DRAFT

Title: Technologies and sustainable environments
Prof. Mary Tiles
Chair, Sustainability Council and Department of Philosophy
University of Hawaii at Manoa
2530 Dole Street
Honolulu, HI 9682
U S A
Tel.: +1-808-956-8649, Fax: +1-808-956-9228
E-Mail : mtiles@hawaii.edu

Abstract

Talk of The Environment has, because of the ideological and political baggage it trails behind it, become something of an obstacle in discussions of sustainability. As a vehicle for opening up discussion, it is suggested that we (re)acquaint ourselves with the many environments that constitute our surroundings. Specific attention is paid to technologies in the form of large infrastructure networks. History has shown us both how costly the maintenance of such infrastructure can be and how devastating can be the consequences of failures of maintenance that lead the infrastructure to collapse. To avoid being locked-in by our own infrastructure dependencies and their associated maintenance costs, would require moving back in the direction of place-based technological solutions. The challenge is to how to retain some of the benefits of global interconnectedness while weaning ourselves off dependence on those connections whose maintenance is both economically and environmentally the most burdensome. Globally the strategy would be to give serious consideration to variations in local conditions in our effort to reduce global greenhouse gas emissions and to create more sustainable human environments.

In recent years climate change has received increasing publicity while climate science has been politicized. It is this science-politics-policy mix that currently frames many discussions of the relationships between technology and the environment. In the mid-twentieth century, during the period of the cold war, the hazards of nuclear technology and of the widespread use of insecticides (such as DDT) in agriculture, occupied similar roles. In the nineteenth century it was the transformation and degradation of landscapes by steam powered industrial technology, as reflected in for example the work of William Blake ("England's dark satanic mills") that framed the context of debate.

These are the contexts of environmental politics, of the clash of values between enthusiasts viewing technological development as an essential indicator of human progress and detractors who have seen technology as a vehicle of domination over both the natural environment and large sectors of humanity. When the terms "technology" and "environment" are juxtaposed in such contexts there is a tendency, to assume that the discussion to follow will be framed in terms of the divide between Man and Nature. Technology is seen as the material expression of Man's ambition to dominate Nature, with the subjugated natural environment the victim of its detrimental impacts.

Here, in brief, we see the ideological load born by juxtaposition of the terms "technology" and "environment" and the near impossibility of entering into any discussion of their relationships from an ideologically neutral standpoint. Many environmentalist critiques of technology have shared with their tacitly or explicitly faith-based opponents an acceptance of the Man-Nature divide. Questions are then framed as questions of environmental ethics and as disputes over the fundamental locus of moral values.[1] This ideological/political burden of "The Environment", particularly in the United States, creates a chasm across which it is difficult to conduct a policy dialogue, let alone construct policy bridges in response to the challenges potentially presented by a changing climate. As in most such standoffs the opposed positions rest on a shared assumption, in this case that humans and their environments, or Man and The Environment, are independently constituted and stand in an external relationship; absolute values can have a basis on one or the other, but not both. Recognizing that such deep ideological differences are unlikely to

[1] See Latour (2004), Whiteside (2002) and Norton (2005) for more detailed and nuanced elaboration of this point.

be resolved either by philosophical debate between the opposed positions or by political or moral evangelism, it would seem that it is past time to challenge the idea that there is any such thing as The Environment standing in an external relation to humans, their histories and their technologies. In other words it is time to become reacquainted with **environments** for humans, for other life forms, for technological devices, for economic and social institutions, and so on. There is a need to focus on our dependencies on multiple environments in addition to our role in shaping those environments. Such environments are formed over the course of a history of human activities. Environments play a formative role in the development of children, the capacities they acquire and their own future interactions with those environments. Technologies function as intermediaries creating human-natural hybrids; our environments are, in part, a product of our technologies. We develop technologies to alter and control our environments [2]as well as to perform specific desired tasks. I will suggest that one way to refocus discussion about sustainable environments is to acknowledge the extent to which our preferred environments (those we get anxious about sustaining) are frequently technologically maintained and frequently environments for technologies on which we depend. There is an understandable tendency to take for granted, and to naturalize the infrastructures that support our ways of life, they are part of our environment (but not of The Environment), but without them most of our ways of life will not survive. Thus we need to think about the sustainability of these infrastructure environments: Can they be sustained? If so, at what cost to other environments, whether natural, economic, social or political?

The Unnaturalness of Technology

There are two contexts that lend credence to and serve to reinforce use of the technology-environment opposition as a surrogate for the Man-Nature opposition and its construal as an external relation. The first is that of mining and manufacturing and the second is the military-industrial model of technological development.

Mining and manufacturing technologies are those that have most frequently been portrayed as threats to the environment because they have most dramatically illustrated the capacity of human technologies to create environments that are hostile to many life forms, human included. Their development is also intimately intertwined with the development of energy and transport technologies. Mining is a paradigm example of an activity that is locally unsustainable, exploitative and hugely disruptive of the natural and social environments in which it begins to operate. Mineral deposits occur in limited quantities that will sooner or later be exhausted and where extraction becomes increasingly uneconomic. Extraction, whether open face or by tunneling, wreaks dramatic physical changes on the landscape. Communities of miners and their associated equipment move into regions that may have been sparsely populated and largely agricultural or pastoral. Roads, railways or waterways, have to be built to supply the mines and to transport materials to and from them.[3] The extraction of metals from mineral ores requires mechanical energy for crushing, and heat for smelting and the byproducts, frequently toxic, migrate into the surroundings, possible continuing to for many years to leach out of large spoil heaps that remain long after a mine’s closure. The local environments surrounding mines, oil-drilling operations, refineries and chemical plants are toxic to most life forms. So it is natural, if this is our image of technology, to put it in opposition to Nature since one of the side effects of its operations has been to create wastelands devoid of anything much in the way of organic life.

To the extent that our reliance on even the most basic technologies requires continued extraction of non-renewable resources, the prospect for a globally sustainable development, benefiting all regions and all peoples, is unrealistic. Globally, resources may last a long time (and the longer the less they are squandered), but locally each resource will be exhausted over a relatively short time frame leaving behind the marks of locally disruptive extraction activities and the rise and fall of a local communities and ways of life.

---

[2] One well documented and striking example is provided by the telling of the story of the remaking of the landscape of modern Germany given in Blackbourn, 2006.

[3] Such enduring marks of past mining operations can be seen for example in Cornwall, Cumbria and South Wales in the UK or in Colorado in the US. Africa provides many examples of the devastation and disruption caused by ongoing mining and oil extraction operations.

A different kind of oppositional relationship is revealed in the context of the military-industrial development of technology. As Serres (1982) notes (crediting Lucretius with a similar insight), military applications have frequently been the spur driving the use of science in technological development. The fact that military applications have played such a role in technological development is of no minor significance for the manner in which the environment has been impacted by the development of technology or for the way in which the technology-environment relation has been conceptualized.

Whether in the remains of ancient China or those of the ancient Roman Empire one can see evidence of the impact of the military impetus toward regimentation, imposed for the sake of efficient and predictable operation, on the technologies used and on the built infrastructure required for their use. Armies need standardized equipment with standardized parts that can be on hand in any location. Army engineers developed standardized methods for the construction of structures such as roads or fortifications, for carriages and ships, for armor and weaponry, methods and specifications developed ahead of time with people trained to deploy them in any required location. Stretches of road used by the Romans to move their troops and supplies rapidly across the outposts of their empire can still be identified by their straightness and by their lack of concern for local topographical or landholding patterns. Military engineers used geometry to assist in the designed of forts walls and ramparts as defenses against anticipated forms of attack (themselves conditioned by available technology) and replicated them across the territory to be defended. Particularly for large imperial powers, military efficiency and effectiveness is linked to the requirements of bureaucratic techniques of administration, techniques that require standardization in modes of operation allowing for centralized design and planning and allowing personnel and equipment to be moved from one location to another without significant retraining or redesign.

This has two effects. It allows design to become a theoretical process, carried out according to general principles, and separated from actual construction. This is turn is a precondition for the technological development driven by theoretical science. Science and technology combined have created environments that made it possible to bring into existence materials, phenomena and organisms that, while not violating any “laws of nature”, would be very unlikely to have come into being in non-technologically created environments or as a result of natural processes. Where there is uniformity there is also much more predictability; but that uniformity has to be created by eradicating or externalizing relevant variations. Mass-production techniques have, with ever stricter quality controls, have brought into being millions of uniform products. With uniformity goes predictability of behavior under given conditions. But the price of uniformity is strict control of the production environment all the way down to material components, and predictable reliable functioning of products requires widespread reproduction and maintenance of conditions constrained to stay within the range required for product performance. In other words it requires that local environmental variations be made irrelevant. They can be made irrelevant either by insulating devices to be used from external impacts that might affect their designated function (the design of a ship’s chronometer – a mechanical time piece designed to keep accurate time through the pitching and rolling of a ship and through the wide variations in temperature that might be experienced on a long sea voyage[4] is one instance where there is documentation of the long sequence of efforts explicitly undertaken to address this challenge) or by altering the local environment to conform to conditions under which the device functions well (build roads for carriages, deforest and flatten areas around forts[5]) or some combination of both.[6] The former route requires devices to be “robust” and “durable” and can add to the cost of design and/or production. The latter can simplify product design and will be the route taken if the costs of ensuring the existence of controlled environments (decent roads, availability of quality-controlled fuel, availability of electrical supply at a consistent voltage, etc. can be externalized). The former alternative creates “unnatural” objects – objects that are very resistant to change by, or in response to, environmental variations. The latter creates “unnatural” environments – environments between which there is little variation, controlled environments.

The close interconnections, both historically and in contemporary society, between the military drive for technological innovation and large private corporations (the bureaucracies of the military-

[4] See for example John Harrison’s various painstaking efforts to achieve this as narrated in Sobel (1995).
[5] See for example Ferguson (1992).
[6] As Latour (1988) p.90 notes, these are the conditions on which science is able to get out of the laboratory and into application. The application of general principles often requires creation of a suitably controlled environment.

industrial complex[7]) have ensured that it is this conception of technology, with its deliberately designed insensitivity to environmental variations and to its own environmental impacts that has been another lens focusing attention on the relation between technology and environment as one of opposed and competing interests and values. This has left in the shadows, and relatively invisible until recently, the factors ignored when concentrating attention in this way.

Technology, Infrastructure and "Natural" Environments

It has frequently been pointed out that one of the most significant shifts in the way humans sought to secure their basic needs was when they made the transition from being nomadic hunter-gathering groups to becoming place-based agricultural societies. It has been through the development of agriculture and technologies to support it that humans traditionally have most altered and created the environments in which they live.[8]

For example, water control technologies have been hugely important for the expansion of cultivated land and the provision of sufficient food surpluses for the emergence of non-agricultural sectors of human activity. The need and ability to control water provides one of the most striking examples of the way in which physical environment prompts development of certain kinds of technologies that then shape and constrain the societies that come to depend on them. The ancient "hydraulic" civilizations of India, the Middle East, South America, China and Bali provide examples.[9] Although the technical details of hydrological challenges and the technologies available to deal with them are location, time and region specific there are common features of dependence on water management. As water control technologies are put in place in the service of agriculture, continued production of food depends on continued water control and this in turn can impose very high maintenance burdens. As Elvin (2004) gives two examples to "suggest the complexities of hydraulic histories and to show how Chinese hydraulic engineering both changed its environment and was, in turn, constrained by it, and even – sometimes – broken by it" p.120. He documents the huge amounts of money, labor and materials and administrative skill required to build and then maintain a water control system and also illustrates the way in which a society can become locked into maintenance, even at very high cost, of such a system because the costs of not doing so would be so socially and economically disruptive. Much of today's agricultural production is even more dependent on the maintenance of irrigation infrastructure and on the continued available of fresh water.

More recently the displacement of human energy in agriculture made possible by reliance on oil-based technologies has changed our societies and our environments in another way. There are now sparsely populated agricultural landscapes, ever growing cities, suburban sprawl and unplanned slums created by the movement of people off the land. Technology has displaced people – has moved them from environments in which they have a relatively close relationship to the land and to other life forms, to another, much more obviously man-made environment, one where people, their activities and the byproducts of those activities dominate. [10]

Of course none of this separation of population concentrations from their sources of food would be possible without transportation networks, trade agreements, refrigeration and food processing technologies. This illustrates the sense in which technologies do not stand-alone but exist, thrive or face extinction depending on other environmental (technological, natural, social) conditions. Large farm machinery is of little use in cultivating small patches of land clinging to hillside or nestling in valley bottoms. US pork production can be concentrated in the huge hog farms of the Carolinas only if there are ways to bring that

---

[7] Walt Disney and Ray Krock, the founder of McDonalds, both transferred their experience of military organization and regimentation to the world of private business. Multi-national corporations can now relocate and replicate manufacturing plants around the world frequently ignoring not only the natural environment but also the local social impacts as on the border between the US and Mexico.

[8] One striking example is the diversion of water for irrigating cotton grown in the Aral Sea basin. The result has been that the Sea has shrunk to about 10% of its former size (800m acre-feet of water). See Pearce (2006) chapter 23.

[9] See for example Elvin (2004), Pearce (2006) and Lansing (1991).

[10] Mike Davis (2006) p. 4-5 lists twenty three third world mega-cities, cities with population over 8m in 2004. Three of these have populations of 20m and more. In 1950 the largest third world city was Shanghai with a population of only 5.3m (by 2004 that had grown to 13.2m).

meat to distant consumer markets and only if regulatory structures permit the widespread use of antibiotics in farm animals and the accumulation of manure in open lagoons (in a manner that would not be permitted for human waste). The rise in meat consumption world wide, made possible by industrial scale livestock operations is in turn having an impact on the atmosphere and thus on climate.[11]

This is just one illustration of the complex network of interactions between human activities and the whole range of conditions – geophysical, technological, economic, legal, political etc. – framing their effectiveness and impact. These networks constitute ecosystems with the same degree of complexity and posing the same kind of challenges to understanding as Darwin's famous "tangled bank". This suggest the need to borrow techniques and concepts from ecology and of thinking in terms of industrial or technological ecology[12] in order to focus on the webs of interdependence between different technologies and the ways in which they form environments for each other as well as for human and other living organisms.

Environments circumscribe the range of possible human action and our relationship to them is interactive; we shape and are shaped by them. The impacts of past human actions contribute to the rural (more "natural") as well as the urban (more man-made) environments of subsequent generations (the Norfolk broads, old canal networks, ruined castles, the hedgerow or dry stone wall enclosure of fields, town squares, government buildings and institutions, paper money and banking systems….).[13] Once our sights are turned in this direction it becomes natural to pay attention to technologies in the form of large infrastructure networks (irrigation systems, power grids, sewer systems, the internet, roads…) that become inseparably woven into the environment that frames our existence and will leave their mark on the environments of future generations, whether or not they are sustained to served their original purposes. These networks are essential to manufacturing and trade, and to the continued utility of many technological devices. (How useful is an automobile without a supply of gasoline and road to run on, or a refrigerator without a supply of electricity?) Once installed, these networks cease to be the focus of attention and are taken for granted until disrupted; we tend to forget that such systems are not self-sustaining and that the burden of maintaining them can be so high as to render the whole system vulnerable to collapse in the medium to long term.[14] The variety and global extent of such infrastructure networks is what perhaps most strikingly marks our current situation. At an accelerated pace we are continuing to lay down webs of wires, pipes, sewers, roads, railways, and filling the airways with flight paths and communication channels all of which need to maintained in order to sustain lifestyles as we know them and whose contributions to the

---

[11] Steinfeld, *et al.* (2006) Reports that the livestock sector accounts for 18 percent of anthropogenic global greenhouse gas emissions measured in CO_2 equivalent.

[12] This term is borrowed from Rosen (2003) she explains "Biologists examining natural ecosystems observe that in nature living organisms are knit together with one another and with the natural world, drawing nourishment from the bodies and wastes of other organisms as well as from the water and minerals in the soil and the energy produced by the sun. So it is for industrial ecologists. They see that business is also woven into the natural world. Business enterprises feed on natural resources found in the earth, or energy ultimately derived from the sun, wind or geological forces deep within the earth, and on the manufactured inputs of their industrial supply chains. They return their wastes to the earth the seas, and the atmosphere." p. 320 I would want to add that business is also thoroughly woven into the human world and that its inputs also include human labor, management and economic capital.

[13] As Cronon (1983) importantly points out "…human groups often have significantly *unstable* interactions with their environments…. An ecological history begins by assuming a dynamic and changing relationship between environment and culture, one as apt to produce contradictions as continuities. Moreover, it assumes that the interactions of the two are dialectical. Environment may initially shape the range of choices available to a people at a given moment, but then culture reshapes the environment in response to those choices.p.13"

[14] An example of such a collapse is one of the factors Davis, (2001) pp. 309-10, cites for the severity of the famines in India and China in the nineteenth century. Lack of financial support for maintenance of irrigation systems led to what he calls an irrigation deficit leaving agricultural production highly vulnerable to ENSO cycles. More recently we have seen examples of infrastructure collapse and its aftermath with the fall of the USSR (see Oberg (2000) and a very interesting comparison in Orlov (2006) , the fate of Zibabwe, and Iraq after the fall of Sadam Husein.

environment that supports those lifestyles is largely invisible to and certainly incompletely known and understood by most of us. These infrastructure networks are the life support systems creating environments favorable to the effective functioning of many of our technological devices; it take energy and money and labor to maintain them. To the extent that our day-to-day existence is mediated by and dependent on the devices that depend on such networks, infrastructure networks have become factors in the human "struggle for existence". Thus they need to be included any accounting of the ecosystems that together make up our human environments.

How Sustainable are Extensive Infrastructure Networks?

A preliminary, unscientific sampling of available data and opinion would suggest that they are economically sustainable only for very wealthy regions. Even then there may be further questions about the sustainability of resource use. It seems clear that even were economic resources to be made available, installation of the kinds of infrastructure currently deployed in wealthy regions is not a viable and certainly not a sustainable option for the rest of the world. There are serious questions even about the sustainability of infrastructure maintenance in the United States, supposedly one of the wealthier nations.

The Government Performance Project[15], located within the Pew Center on the States, issues a report every three year's in which it grades each States performance on a number of measures of public interest. One of these is performance on infrastructure repair and maintenance. In their report for 2005 they say the following

> "... no matter how carefully planned a project is, it will deteriorate if states shortchange maintenance. This happens with some frequency: It's easy to put off a year or two of maintenance – especially when legislators are dealing with tight budgets. But if neglect becomes the status quo, the deteriorating quality becomes apparent and the costs of remediation climb."
>
> "The issue of unfunded maintenance is unquestionably the biggest problem for states in their management of infrastructure. Oklahoma, for example, budgeted no money for facilities maintenance last year. California, where to DOT has an impressive maintenance-management system, has shifted funds from maintenance to the state's general operating budget for the past two years. Colorado has an estimated $8 billion in deferred maintenance for rods and bridges. Pennsylvania's transportation maintenance needs are even high, clocking in at an estimated $10 billion."[16]

It should be remembered that States are not responsible for City and County infrastructure. So this report gives only a very partial picture.

In developed countries, such as the United States, people expect to have drinking water piped to their homes and to be able to flush away wastewater including sewage. Few give much thought to the infrastructure this requires or the costs associated with its maintenance. Americans consume approximately 550 L of drinking water per person per day (about 57 billion cubic meters). The treated water is transported through 1.4 million km of municipal water pipes all of which are subject to internal and external corrosion. In 2000 Water Infrastructure Network estimated cost of new investments, maintenance, operation and financing of the national drinking water system to be $38.5 billion per year and that of the sewer system at $27.5 billion per year. It also noted that current levels of spending on this infrastructure were insufficient to prevent large failure rates in aging infrastructure in the next 20 years.[17] In rural settings, especially with decreasing populations, the per capita cost of such infrastructure repair and maintenance starts to become prohibitive. An infrastructure report for West Central Minnesota is instructive in this regard. The report (at www.wcif.org) was the result of a study conducted for the West Central Initiative when it was discovered that no regional, state or federal source had been collecting

---

[15] www.gpponline.org

[16] The comments on Hawai'i, which gets a C- in this area (as opposed to Pennsylvania's B+) are more alarming "Hawai'i leaves an impression that it relies on performance measurements and other information to create its budget… In reality, the use of serious information to actually manage or budget in Hawai'i is about as rare as a blizzard in Honolulu." Needless to say there is a long list of backlogged maintenance.

[17] Brongers, Michiel P. H. "Drinking Water and Sewer Systems" at http://www.corrosioncost.com.

information on the status of community infrastructure. There was concern because much of the infrastructure was constructed in the 1930s as WPA projects. Now the systems are in poor repair, having outlived their design life. Communities lack the funds to repair or replace the facilities and if substantial resources are not provided in the near future the report concludes many communities in Greater Minnesota will be in jeopardy. The estimated immediate statewide need was $2.8 billion for wastewater, $3.2 billion for water, and $0.9 billion for storm sewers for a total of $6.9 billion. The per capita cost is highest for the smallest communities ($14,000 for communities of 200 or less, where average family income is also lowest as opposed to $4,000 for communities of more than 3,000).

By way of contrast, there are many millions of people crammed in to cities in less developed countries with virtually no infrastructure – no running water, no sewer system. This has reproduced many times over the appalling conditions of the early growth of European cities. Those cities eventually reduced the health hazards presented by large slums by building sewer systems and developing the infrastructure of water supply, flush toilets and sewers and destroying the slum dwellings. That path of solving the problem by implementing large, water based, infrastructure projects continues to be reflected in the thinking of water industrialists and even some quarters of the UN. Pearce (2003) suggests that there is good reason to question the wisdom of taking such an approach. Conventional sewer systems are argued to be expensive, to pollute rivers, to use a lot of water for flushing that could be set aside for drinking, and to deprive farm soils of nutrients. The solution suggested by representatives of the UN Environment Programme is a system (EcoSan) that involves composting sewage. In India there are also home-grown proponents of composting toilets, such as Bindeshwar Pathak founder of the Sulabh Sanitation Movement,[18] as the more sustainable solution to this particular waste disposal problem. The Sublabh movement has established some public composting toilets that incorporate bio-gas generation. One feature of these proposals is that they can be started and maintained without reliance of a large infrastructure network.

A very similar story can be told in connection with electrical supply. In a recent Press release the US Department of Energy Office of Public Affairs (http://www.energy.gov/print/4999.htm) said the following:

> Along with increased demand for electricity, we must recognize the need for higher reliability – to levels beyond those for which our grid system was originally designed. Consider this: a recent industry-funded study estimates that total electricity used by computer servers and other Internet infrastructure doubled between 2000 and 2005, amounting to 1.2% of total U.S. electricity consumption in 2005. At the same time, the current power infrastructure nominally maintains 99.99% reliability. But this statistic ignores momentary interruptions. Current reliability practices may be adequate to keep the lights on and the motors running; but today's microprocessor-controlled electrical devices can be affected by power interruptions or distortions lasting a few seconds – or even much less.
>
> Despite increasing demand, we have (paradoxically) experienced a long period of underinvestment in power generation, power transmission, and infrastructure maintenance. The reasons are many and complex they range from changing market dynamics, to issues related to siting and permitting, to environmental concerns. On top of that, as it has become more and more burdened, the grid system has become more susceptible to both human errors and natural disasters such as hurricanes and ice storms which we have experienced recently with devastating consequences to the well-being of our people and to our economy. And, I would just add that we cannot ignore the threat of terrorism that our country continues to face. Improving the physical security of our grid is a very significant challenge.
>
> So, to summarize, these are just some of the factors weighing on a delivery system already under duress: steady demand growth that will continue into the future an increasing need for higher reliability a greater reliance on generation sited far from load centers a long period of under-investment in transmission facilities and a heightened susceptibility to errors and disasters – be they natural or man-made. I don't mean to sound overly bleak after all, our system is working and, generally speaking, working well. But it is aging, and it is stressed. This problem was highlighted in President Bush's National Energy Policy of 2001, and while we've made progress,

[18] See Pathak (2004)

it remains a significant challenge for this country.

Large infrastructure networks are vulnerable to disruption and for this very reason military strategists wanted an information infrastructure that was decentralized (now the world wide web). Whereas some energy suppliers see hydrogen as an attractive alternative vehicle fuel because it could use traditional distribution systems, dependent on delivery from large corporate suppliers, the military is exploring hydrogen as an alternative vehicle fuel that could free vehicle operation from dependence on long supply lines. This is possible using modular electrolysis units for producing hydrogen and using solar panels to provide power for electrolysis. If we know that in the longer term large infrastructure networks are increasing likely to suffer disruption for lack of maintenance, it would seem sensible to follow the military's lead and seek to design and deploy technologies that are "modular", but unlike the military, for whom cost is rarely a controlling factor, to think about modular technologies that can work with and be adapted to local conditions, rather than seeking to be invulnerable to their variations.

It was that the realization that predictability and control could be secured by creating uniformity and externalizing natural environmental variations that set us down the path of creating environments for technological devices. To avoid being locked-in by our own infrastructure dependencies and their associated maintenance costs, would require moving back in the direction of place-based technological solutions, using locally available materials where possible, with devices designed either to be relatively impervious to environmental variation, or pervious by design – designed to be able to take advantage of features specific to a local environment. [19] Global warming is a statistical phenomenon since the globe does not have a temperature. Each locality will be affected differently. The rise in concentrations of atmospheric carbon dioxide affects all regions, but human actions generating such emissions (and those of other greenhouse gases) are concentrated in localities and do not occur uniformly around the globe. Globalization has meant that for some purposes there is no distinction between global and local. The challenge is to how to retain some of the benefits of global interconnectedness while weaning ourselves off dependence on those connections whose maintenance is both economically and environmentally the most burdensome. Globally the strategy would be to give serious consideration to variations in local conditions in our effort to reduce global greenhouse gas emissions and to create more sustainable human environments.

[19] For example the British Soil Association recently proposed that food that has been transported by air-freight should not in future be certified as organic. This is part of a campaign to reduce the distance between producers and consumers of food and thus the amount of fossil fuel required to get food from one to the other.

References

Blackbourn, David 2006 *The Conquest of Nature: Water, Landscape and the Making of Modern Germany*, New York: Norton & Company Inc.

Canguilhem, Georges 1988, *Ideology and Rationality in the History of the Life Sciences*, trans. Arthur Goldhammer, Cambridge Mass.: The MIT Press. Originally published as *Idéologie et retionalité dans l'histoire des sciences de la vie: Nouvelles etudes d'histoire et de philosophie des sciences*, Paris: J. Vrin, 1977.

Canguilhem, Georges 1985, *La connaissance de la vie*, Paris: J Vrin.

Cooper, Gregory J. 2003, *The Science of the Struggle for Existence: On the Foundations of Ecology*, Cambridge, UK: Cambridge University Press.

Cronon, William 1983 *Changes in the Land: Indians, Colonists and the Ecology of New England*, New York: Hill and Wang.

Davis, Mike 2001 *Late Victorian Holocausts: El Niño Famines and the Making of the Third World*, London and New York: Verso.

Diamond, Jared 1999, *Guns, Germs and Steel: The Fates of Human Societies*, New York: Norton.

Elvin, Mark 2004 *The Retreat of the Elephants: an environmental history of China*, New Haven and London: Yale University Press.

Ferguson, Eugene, S. 1992, *Engineering and the Mind's Eye*, Cambridge Mass.: The MIT Press.

Gillispie, Charles Coulston 1951, *Genesis and Geology: The Impact of Scientific Discoveries upon Religious Beliefs in the Decades Before Darwin*, New York: Harper Torchbooks.

Kunstler, James Howard 2005, *The Long Emergency: Surviving the End of Oil, Climate Change, and Other Converging Catastrophes of the Twenty-First Century*, New York: Grove Press.

Lansing, J. Stephen 1991, *Priests and Programmers: Technologies of Power in the Engineered Landscape of Bali*, Princeton : Princeton University Press.

Latour, Bruno 1988, *The Pasteurization of France*, trans. Alan Sheridan and john law, Cambridge Mass. and London: Harvard University Press. Originally published as *Les Microbes: guerre et paix suivi de ireductions*, Paris: Editions A.M. Métailié, 1984.

Latour, Bruno 1993, *We Have Never Been Modern*, trans. Catherine Porter, Cambridge, Mass.: Harvard University Press. Originally published as *Nous n'avons jamais été modernes: Essais d'anthropoloie symmétrique*, Paris: La Découverte, 1991.

Latour, Bruno. 2004, *Politics of Nature: How to bring the sciences into democracy*, Harvard: Harvard University Press.

Norton, Bryan G. 2005, *Sustainability: A Philosophy of Adaptive Ecosystem Management*, Chicago and London: The University of Chicago Press.

Oberg, James 2000, "Russia's Sorry Infrastructure" SPECTRUM (IEEE), December (http://ieeexplore.ieee.org/Xplore/login.jsp?url=/iel5/6/19179/00887596.pdf)

Orlov, Dmitry 2006 "Closing the 'Collapse Gap': the USSR was better prepared for peak oil than the US" in *Energy Bulletin*, 4 December (http://energybulletin.net/23259.html).

Pathak, Bindeshwar 2004 "Sulabh Sanitation Technologies to achieve Millenium Development Goals on Sanitation", paper presented to the Delhi Sustainability Summit 2004. (http://www.teriin.org/dsds/2004/papers/abstract2.pdf)

Pearce, Fred 2003, "Composting toilets key to global sanitation, say scientists", *New Scientist* 18 March 2003.

Rosen, Christine Meisner 2003 "Industrial Ecology and the Transformation of Corporate Environmental management: A Business Historian's Perspective" in Molella, Arthur and Bedi, Joyce ed. *Inventing for the Environment*, Cambridge Mass.: The MIT Press.

Serres, Michel 1982 "Lucretius: Science and Religion" pp.98-124" in *Hermes: Literature, Science, Philosophy*, ed. Josué V. Harari and david F. Bell, Baltimore, Maryland: Johns Hopkins University Press. Originally published as Conditions culturelle. Violence et contrat: Science et religion" in Michel Serres *La Naissance de la physique dans le texts de Lucrèce: Fleuves et turbulences*, Paris: Minuit, 1977.

Sobel, Dava 1995, *Longitude: The True Story of a Lone Genius Who Solved the Greatest Scientific Problem of His Time*, Harmondsworth, Middlesex, U.K.: Penguin Books.

Steinfeld, Henning; Gerber, Pierre; Wassenaar, Tom; Castel,Vincent; Rosales, Mauricio; deHaan, Cees, 2006, *Livestock's Long Shadow: environmental issues and options*, Food and Agriculture Organization of the United Nations, LEAD website http: www.virtualcentre.org

Whiteside, Kerry H. 2002, *Divided Natures: French Contributions to Political Ecology*, Cambridge, Mass. and London: The MIT Press.