

Ecosystems and World Systems: Accumulation as an Ecological Process¹

by

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World-systemic processes of capital accumulation are inextricably intermeshed with ecology. Not only do they have obvious repercussions on landscapes and ecosystems (e.g., erosion, deforestation), but they are also fundamentally *dependent* on ecological assets such as topsoil, forests, or minerals. The analytical disjunction of ecology and economics is a persistent feature of modern science. The minority of researchers who have seriously tried to integrate them in a common theoretical framework (cf. Martinez-Alier 1987) have run into major, conceptual difficulties. This paper addresses some of the issues raised in an attempt to ground the notion of *capital accumulation* in the physical realities of ecology and thermodynamics (cf. Hornborg 1992, 1998).

There are two bodies of data that would need to be brought together, if we are to get a fuller picture of the last few centuries of global environmental change. On the one hand, there is the tangible evidence from paleobotany, geology, and other natural sciences of long-term changes in vegetation, soil quality, and other parameters. On the other hand, there is the record of economic history, plotting the expansion and decline of centers of accumulation founded on various regimes of production and trade. Both types of data are easily and regularly represented in the form of *maps*. It would be most useful if maps could be developed which highlighted the very *connections* between economic history and changes in land cover. An example of the kind of work I mean would be Christiansson's (1981) study of the imprint of 19th century caravan trade on the vegetation and soil of Tanzania. Another example would be Chew's (1997) attempt to outline connections between the dynamic of world system accumulation and deforestation from 2500 BC to AD 1990.

Making such connections clearer would be an important corrective to the illusion of a "disembodied" economy which seems to underlie mainstream economic thought. A "greening" of world system theory could thus serve as an empirical complement to the emerging field of "ecological economics" (Martinez-Alier 1987). It would also provide a deeper understanding of the complex relationship between issues of ecological sustainability, on the one hand, and issues relating to the global distribution of resources, on the other. Although the connection between these two threats to human survival have been at the center of attention since the UNCED conference in Rio de Janeiro in 1992, its fundamental logic continues to escape us as we reiterate the conventional rhetoric on "sustainable development".

In several articles (Hornborg 1992, 1993, 1998, *in press*), I have argued that the capacity of technological systems and other social institutions to *shift resource extraction to less empowered social categories* renders ecological and distributional issues inseparable. To restrict attention to either type of issues is to miss the complete picture. Ecological conditions are implicated in all processes of accumulation, and such processes of accumulation in turn tend to transform ecosystems. It would be impossible to understand the global polarization of rich and poor without reference to ecological factors (such as net energy transfer; cf. Bunker 1985), just as it would be impossible to understand the expansion of unsustainable technological systems without reference to unequal, global exchange. Yet, the hegemonic doctrines of economics remain impervious to *both* these issues, i.e. the material and the moral correlates of capital flows, the first by ignoring the laws of physics (Georgescu-Roegen 1971), the second by assuming, as an implicit axiom, that (non-coerced) market prices by definition are just and fair.

Challenging these dominant doctrines, I would advocate an ecologized version of dependency theory, that recognizes the world market and modern technology as more of a zero-sum game than a cornucopia. What we have long perceived as "development" is basically a manifestation of capital accumulation, and capital accumulation has always been an uneven and inequitable process, generating an increasing polarization between "developed" centers and "underdeveloped" peripheries. Against this background, the faith of the Brundtland report in global economic growth as a road to equity and sustainability is not very persuasive. We need only recall Wackernagel's (1997) observation that global equity along Western standards of living would require three additional Earths.

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How do we conceptualize the interface between ecosystems and world systems? It is my conviction that all the major issues of global survival (environmental destruction, resource depletion, world poverty, armament) can ultimately be traced to capital accumulation. The concept of "capital", however, continues to elude stringent analysis. To many authors (Marx included) it has an aspect that leads us to think of a material infrastructure of some kind. On the other hand, it suggests abstract wealth, or purchasing

power. This is the dimension of capital emphasized, for instance, by Max Weber. It is also the perspective that has achieved hegemony both in standard economics and in world system theory (cf. Wallerstein 1974-1989, Braudel 1979, Frank 1978), suggesting a disembodied, immaterial force moving about the planet in pursuit of rewarding investment opportunities. In advocating a revival of Aristotle's distinction between *oikonomia* and "chrematistics" (Martinez-Alier 1987, Daly & Cobb 1989), the proponents of "ecological economics" in a sense join forces with Marx in trying to show how the symbolic and the material interact. There are a lot of obstacles on the way, however. Most "ecological economists" are as ignorant of world system theory as Marx was of thermodynamics.

The absence of a common definition of "capital" has made it difficult for historians to date the origins of "capitalism". The orthodox, Marxist definition (involving industrial machinery and the commoditization of labour) would date capitalism no earlier than eighteenth-century England (cf. Wolf 1982). If the focus is shifted from industrial to merchant capital, and to production for the world market as the basic criterion, "capitalism" recedes backward in history. Wallerstein (1974) traces it to the sixteenth century, Braudel (1979) to the thirteenth, and finally Frank (1995) collapses the concept entirely by identifying capital accumulation and a world system as far back as 3000 B.C.

The old debate between "productionists" and "circulationists" is resolved by recognizing "industrial capitalism" and "merchant capitalism" not as different historical stages, but as strategies for accumulation practiced by different agents in the same system. Industrial capitalism could thus be viewed as the latest in a series of local "modes of production" anchored in material infrastructures of different kinds, whereas supra-local strategies of merchant capitalism have always integrated such local production processes in larger reproductive totalities. It is the complex interdependency of local and supra-local strategies that tends to obscure this analytical distinction.

Let us systematically consider the various strategies possible. We may speak of them as *modes of accumulation*, or simply *ways of increasing one's access to resources*. The strategies can be grouped into five main categories:

1. The first and simplest category is *plunder*. There are good reasons to believe that it is as old as the human species. To this category belongs, for instance, the practice of bride capture, horse raids, slave raids, and colonial wars of conquest.
2. The second major category is *merchant capitalism*, or the exploitation of cultural differences in how goods are evaluated ("buying cheap and selling dear".) This strategy can certainly be traced back thousands of years, e.g. to the ancient tin-silver trade between Assyria and Anatolia in the second millennium B.C. (Yoffee 1988). Merchant capitalism does not *in itself* imply any form of material (infrastructural) "capital", but historically it has generally required some form of transport apparatus, e.g. ships, wagons, horses, camels, donkeys, or llamas, as well as a military apparatus to protect its interests.

3. The third category is *financial capitalism*, or the servicing of debts. Demanding interest on credit can be traced back to ancient Sumer in 3000 B.C. It was controversial in Europe prior to its explicit legitimization in the Reformation. Today it is the major institutional means by which resources from the "underdeveloped" South are transferred to the affluent North. Financial capitalism does not either *in itself* imply material capital, but tends to require a voluminous financial bureaucracy, judicial apparatus and police force, both nationally and internationally.

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4. The fourth category is *undercompensation of labour*. I would specify "undercompensation" as referring to the relation between what the labourer produces and what he or she gets in return, either in terms of labour time, energy, resources, or money. Various cultural strategies are applied. (a) The most obvious form is coercion, i.e. *slavery*, known at least from the time of the earliest urban civilizations and particularly essential to the economies of ancient Greece and Rome. (b) The most ancient form is undoubtedly that which may occur in conjunction with gift exchange or barter, i.e. transactions conforming to the principle which Karl Polanyi (1944) called *reciprocity*. It has been shown that even the direct exchange of simple, manufactured items between tribal groups can entail an asymmetric transfer of labour time (Godelier 1969). (c) The classic form is associated with the principle which Polanyi called *redistribution*. It has been characteristic of chiefdoms, states, and empires, where it is usually quite easy to show that the grassroot producers deliver more tribute, taxes, etc. to the centers of power than is returned to them, or those centers would not survive. (d) The most subtle form is wage labour, which belongs to Polanyi's third principle, the *market*. Marx showed that capitalist accumulation can be based on the difference between the value of what a labourer produces and the wages that he or she is paid, i.e. the difference between the output and the cost of labour.

The first of these forms (4a), like category 1, differ from all the rest in not involving some form of cultural persuasion, i.e. in not requiring that the exploited party subscribes to some particular form of ideology which represents the exchange as reciprocal or at least legitimate. In all the other cases listed in this typology, there are fundamental, cultural concepts - "price", "interest", "wage", etc. - that have to be shared by both parties in order for the mode of accumulation to operate.

5. The fifth and final category is *underpayment for resources*, including raw materials and other forms of energy than labour. Again, by "underpayment" I refer to the relation between the quantity of finished goods or services that these resources can be converted into (their *productive potential*, so to speak) and the fraction of that quantity (or equivalent of it) which is obtained in exchange for them. The nature of the resources involved is geared to the technological mode of production and the kind of material infrastructure that needs to be reproduced. (a) For pre-industrial, urban manufacturing

centers, mines or specialized slave plantations, a major source of energy are the *foodstuffs* imported to maintain the labour force. (b) For the maintenance of draught animals, caravans, or cavalry, the major source of energy is *fodder*. (c) For most workshops or industries, finally, the primary energy resource is *fuels*. As mentioned, specific kinds of raw materials (e.g., ores or fibres) may also be required and underpaid in the process.

We could define "undercompensation" and "underpayment" as a condition in which the exchange rates allow the manufacturer to increase his relative share of the system's total purchasing power, at the expense of the groups delivering labour power, energy or raw materials. By "purchasing power" I here mean something more general than money, viz. the *symbolic capacity to make claims on other people's resources*. If the total purchasing power was constant, it would not be hard to conclude that any increase is unilateral and that the system is obviously a zero-sum game. However, the total purchasing power in a system can obviously expand (e.g. by striking gold or printing more money), which gives the illusion of global "growth" and tends to obscure its zero-sum properties. Nevertheless, any increment in one party's *relative* share of that power will alter the exchange rates, or terms of trade. Such relative increments are often self-reinforcing, since the altered terms of trade in material goods and resources may increase the aggrandized party's capacity to accumulate an even greater share of the purchasing power, and so on. In other words, even if the system as a whole gives the appearance of "growing", any increase in the *relative* share of total purchasing power will be at the long-run *expense* of another party, since it will aggravate unequal exchange and systematically drain the latter's labour (cf. Emmanuel 1972) or other resources.

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Let us now apply these perspectives to a classic example of accumulation, the triangle trade between Europe, West Africa and America, in order to consider how different modes of accumulation can be combined in the same system. Merchants carried manufactured goods such as rifles and textiles from England to Africa, where they were exchanged for slaves. The slaves were then transported to America and sold in exchange for cotton and other plantation produce. Finally, the cotton was brought back to England and exchanged for manufactured goods. The completed cycle involved several points of accumulation, enriching merchants, African chiefs, American plantation owners, and British industrialists. With reference to the typology offered above, we can detect, within this trading system, the occurrence of *all* the modes of accumulation mentioned: 1. European and African slave raiders pursuing their victims, 2. European merchants exploiting cultural differences between three continents, 3. Merchants, cotton growers, and industrialists servicing their debts to European bankers, 4a. American slave owners thrashing their African labour, 4b. African chiefs bartering slaves for rifles, 4c. African commoners paying tribute to their chiefs, 4d. British textile workers collecting their wages, 5a. slave owners bargaining for cheap corn and wheat to feed their slaves, 5b.

American grain merchants buying fodder for their horse-drawn transports to the eastern slave plantations, and 5c. British industrialists haggling the price of cotton and coal.

All in all, this combination of strategies within a larger, reproductive totality provided the conditions for the Industrial Revolution. Marx' theoretical edifice on "capitalism" was built on the observation that the local mode of production in England combined strategies 4d and 5c, i.e. wage labour and mechanization. But rather than an historical stage, industrial capitalism should be understood as a functional specialization within a larger field of accumulative strategies. Rosa Luxemburg (1951[1913]) was probably the first to see the full implications of this. Still today, industrial capitalism is very far from the universal condition of mankind, but rather a privileged activity, the existence of which would be unthinkable without various other modes of transferring surpluses of labour and resources from peripheral sectors to centers of accumulation at different spatial scales.

The debate about whether to define "capitalism" in terms of merchant or industrial capital can thus only be solved by recognizing that circulation and production are mutually interdependent. In relying on fossil fuels and combustion engines, industrialization was certainly revolutionary, but the growth of a material infrastructure through unequal exchange was not an innovation of eighteenth century England. In order to trace such processes further back in history, as would Wallerstein, Braudel, and Frank, we would need to widen Marx' concept of "capital" so as to make it more abstract and inclusive, both in its symbolic and its material aspects. I have elsewhere (Hornborg 1998) argued that such an extended concept of "capital" could be defined as *a recursive (positive feedback) relationship between some kind of technological infrastructure and some kind of symbolic capacity to make claims on other people's resources*. Such a general understanding of capital accumulation would be as applicable to the agricultural terraces of the Inca emperor in ancient Peru as to the textile factories of eighteenth century England. What the two examples have in common is the recursivity between the symbolic and the material. In both cases, the material infrastructure is used to produce an output that is culturally transformed (i.e. through the mediation of symbolic constructs) into more infrastructure. Industrial machinery is only the latest version of infrastructure, wage labour only the latest version of cultural persuasion.

Marx was too focused on labour to see that exploitation could also take the form of draining another society's natural resources. Nor could he see Luxemburg's (1951[1913]) crucial deduction that capitalism could never constitute its own, self-contained market. He was thus able to put his faith, like his contemporaries, in the global, emancipatory potential of the industrial machine. As the twentieth century draws to a close, however, mounting global inequities give us reason to reexamine the promise of the machine. Could the industrial infrastructures of Europe, North America and Japan *exist* without the abysmal gap between rich and poor? Or are they one and the same, inextricably linked, as the material and the social dimensions of a single, global phenomenon?

The global gap is deepening (cf. Adams 1993), yet, ironically, dependency theory has been on the wane. A major problem for its opponents seems to be the difficulties they are having in visualizing "metropolis-satellite" (Frank 1966) or "core-periphery" (Wallerstein 1974) relationships and "surplus exploitation" as spatial, material realities (cf. Brewer 1990:168-169). There is often a tenuous congruity between the different spatial parameters that one can think of. Where are the investments made? Where do the capitalists live? Where are their bank accounts? Where is the infrastructure being accumulated? Where are the products consumed? These difficulties can be alleviated, I believe, by thinking less in terms of national trade statistics and more in terms of net flows of energy and materials, irrespective of political boundaries. Nightly satellite images of luminescent technomass in Europe, Japan and eastern North America are convincing evidence of the material reality of center-periphery relationships.

A "greening" of world system theory essentially means supplementing the labour-oriented, Marxist concept of exploitation (focused on category 4 above) with a resource-oriented one (category 5). A lot of analytical work remains to be done, however (Bunker 1985, Martinez-Alier 1987, Hornborg 1998). An important step is to see that human economies rely on two types of resources, *labour time* and *natural space*. These correspond to the two factors of production known as "labour" and "land". They can be variously combined and transformed into material infrastructure ("capital"), generally for purposes of saving time and/or space for somebody. This is the essence of human technology: the *use* of time and space to *save* time and/or space for *some social category*. Technology or capital thus amounts to a way of *redistributing* temporal and spatial resources in global society. The time saved by nineteenth century train passengers (relative to stagecoach) should be weighed against the time spent by steel and railway workers to make these train rides possible. Similarly, the space (land) saved by more "efficient" (intensive) forms of industrial agriculture in nineteenth century England should be weighed against the space elsewhere devoted to making this local mode of production possible, e.g. cotton plantations in America, sheep pastures in Australia, and mines and forests in Sweden (cf. Wilkinson 1973, 1988). More recently, we could add the land devoted to provisioning industrial farmers with fossil fuels, chemical fertilizers, pesticides, machinery, biotechnology, etc. In becoming interfused with one another in "capital", moreover, the economies of time and space are rendered indistinguishable, so that time saved can represent space lost, and vice versa. Perhaps it is in the very nature of advanced technology that one party's gain of time or space is some other party's loss.

A major handicap in our pursuit of a clearer understanding of these relationships is the fact that most trade statistics are in monetary units, rather than invested labour time, energy, or hectares. Let me give an example of how this can lead us astray. Opponents of Emmanuel's (1972) argument that low-salary countries were victims of unequal exchange suggested that the import into developed countries of produce from the developing countries was too marginal (2.5% in 1965) to be of any significance to the condition of either category. Emmanuel replied, however, that if salaries had been the same as in the advanced countries, the cost of that import would have been ten times as high, or

equivalent to 25% (Brewer 1990:208). Brewer (ibid.) writes that one can "doubt whether anything like the same volume of trade would take place at these prices," but this, of course, is precisely the point. The entire rationale of the trade is the asymmetric transfer of labour time. Statistics in dollars obscure the real transfers in hours of labour. Similarly, if invested energy (Odum & Arding 1991) or hectares (Wackernagel & Rees 1996) were counted instead of dollars, the significance of imports from the South would be recognized as much greater than that suggested by monetary measures. Still, even the dollar-based G.A.T.T. statistics reflect a fundamental feature of global, center-periphery relationships: in 1984, fuels accounted for 46.8% of exports from "developing areas", but only 7.8% of those from developed countries (cf. Chisholm 1990:96).

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If I have been preoccupied more with the dynamic of world systems than with the transformations of ecosystems, it is because we are so much better acquainted with the latter. I need here only hint at the connections between the two types of systems. Let us return to the trans-atlantic trade and briefly consider some of its ecological repercussions. Without this particular constellation of accumulative strategies, England would not have industrialized in the eighteenth century, and the environmental history of the past few centuries would have taken a different course (Worster 1988). The soils of the American South would not have been cultivated in such an abusive manner (cf. Earle 1988). The American wheat belt would not have been pushed as far into areas vulnerable to erosion. Australia and Argentine would not have been converted in such a wholesale fashion into pasture, nor the West Indies into sugar plantations. The deforestation of India would probably not have been as severe (Tucker 1988). The list can be extended indefinitely. These global, environmental changes are tangible imprints of the world system of capital accumulation. The industrial infrastructure of eighteenth century Lancashire grew not only from the sweat of the British proletariat and of African slaves, but from American soils, Australian pastures, and Swedish forests. Vast quantities of human time and natural space were exploited and intertwined in the process. After two hundred years, such concentrations of technomass in Europe, North America and Japan are still expanding at the expense of their peripheries and of global life-support systems. Capital accumulation is a blind, self-reinforcing process. Instead of just continuing to monitor its ecological effects, we urgently need to grasp its fundamental dynamics. Recent concepts such as "political ecology" (Johnston 1994) and "environmental justice" (Harvey 1996) recognize that such an understanding can only emerge from a consideration of how ecological issues and distributional issues are interfused.

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Notes

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