# TECHNOLOGY AND CHANGE IN THE BIO-ENVIRONMENT: SOME CONTRIBUTIONS TO PROCESS THEORY

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Changes in the bio-environment (a composite term which may be taken to include all those physical and organic constituents which comprise it, as well as the all-important interlinkages between them) are taking place continuously. No environment is completely stable in its natural state, except for the shortest possible periods of time; and nor the normal patterns of competition will see to that. Additionally, all animal and plant populations oscillate in their sizes around mean population figures in a very complex manner, and these oscillations will trigger off minor environmental changes as well. Cycles of change in the environment, the most significant of which are climatically-induced, are endemic everywhere, some short-term, lasting for only a few seasons, and others on a much broader front, effective over some tens of thousands of years. Other world-wide environmental changes have been set in train by man in recent years, such as the increase since the 1870's in atmospheric carbon dioxide levels of from 260 to c 380 ppm (by volume), though the potential effects of these are far from being fully understood as yet. Chlorofluorocarbons released from sprays and hard foams are likely to be influencing the extent of the high-altitude ozone layer in the atmosphere, and limiting its effectiveness as a protection against excessive ultra-violet radiation arriving from solar sources. Other human-induced influences are much more direct, quickly affecting bio-environmental resources, often in a negative way and, unless constrained, they may lead to such features as excessive deforestation, erosion and plant and animal extinction's.

In any environment in which mankind is present, modification is brought about by adaptation to changing circumstances. It has recently been suggested (Kirch, 1980) that such adaptation should be regarded as referring to the means whereby people become and remain viable, capable of reproducing and sustaining themselves in that environment. In turn, this may be taken to involve all the processes of change taking place in a group as it responds both to the evolution of the bio-environment in which it lives, and to internal demographic, economic and organisational stimuli. Increasing population pressure on biological resources is one well-known instigator of change, in almost every group which has encountered it. The process can hardly fail to exclude as well those externally-imposed economic, political and social forces which affect virtually all environments and their development, metropolitanism (the control of market and developmental forces by one major urban centre) being one of the most long-standing and persistent of these. Not least among these forces are those of technology, with which this section of the conference is particularly concerned. Technology may be endemic to particular areas, or imposed upon them; but, whichever the case, the impact of technological innovations on the bio-environment may vary according to the understanding and perception of them by the social systems which use them, or as a response to the nature of the bio-environment itself. In recent years, albeit with notable exceptions (China is one of them), it must be said that endemic technologies are rapidly being replaced by world-wide ones, and this undoubtedly increases the chances of their being misused and misunderstood in bio-environments and social systems which lie some distance from their source.

Not all available technology will of course reach every part of the world which is open to it: a selective filtering process appears to operate once the export of technology is under way. Customarily, this is related to the existence of particular patterns of resistance to change in districts which are recipients of the new ideas. The classic case is that of the agricultural revolution of north-west Europe in the seventeenth and eighteenth centuries, technologies from which were exported largely "en bloc" to North America. In the West Indies, however, where they might also have been used effectively at the time, they had only a marginal impact on the estate agriculture which was prevalent there. During the seventeenth century, for example, technological innovations in manuring, and in the use of the windmill, were transferred from north-west Europe, as also (for a short time only) the use of the plough into Martinique, though not elsewhere; but very little else was. In the eighteenth century, more agricultural-revolution innovations were transferred at more general level into the island Caribbean, though some further filtering did take place, irrigation for example being taken up only in those islands occupied by the French, who were the foremost irrigation engineers of the age. The use of the wheelbarrow was abhorred by all, it being regarded by estate owners and slaves alike not as an easement of labour, as it was thought to be in north-west Europe, but as an item which would destroy established work routines, and even threaten the future of estates themselves. Similar instances to these may be seen in other cases of technological transfer, right through to the present day.

Once technology has been exported to other areas from source, or has been developed endemically, it is clearly then useful for a wide range of parties to be able to have some idea as to what extent it might modify, for better or for worse, the bio-environment. Certain key factors appear to be important here, and they may me summarised in the following equation:

$$D\ B/E=f\ (A, NE, FM, IS, C, EM)$$

which, interpreted, means that any possible changes in the bio-environment arising out of technological innovations will be a function of the area (D=size) of the district in which the innovation has been introduced, the nature of its bio-environment (NE), the extent of the natural feedback mechanisms within that environment (FM), the institutions of settlements (S), the intensity of cropping (C), and the pattern of bio-environmental management (EM) within it. Some further elaboration is perhaps required.

It is well-known ecological premise that, all other things being equal, small areas (and, especially, small island areas) are more vulnerable to change than larger ones. Smaller areas tend to have fewer component plants and animals within them, and their ecological and environmental networks are usually simpler and more fragile than those of larger areas: breaks in these networks arising out of new technologies are accordingly frequently more easy to initiate, and once initiated, the consequences to the bio-environment are often more devastating. Rates of extinction are always greater on small islands than on larger ones, or in areas of equivalent size on continents, in which the species mix is greater. Thus in Barbados, large numbers of forest species, both plant and animal, were made extinct within 20 years between 1645 and 1665, as the island was cleared wholesale to make way for sugar estates; yet, in the much larger island of Espanola (Haiti and the Dominican Republic) in the same chain, where "refuges" are more common, many forest plants and animals in remote areas have remained virtually undisturbed to the present day. World-wide, many island species, and especially small-island species, represent very specialised forms which are intolerant to those changes induced by technological innovations, whereas continental species in general have much greater competitive abilities, and a greater capacity to survive such changes.

It is clearly important to have a thorough understanding of the environment into which a particular technology is to be introduced if, as is usually the case, it is not the same as that of the sources area. For example, very different patterns of weathering, nutrient and water flow, soil-bonding capacities, erosivity and erodability prevail generally in the wet tropics as compared to template latitudes, and these also vary widely on a micro-scale. Tropical plant and animal communities too are much more complexly interactive than in temperate lands. It is additionally still not generally realised that, in many tropical regions, most of the nutrient store lies in the vegetation and not the soil, so that once forest is cleared wholesale to make way for techno-centric agriculture (the processes are essentially the same today in Brazilian part of the Amazon basin as they were in seventeenth-century Barbados, above, albeit that the technology has advanced), relatively few nutrients remain to encourage the development of the latter. Environmentalists which experience potentially severe conditions every now and then, such as earthquakes, volcanic activity, periodic flooding or phases of drought, also require more care than most in the initiation of new technologies. Those with steep slopes, heavy seasonal rains, and high water tables, fall into the same category. All this perhaps needs to be restressed at intervals, since the same bio-environmental mistakes arising out of land-development by new technologies tend to be repeated over time. As regards feedback mechanisms, the more there are of these in bio-environments, and in the social systems which use them as well, the less the danger that adverse reactions will set in as a result of such development.

Institutions of settlements provide the political and legal framework for the fixing of technological innovations into particular bio-environments, and they may be favourably disposed towards them, or reactive against them. In aboriginal times in the West Indies, for example, these often took into account the nature of the bio-environmental milieu, and ensured that chosen technology was well adapted to it. Thus, over 6 million Indians in that region were able to live comfortably, utilising a sound and sustainable agricultural base with a sophisticated array of crops, for several centuries prior to 1492, while in contrast the handful of Europeans who replaced them, using Iberian institutions of settlement which were not suited to the environmental complexity of the region, created a massive environmental disturbance, and huge erosional scars, within the space of a few years, notably within the confines of the Greater Antilles (Watts, 1987). When sugar cane estates later came to be established by the English and French, these usually involved total land clearance, and all too often similar bio-environmental effects.

Where the institutions of settlement controlling sugar cane development and technology then broke down, as during the St. Domingue revolution of 1791-1804, the worst bio-environmental changes of all were instigated in the form of the major gulled wastelands which evolved on former estateland, specially in the north of the country, and these subsequently have been extended and expanded over large areas through to the present day. The dominant process involved the destruction of irrigation channels along mountain sides, and the consequent cascading of water downslope in considerable quantities. One other factor is important here, namely that literacy is absent in most of the population of post-revolutionary St. Dominique, or Haiti as it came to be called. It is perhaps no accident that erosion on such a scale in the Caribbean has developed only in Haiti, where literacy levels have remained persistently below 10%. Elsewhere any tendency towards its emergence has been curtailed as literacy levels have improved and techniques learnt to prevent or control it. One cannot fail to note the correlation in this region: Caribbean experience points strongly to the fact that adequate education levels are extremely important in the preservation of bio-environmental quality at acceptable levels. especially in environments which may be difficult. Today one should seek to provide a wider understanding of the potential dangers to the bio-environment of the introduction of ever-more complex technologies at every possible educational level, but perhaps especially in the early school years, when major attitude-forming takes place.

The intensity of cropping tends to reflect population, social and economic pressures, and wherever these are increased beyond a comfortable level for a given area, technological innovation is introduced to dispel them: the case has been admirably made by Esther Boserup, as long ago as 1965. In turn, such innovation then also reacts on the bio-environment. Bio-environmental management, relating to particular types of technology, may either aggravate habitat changes, as in the too-thorough clearance of timber my mechanical or other means on steep slopes (the Himalayas today), or along arid-land fringes (the Prairie regions of North America one century ago); or restrain them, as in conservationally-oriented agriculture.

To conclude, one may argue that naturally-induced and technologically-induced changes in the bio-environment always need to be looked at in conjunction with each other, for their patterns are often interlinked. Nevertheless, a separation of the one group form the other is also essential if one is to understand thoroughly the effects of technology on particular environments, and vice versa: this separation is, however, at times difficult to achieve. A micro - rather than a macro - scale approach is perhaps best suited for this, though without forgetting the macro-scale imperatives.

**References**

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