Headrick, 'Role.'
[21] Headrick, *The Tools of Empire*; Headrick, *Tentacles of Progress*.
[22] E.g., Cameron, 'Imperialism and Technology;' McClellan and Dorn, *Science and Technology*.
[23] Landes, *The Wealth and Poverty*; Diamond, *Guns, Germs and Steel*.
[24] Adas, *Machines as the Measure of Men*.
[25] Arnold, *Colonizing the Body*.
[26] For the latter, see Hunt, *A Colonial Lexicon*, ch. 4.
[27] Raghavan, *Indigenous Agricultural Implements*.
[28] Mosse, *Rule of Water*. For the other examples of the relationship between colonialism and water-management technology in India, see Gilmartin, 'Scientific Empire and Imperial Science;' and the essays by Gilmartin, Hardiman and Whitcombe in Arnold and Guha, *Nature, Culture, Imperialism*.
[29] E.g., McClellan and Dorn, *Science and Technology*; Caldwell, *Fontana History of Technology*.
[30] One might add the Depression, which had a profound, often destructive, impact in many colonies: for one illustration, see Elson, *Javanese Peasants*.
[31] For an illustration of how war intersected with other technologies, see Mitchell, *Rule of Experts*, ch. 1.
[32] Ferguson, *Expectations of Modernity*.
[33] Perkins, *Geopolitics and the Green Revolution*; Moon, 'Takeoff or Self-Sufficiency?'
[34] For one illustration of these new technologies at work, from West Africa through the Middle East to India, see Barjot *et al.*, *L'électrification*.
[35] Goonatilake, *Aborted Discovery*; Nandy, *Science, Hegemony and Violence*; Shiva, *The Violence of the Green Revolution*. This polemic generated its own critical response: see the 'Introduction' to Cooper and Packard, *International Development and the Social Sciences*, 25; Mosse, *Rule of Water*, 8–11.
[36] Escobar, *Encountering Development*; Ferguson, *The Anti-Politics Machine*; Gupta, *Postcolonial Developments*.
[37] Pang, *Empire and the Sun*.
[38] Galison, *Einstein's Clocks*, 175.
[39] Worboys, 'The Emergence of Tropical Medicine.' For a dated but significantly 'tropical' review of colonial science and technology in Africa, see Worthington, *Science in Africa*, and for its context and significance, Tilley, 'African Environments.'
[40] Haynes, *Imperial Medicine*. It was often, too, in overseas territories like South Africa that investigations into the supposed biological and psychological characteristics of races were investigated: e.g., Dubow, 'Mental Testing.'
[41] Redfield, *Space in the Tropics*.

[42] Peluso, *Rich Forests*.
[43] Beinart, 'Soil Erosion.'
[44] Guha, *Unquiet Woods*; Peluso and Vandergeest, 'Genealogies of the Political Forest.'
[45] Agrawal, 'Dismantling the Divide'; Gupta, *Postcolonial Developments*.
[46] Cf. Scott, *Seeing like a State*.
[47] Beinart, 'Introduction.'
[48] Kerr, *Building the Railways*; Chandavarkar, *Origins of Industrial Capitalism*; Sen, *Women and Labour*; Daniel, *Charred Lullabies*. For an African example, see Guy and Thabane, 'Technology, Ethnicity and Ideology.'
[49] See Ahuja, 'The Bridge-Builders.'
[50] Appadurai, *Social Life of Things*.
[51] Pinney, *Camera Indica*. Cf. Landau and Kaspin, *Images and Empires*.
[52] Mrazek, *Engineers of Happy Land*.
[53] Basalla, 'Spread of Western Science.' Cf. Adas, 'Introduction' to *Technology and European Overseas Enterprise*. For a recent critique, see MacLeod, 'Introduction.'
[54] E.g., Ronan, *The Shorter Science and Civilisation*, Vol. 1, ch. 6.
[55] Watson, *Agricultural Innovation*, 2–5.
[56] For a recent exploration of these issues, including the varied uses of military and print technology, see Bayly, *Birth of the Modern World*.
[57] See Howard, *Sir Albert Howard*.
[58] Sengoopta, *Imprint of the Raj*.
[59] For Kew's role, see Brockway, *Science and Colonial Expansion*.
[60] For this reaction, see Adas, *Machines as the Measure*, ch. 6.
[61] Richards, *Indigenous Agricultural Revolution*, ch. 1; Tilley, 'African Environments.'
[62] Howard, *Crop-Production*. For the phases of colonial technoscience, see Arnold, *Science, Tecnology and Medicine*.
[63] As in Egypt: Mitchell, *Rule of Experts*, ch. 1.

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