International Journal of Comparative Sociology

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International Journal of Comparative Sociology 2009; 50; 237
DOI: 10.1177/0020715209105141

The online version of this article can be found at:
http://cos.sagepub.com/cgi/content/abstract/50/3-4/237

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IJCS

International Journal of Comparative Sociology

http://cos.sagepub.com
Vol 50(3–4): 237–262
DOI: 10.1177/0020715209105141

Zero-Sum World

Challenges in Conceptualizing Environmental Load Displacement and Ecologically Unequal Exchange in the World-System

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Abstract

This article discusses various ways in which conventional discourse on sustainability fails to acknowledge the distributive, political, and cultural dimensions of global environmental problems. It traces some lineages of critical thinking on environmental load displacement and ecologically unequal exchange, arguing that such acknowledgement of a global environmental 'zero-sum game' is essential to recognizing the extent to which cornucopian perceptions of 'development' represent an illusion. It identifies five interconnected illusions currently postponing systemic crisis and obstructing rational societal negotiations that acknowledge the political dimensions of global ecology: 1) The fragmentation of scientific perspectives into bounded categories such as 'technology', 'economy', and 'ecology'. 2) The assumption that the operation of market prices is tantamount to reciprocity. 3) The illusion of machine fetishism, that is, that the technological capacity of a given population is independent of that population's position in a global system of resource flows. 4) The representation of inequalities in societal space as developmental stages in historical time. 5) The conviction that 'sustainable development' can be achieved through consensus. The article offers some examples of how the rising global anticipation of socio-ecological contradiction and disaster is being ideologically disarmed by the rhetoric on 'sustainability' and 'resilience'.

Key words: ecologically unequal exchange • machine fetishism • resilience • sustainability • world-system

INTRODUCTION

The social sciences in the early 21st century face a challenge so formidable that they may prove incapable of dealing with it, in which case our current capitalist civilization may well share the fate of ancient Rome and similar historical

instances of socio-ecological collapse (Tainter, 1988). This alarmist introduction is meant to underscore the urgency of the analytical task that I attempt to outline in this article. The currently globalizing connections through market exchange and technologies of trade and communication are widely celebrated as a road to a more integrated, prosperous, and even egalitarian future world, yet there is overwhelming evidence that precisely these connections continue to generate devastating ecological deterioration and increasingly severe inequalities within and between nations (Millennium Ecosystem Assessment, 2005; United Nations Development Program, 1998). Almost seven billion human beings are currently, to paraphrase Clifford Geertz, suspended in a global 'web of significance' that seems inexorably to bring us all closer and closer to socio-ecological collapse. There is nothing inevitable about this process, many of us are aware of its fundamental direction, yet we seem quite unable to halt it.

This incapacity to evade catastrophe has two basic aspects that are intricately interrelated. One is that our way of thinking and talking about the world prevents us from grasping or at least efficaciously questioning the mechanisms propelling this development. The other is that there are extremely powerful interests at stake. We are not all sitting in the same boat, as the metaphor goes. We are sitting in at least two different boats, but one is pulling us all toward disaster. There are definitely powerful social groups who have very much to gain – at least within the anticipated time-frame of their own lifetimes – from the current organization of global society. As Michel Foucault and many other social scientists have shown, it is precisely these social groups who tend to exert a primary influence over the way social processes are defined – and even questioned. The language devised to manage socio-ecological 'problems' viewed through such system-serving lenses will naturally constrain our capacity to actually 'solve' problems in the sense of changing the direction of societal development, which may well require fundamentally reorganizing social institutions. The language of policy and management thus tends to avoid questions of power, conflicts, and inequalities. Although conspicuously present – and increasingly problematic – in global human society, such issues are rarely identified as problems to be solved. There is rather a pervasive assumption of consensus with regard to appropriate policy and management.

A crucial challenge for social sciences struggling with these issues is that the global 'webs of significance' in which we are all suspended, and which are generally described for us in terms of flows of money and information, have very tangible material properties and consequences. These material aspects of global society are widely ignored in social science, in part because they implicate knowledge and methodologies generally reserved for the natural sciences. Nor can they be fully grasped by the natural scientists themselves, simply because these researchers generally have a poor understanding of society. Yet the logic of these material aspects of society – what are increasingly referred to as 'socio-ecological' systems – urgently needs to be understood (Berkes and Folke, 1998;

Hornborg and Crumley, 2007). But even here, in contemporary attempts to transcend the academic distinction between social and natural sciences, there is a clear divergence between perspectives emphasizing, respectively, consensus and conflict. In this article, I will take power, contradiction, and 'capital accumulation by dispossession' (Harvey, 2003) as a point of departure for understanding the disastrous course of current socio-ecological processes. In other words, I will argue that economic growth will generally tend to occur *at the expense* of other social groups. I will also briefly demonstrate why the hegemonic interpretations and policies that instead assume consensus (e.g. the functionalist discourse on 'resilience') are so misguided.

The article is divided into three parts. The first discusses how a population's perceptions of technology, economy, and ecology are conditioned by its position within global systems of resource flows, and how mainstream modern perceptions of 'development' can be viewed as a cultural illusion confusing a privileged position in social space with an advanced position in historical time. The second part traces some lineages of critical thinking on environmental load displacement and ecologically unequal exchange, arguing that such acknowledgement of a global environmental 'zero-sum game' is essential to recognizing the extent to which cornucopian perceptions of 'development' indeed represent an illusion. The third part, finally, offers some examples of how the rising global anticipation of socio-ecological contradiction and disaster is being ideologically disarmed by the rhetoric on 'sustainability' and 'resilience'.

1. MACHINE FETISHISM: TECHNOLOGY/ECONOMY/ECOLOGY AS CULTURE

In the mainstream language of policy for sustainable development, the words 'technology', 'economy', and 'ecology' are used in an unreflective, matter-of-fact way that suggests bounded categories of reality given once and for all and exempt from critical scrutiny. This is the language of positivism and simple empiricism, the diametrical antithesis to those traditions in social research that emphasize a deeper and second look at the surfaces of the world that present themselves to our senses. In this latter tradition I would include what David Harvey (1996) calls 'dialectics', but also the whole thrust of 'deconstruction' and 'defamiliarization' (Marcus and Fischer, 1986) that has characterized so much of the work in humanities and some of the social sciences in recent decades. Researchers from these traditions will find it easier to digest what I am now going to propose, viz. that our notions of 'technology', 'economy', and 'ecology' are *cultural* categories that train us to think about our socio-ecological realities in particular ways. These three categories represent overlapping phenomena, the analytical separation of which diminishes our chances of grasping the totality of which each gives a glimpse. The three concepts represent distinct and extremely influential fields of research lodged in separate academic faculties, yet each can simultaneously be used as a point of departure for extensive anthropological reflection on how mainstream thought is culturally constituted (e.g. Croll and

Parkin, 1992; Descola and Pálsson, 1996; Ellen and Fukui, 1996; Godelier, 1986; Gudeman, 1986; Hornborg, 2001; Ingold, 2000; Latour, 1993; Sahlins, 1976; Wilk, 1996). 'Technology' can thus be understood as referring to combustion engines and the development of new agrofuels, or it can be understood as a realm of fetishism, magic, and ritual. 'Economy' can be represented as dealing with market institutions and the measurement of GDP, or it can be thought of as concerned with ideology, permutations of reciprocity, and the driving forces of consumption. Finally, 'ecology' can be perceived as a biophysical domain of natural processes uncontaminated by human ideas and relations, or as the material-cum-relational substrate enveloping – and implicated in – all human life (including technology and economy).

David Harvey (1996) articulates the important but difficult ambition to bridge the divide between local particularities of experience, on one hand, and universalizing understandings of global socio-ecological processes, on the other. Much of the contemporary work in humanities and social sciences tends to focus on the former, to the exclusion of the latter. In this article I will have very little to say on local particularities of experience, but I agree with Harvey's conclusion that social science can and should try to account for how they are recursively related to global socio-ecological processes. A promising approach is to focus, as he does, on *money* as a social and cultural institution that generates 'space-time' as simultaneously an objective, political-ecological framework and a subjective experience (e.g. of 'time-space compression'). Money is the vehicle by which ideas about reciprocity and relations of exchange are translated into material processes capable of transforming not only human societies and technologies, but the entire biosphere (Hornborg, 2001). In looking at how different *kinds* of money can generate different kinds of material processes (or kinds of 'space-time'), we come closer to an understanding of what is required for us to actually make progress in our (rhetorical) pursuit of sustainability. My conclusion is that the only way of achieving 'sustainability' would be by transforming the very idea and institution of money itself (Hornborg, 2007c).

The main argument regarding 'machine fetishism' is that the modern concept of 'technology' is a cultural category (Hornborg, 1992, 2001). It refers to what is technically feasible to achieve at a given time and place, but remains largely oblivious to the extent to which a local increase in technological capacity is a matter of shifting resources from one social category to another within global society. The notion of 'fetishism' can be applied so as to suggest that the apparent generative capacity of machine technology is an instance of how the attribution of autonomous productivity to material artefacts can serve to conceal unequal relations of exchange. The unequal exchange underlying machine technology can only be revealed by exposing, beyond the monetary price tags reified by conventional market ideology, material asymmetries in the net flows of biophysical resources gauged in terms of alternative metrics such as energy, matter, embodied land (ecological footprints), or embodied labor. The

mechanical 'power' of the machine is thus an expression of the economic and ideological 'power' through which it is sustained. Ultimately, what keeps our machines running are global terms of trade.

The prospect of peaking oil extraction presently prompts us to rethink processes of development and decline in the world-system. Rather than simply revive Malthusian concerns over the dismal destiny of humankind as a whole, we need to approach the popular notion of 'cheap energy' as an experience situated in societal space as well as in historical time. Energy has been perceived as 'cheap' only within core segments of world society, whose ideology of progress and development has tended to construe contemporary global inequalities as representing different stages in time. Draught-animals and wood fuel are here often perceived as elements of the past, yet remain an everyday reality for significant parts of the world's population. Conversely, fossil-fuel technology is conceived as a 'now' rather than a 'here'. For many of the farmers who survived the collapse of the Soviet Union, the age of the machine is already a thing of the past. The machine is an index of purchasing power and a specific form of capital accumulation that is as mystified and fetishized as any other power strategy in history. As we begin to anticipate its demise, we might reflect on the fact that the war in Iraq and global climate change are opposite sides of the same coin. The structural problem of fossil-fuelled capitalism is to maintain imports of energy (e.g. oil) and exports of entropy (material disorder, e.g. in the form of carbon dioxide), two imperatives of 'development' that are both increasingly difficult to sustain.

There seems to be a growing expectation, at least in North America and Europe, that the age of fossil fuels is approaching an end. This anticipation of peaking oil and a post-petroleum era may at first glance seem a straightforward, 'practical' problem of technology and resource management, but it is in fact a condition that must be understood through the lens of cultural analysis, particularly a cultural analysis of power within the capitalist world-system.

Let us begin by recalling that all technological systems are embedded in cultural – and political – webs of significance that tend to remain invisible (because self-evident) to the users of these technologies. Technologies are never 'merely' material strategies for getting certain kinds of work done; they also tend to embody tacit assumptions about their own rationality and efficiency. In other words, significant aspects of the functioning of technological systems rely on *beliefs* about their efficacy. Many anthropologists have thus already accepted that the boundary between technology and magic is difficult to draw. It is generally not difficult for us to imagine, for instance, how the ancient inhabitants of Easter Island found it imperative to struggle with those huge stone statues because they were perceived as *essential* for the implementation of some practical task, as understood through the local cosmology. We can similarly rest assured that the temple pyramids of the Maya and the sun rituals of the Inca – in this sense – should be regarded as technologies. To the extent that social life progressed, by

and large, as these pre-modern peoples hoped, they no doubt perceived their respective technologies as efficient in relation to the tasks they were assumed to fulfill. Early 16th-century Andean harvests of corn, for instance, testified to the efficacy of the Inca emperor's sacrifices and ritual communication with his father the Sun.

But can our modern fossil-fuel technology really be compared to these exotic practices and cosmologies? Isn't the crucial difference that our machines actually *work*, whereas Inca ritual was just mystification? I don't think it is as simple as that. In both cases – the divine Inca emperor and our modern machinery – a particular material entity is perceived as productive or generative *in itself*: a cornucopia. In both cases, also, it is possible to demonstrate that productivity is the result not of properties intrinsic to either entity – the body of the Inca emperor or the design of the machine – but of the societal flows of resources which reproduce, and are reproduced by, these entities. Without the asymmetric exchanges with his many subordinates at different levels, the Inca emperor would not have been able to fill his warehouses with the stores of food, textiles, and other treasures that so impressed the Spaniards. Without those exchanges, he would never have appeared a generous cornucopia. And today, without the asymmetric exchanges of high-quality energy on the world market, our machines would achieve absolutely nothing. As many post-Soviet farmers have experienced, when there is no longer any diesel in the tractor, it is just an assemblage of scrap metal. Again, what ultimately keep the machines running are global terms of trade.

Most of us are probably prepared to accept as a fact that resource flows within the Inca empire were asymmetric, or unequal. When his subordinates labored on his fields in exchange for ceremonially served corn beer, it is obvious that their labor yielded more corn for the emperor's warehouses than they were able to consume in the form of beer, however great was their thirst. It is much more difficult to argue that the maintenance of modern machinery – as much as the maintenance of the Inca court – relies on unequal exchange. It is more difficult because *we* are now the ones inside the cultural bubble, so to speak. Much as the prevailing cosmology in 16th-century Peru probably made it difficult to question the divinity and productivity of the emperor, we are today suspended in a web of significance which makes it difficult to see – or at least to *say* – that industrial machinery relies on unequal exchange of resources in the world-system. The currently hegemonic cosmology – known as economics – trains us to think that voluntary market transactions are by definition equal and fair. Of course, when gauged in terms of monetary price, they must be. But the cultural bubble of neoliberal economics excludes all those other possible measures of exchange – such as energy, materials, hectares, labor time – with which it is fairly easy to show that world trade is indeed highly unequal. The concept of 'market prices' thus performs an ideological function similar to the Inca concept of *minka*, that is, the

ceremonial mobilization of labor in which the land-owning host was represented as generous, and the toil of the participants as reciprocation.

Maurice Godelier (1986) has argued that unequal exchange in human societies tends to present itself as a reciprocal exchange of services, and that economic anthropology should try to unravel the various ways in which this is done. Fundamental to these political arrangements is that the exploited are led to believe that they should be grateful to the exploiters. Inca ritual seems an obvious case, but are we now prepared to see that Godelier's observation is equally applicable to our own society and the entire industrial world order? Ever since the first major 'oil crisis' over 30 years ago, the dominant enthusiasm over development and growth has been accompanied by the uneasy realization that the success of our techno-economic cornucopia seems to hinge on the world market price of oil. The least disturbing implication that might be drawn is that there is a 'correct' price of oil, which is defined by the rate at which industrial economies can continue to export their commodities in exchange for ever greater quantities of oil. A more disturbing conclusion would be that there is no 'correct' price of oil, only a more or less profitable price of oil, from the point of view of industrial economies. It would imply that when that price – that is, that profitable rate of exchange between industrial products and the resources that go into their production – is no longer tenable, our machines will grind to a halt.

After two centuries of living with machines propelled by fossil fuels, most of us are highly committed to the notion of ever more powerful technologies. The thought that the high-energy age of fossil fuels may turn out to be an historical parenthesis is generally dismissed as ridiculous. Yet we should be open to that possibility. The age of fossil fuels has not just been a period in time, but a condition situated in socio-political space. It has provided a minority of the world's population with an unprecedented source of *power* – in both a thermodynamic and a political sense. But we are now beginning to realize that the combustion of fossil fuels has represented an *illusory* emancipation from land. This illusory emancipation has two aspects. First, it has seemed to enable us to transcend the constraints of limited land area and soil fertility that so preoccupied the Physiocrats and other economic schools of thought prior to the Industrial Revolution. Second, it has until quite recently kept us largely ignorant about the negative consequences of burning fossil fuels for the long-term productivity of the biosphere as a source of human livelihood. For two and a half centuries, the more affluent parts of the world's population have been building a technology based on solar energy accumulated on the surface of the Earth a very long time ago. Each year, we have been dissipating energy representing *millions* of years of ecological production over significant parts of the Earth's surface. In other words, we have relied on acreages of the *past*. What the contemporary scramble for so-called biofuels (such as ethanol) really represents is our determination to try to sustain that same technology on the capacity of *presently* available land to

accumulate solar energy. There seems to be a general confidence that it can be done. It is just a matter of getting the technology right. But what if it can't?

Generally speaking, social scientists will probably not get too involved in discussions about ethanol with all those engineers, agronomists, and economists who are committed to keeping the global technomass going by feeding it with corn or sugar cane. But we can listen attentively to the debate. We are told, for instance, that the conditions of people harvesting sugar cane for ethanol production in Brazil are appalling. We are told that ethanol production might in fact generate more greenhouse gases than the combustion of fossil fuels. We are told that it will accelerate tropical deforestation and loss of biodiversity. We are told that it will probably yield less horsepower per hectare than just simply growing fodder for horses. And what undoubtedly worries us the most, we are told that it is making food more expensive and contributing to malnutrition and starvation among the global poor. None of this should really come as a surprise. The technomass accumulated over two and a half centuries of fossil-fuelled capitalism is now competing with human and other biomass for living-space on this planet. The human agents committed to keeping this technomass growing have pursued various strategies for doing so, including military intervention in oil-producing countries, refusal to accept restraints on carbon dioxide emissions, and the appropriation of vast land areas for the production of alternative fuels.

Anthropologists can show how all of this can be understood in terms of a cultural analysis of power. Like the statues of Easter Island or the temple pyramids of the Maya, our machine technology has become fetishized to the point where it must be maintained at all cost, even at the cost of the land that can support us. And as we coax rural people in Brazil and Mozambique to devote their land and labor to support our technomass, the economists are seriously proposing that those rural people in the South are the ones who should be grateful – for the opportunity to 'develop'. Perhaps, at some point in the future, this will appear as absurd as it now would appear to us, if someone in 16th-century Peru had tried to persuade the peasants that one day, in the future, they would all have access to warehouses equal in size to those of the Inca emperor.

If we do accept that human understandings of socio-ecological processes are cultural (and necessarily also ideological, i.e. power-serving) constructions, we are in a better position to understand the European history of economic ideas as geared to the technological history of capital accumulation. Conventional economic science recognizes three significant 'factors of production', viz. land, labor, and capital. Different degrees of significance have over time been attributed to these factors as sources of productivity or 'value' (see Gudeman, 1986). In the agrarian world of the 18th-century Physiocrats, land was the ultimate source of value. In the 19th-century world of industrial factories, Adam Smith, David Ricardo, and Karl Marx championed labor as the main generative force. It could be argued that the 20th century was dominated by the conviction that access to capital was the true bottleneck, as reflected, for instance, in the discourse on

'development'. As we proceed into the 21st century, there are signs that we may be returning to land as the key resource, as witnessed by the current scramble for vast acreages in Africa, Latin America, and Russia. As seems constantly to be the case in capitalist development (Harvey, 2003), even this strategy for accumulation operates according to a principle of 'dispossession'. Accumulation by dispossession is the underlying logic of the unsustainable socio-ecological processes to which we shall now turn. Before doing so, however, we should pause to reflect on the implications of the above relativization of theories of 'value', including the Marxian labor theory of value and various versions of energy theories of value. Rather than ascribe to labor or energy uniquely generative powers, it should suffice to say that, for a successful capitalist, the price of labor (or energy) is significantly cheaper than the price of its products (Hornborg, 2005). The advantage with this formulation is that it is equally applicable to other indispensable inputs such as raw materials.

2. THE METABOLIC RIFT: ENVIRONMENTAL LOAD DISPLACEMENT AND ECOLOGICALLY UNEQUAL EXCHANGE

For centuries, there has been a widespread intuition in both capitalist core nations and more peripheral areas that the economic and technological expansion of the former occurs at the expense of the latter. To simplify, we can call this world view a 'zero-sum game' model of development, as opposed to the 'cornucopia' model, which instead proposes that capitalist growth in core areas is of benefit to their peripheries. Although morally compelling and widespread, the zero-sum game intuition has not become a part of mainstream thinking about development. Various kinds of discursive filters have resisted its incorporation in those versions of social science that are prominent in formulating policy and official political rhetoric. It is not difficult to understand this discursive resistance to moral qualms about development. In the core nations, politicians would be unwise to suggest that the average living standard in the country is unjustly high from a global perspective. In peripheral nations (the so-called 'developing' or 'less developed' nations), attempts by individual politicians to challenge global inequities and power structures have backfired in various ways, for instance through military interventions sponsored by the core, loss of economic benefits and support linked to established trade patterns, and the inability to offer a credible and attractive political program to the electorate (see Hettne, 1990). A fundamental problem is the inclination in both core and periphery to define 'progress' in terms of economic growth and technological advances (Norgaard, 1994). A spatially restricted process of capital accumulation is thus presented as a temporal difference, that is, the highly desirable future of all nations, and any politician offering anything else than such progress is not likely to have a future in politics.

Academics are widely assumed to conduct their research in accordance with established ideals of objectivity, integrity, and intellectual honesty. Yet most social

scientists find themselves pursuing research agendas articulated by the politicians who ultimately control their funding, and subtle processes of selection tend to ensure that key positions of academic authority are not occupied by individuals with anything subversive to say about growth or development. Nevertheless, a minority of academics – today often referred to as 'activist scholars' – have been unable to suppress the 'zero-sum game' intuition and instead pursued various research strategies to substantiate it. I am not referring here to dissidence in general terms, which would include the entire Marxist tradition, but to that specific variant of dissidence that seeks to reveal how the accumulation of money and technology in core areas of the world-system occurs at the expense of the natural resources, environment, and health of their peripheries. This kind of thinking can be given many labels. Perhaps the most encompassing is 'political ecology' (Bryant and Bailey, 1997; Low and Gleeson, 1998; Martinez-Alier, 2002; Paulson and Gezon, 2005), but underneath this umbrella we can identify a number of more specific approaches, theories, and methodologies, such as 'environmental justice' (Harvey, 1996), 'ecologically unequal exchange' (Bunker, 1985; Hornborg, 1998; Rice, 2007), 'ecological footprint analysis' (Wackernagel and Rees, 1996), and so on. Common to all these approaches are concerns with the uneven deterioration of the natural environment, and with the relations of power that generate and maintain unevenly distributed environmental impacts in global society. There is also a concern, dating back to the earliest days of the Industrial Revolution, that modern forms of resource management, for example, in industrial agriculture, are not at all as 'efficient' as the economists would have us believe, but instead wasteful and unsustainable. It is ironic, for instance, that the many observations on the negative 'energy return on (energy) investment' (EROI) in industrial agriculture can now be directed at the production of energy itself (Patzek and Pimentel, 2005; Pimentel, 1991, 2001; Pimentel et al., 2007). Joined together, these two concerns suggest that the wastefulness and unsustainability of industrial resource management is made possible by displacing environmental impacts to other areas, populations, or social categories. This is the central contention of what I have called the 'zero-sum game' understanding of development. It runs counter to the thrust of most social policy and discourse in industrial capitalism, yet has preoccupied a long line of analysts over the past two centuries.

The early history of this lineage of dissidents has been traced by Joan Martinez-Alier (1987). He reviews a long line of skeptical anti-modernists, many of whom were concerned with unsustainable flows of energy and nutrients in agriculture. These analysts, he concludes, were precursors to what is now known as 'ecological economics'. It is noteworthy that many of these early dissidents – for example, Josef Popper-Lynkeus (1838–1921), Karl Ballod-Atlanticus (1864–1933), Sergei Podolinsky (1850–91), and Frederick Soddy (1877–1956) – were heavily influenced by Karl Marx (1818–83). Other early sources of inspiration include John Ruskin (1819–1900), Wilhelm Ostwald (1853–1932), Joseph

Henry (1797–1878), and Thorstein Veblen (1857–1929). The influence of these eight men was in turn extended to their disciples, such as Otto Neurath (1882–1945), Vladimir Vernadsky (1863–1945), Eduard Sacher (1834–1903), Patrick Geddes (1854–1932), Henry Adams (1838–1918), Alfred Lotka (1880–1949), and Alexander Bogdanov (1873–1928). Among their students, in turn, we find names like Nicholas Georgescu-Roegen (1906–94), Lewis Mumford (1895–1990), M. King Hubbert (1903–89), and Leslie White (1900–75), all prominent mid-20th-century critics of industrial civilization. Vernadsky's students Hutchinson and Lindeman became tutors for ecologists such as Ramon Margalef and the brothers Eugene and Howard Odum, and his student Georgescu-Roegen became the father of ecological economics, tutoring Herman Daly, Kenneth Boulding, and Garrett Hardin. White is recognized as one of the founders of ecological anthropology, and counted, for example, Marshall Sahlins and Elman Service among his students.

This rather restricted number of critics of industrial capitalism has had a decisive influence on the development of theories and methods for understanding unsustainable and inequitable use of natural resources. Although rarely acknowledged, most of these approaches can trace a direct genealogy back to Karl Marx. For example, Herman Daly's intellectual ancestry can be traced through Georgescu-Roegen, Vernadsky, and Podolinsky (Martinez-Alier, 1987) to Marx's strong concerns about what he called the 'metabolic rift' (Burkett and Foster, 2006; Foster, 2000; Foster and Burkett, 2004; Foster and Clark, 2004). Marx was very much concerned with the asymmetric exchange of nutrients and other material resources between town and countryside in 19th-century Europe, which among other things resulted in the impoverishment of rural soils and the accumulation of garbage and sewage in urban areas. The deterioration of European soils prompted capitalist entrepreneurs to exploit phosphates in Oceania and deposits of guano along the west coast of South America, and to develop artificial fertilizers requiring significant inputs of energy. Marx's crucial observation can today be extended to the metabolism of the entire world-system (Clark and York, 2005; Moore, 2000), some parts of which are ecologically impoverished while other parts are smothered with garbage, air and water pollution, and other forms of material overload (Hornborg, 2003). The pattern is quite simple, if not self-obvious. When too much biomass, nutrients, water, or other natural resources are removed, the result is loss of biodiversity, topsoil, fish stocks, or other vital assets (see Bunker, 2007). Conversely, when too much matter and energy use is concentrated in an area, it may suffer from smog, acidification, eutrophication, accumulation of heavy metals, and problems with the disposal of solid waste (see McNeill, 2000). In fact, even the global logic of carbon dioxide emissions and climate change can be understood within this theoretical framework (Clark and York, 2005).

As we turn to the work of modern researchers in this tradition, I will briefly show how they fit into the genealogy of development dissidence sketched

above. We have already mentioned Nicholas Georgescu-Roegen and Howard T. Odum as heirs to the criticism of industrial energy flows going back to Marx and his contemporaries. Georgescu-Roegen (1971) brought economics and thermodynamics together by showing how production processes necessarily and inexorably increase total *entropy*, that is, material and energetic disorder. Odum (1971) was influenced by the so-called Technocrat movement led by the above-mentioned M. King Hubbert. He offered an energy theory of value similar to that of the Technocrats, suggesting that *emergy* ('energy memory') – that is, the amount of solar energy spent to produce a given commodity or organism – is an adequate measure of economic utility (Odum, 1988). In a paper co-authored with J.E. Arding, Odum used this notion of 'emergy' to argue that trade between nations at different levels of technological development tended to be unequal in terms of net flows of energy (Odum and Arding, 1991). Odum's concepts of 'emergy' and 'embodied energy' are clearly similar to Marx's concept of embodied labor, and both shared the problematic conviction that such past investments (of energy or labor) should be a measure of value.

Odum's attempts to ground economic increases in (exchange) value in thermodynamics can be criticized from the perspective of both economics and thermodynamics (Hornborg, 1998). In physical terms, as Georgescu-Roegen showed, increases in value in a production process correspond to a *decrease* in total energy quality (*negentropy*, or 'negative entropy', closely related to *exergy*). Accumulation of 'emergy' or 'energy memory' thus represents a dissipation of exergy. The concepts of emergy and exergy, in other words, suggest inverse ways of describing processes of energy transformation. Although a common pitfall, ever since the days of Podolinsky, has been to seek a thermodynamic foundation for an objective measure of value, more 'real' than price (see Hornborg, 1992), such arguments should be abandoned. The driving forces of consumption are cultural, both in general terms and in specifics (Sahlins, 1976). 'Value' must pertain to what human beings perceive, rather than to physics. In fact, it is only by keeping human valuation and physical properties analytically separate that we can reveal the destructive logic of capitalist processes: the more people are willing to pay for a particular product, the faster will be the dissipation of resources required to produce it. Because of the universal interchangeability of all things on the capitalist world market, the accelerating dissipation of resources will be rewarded with increasing amounts of resources to dissipate.

At about the same time that Georgescu-Roegen and Odum published their most widely cited books, two other scientific approaches to global inequalities were emerging. One, explicitly lodged in the Marxist tradition, was concerned with revealing asymmetries in international exchange, for example, through unequal net flows of embodied labor (Emmanuel, 1972) and structural relations of dependency between peripheries and cores, or satellites and metropoles (Frank, 1967). This framework, itself building on earlier work on structural inequalities in Latin America (Prebisch, 1950), became fundamental to what today is known

as world-system analysis (Wallerstein, 1974–89). The other, pioneered by Georg Borgström (1965) and William Catton (1980), focused on the international appropriation of what we might call 'embodied land', that is, the consumption of resources requiring land surfaces in excess of what is nationally available. Both these approaches have stimulated interesting new research over the past two decades. By combining the world-system perspective of Frank and Wallerstein with Emmanuel's notion of unequal exchange and Odum's notion of energy value, Stephen Bunker (1985) assembled the first formulation of a concept of ecologically unequal exchange. A few years later, Mathis Wackernagel and William Rees (1996) popularized Borgström's and Catton's notion of 'ghost acreages' into the highly influential concept of an 'ecological footprint', that is, the per capita quantity of eco-productive land surface required to sustain a given level of resource consumption. Several researchers have found this measure useful in analyzing uneven flows of international trade, as flows of commodities can be converted into flows of 'embodied footprints', that is, embodied land (Andersson, forthcoming; Andersson and Lindroth, 2001; Jorgenson, 2003; Jorgenson and Rice, 2005, 2007; Nordlund, 2009; York et al., 2003).

The Marxian concern with unequal exchange and the metabolic rift can also be traced to three additional modern scholars with a wide sphere of influence in political ecology and sustainability studies. I will first mention Joan Martinez-Alier, who compiled the above-mentioned genealogy of ecological economics, but whose later publications (e.g. 2002, 2007, forthcoming) have addressed current 'ecological distribution conflicts', particularly in the so-called South. His (2002) conclusions about the North's 'ecological debt' to the South have recently been confirmed by a study published by the US National Academy of Sciences (Srinivasan et al., 2008). Martinez-Alier's ambition seems to be to create a synthesis of environmentalism and Marxism, in the vein of what is often referred to as 'ecosocialism' or 'ecological Marxism'. This also applies to John Bellamy Foster, who has published extensively on the relation between Marxism and ecological theory (e.g. Foster, 2000; Foster and Burkett, 2008). However, Foster and Martinez-Alier appear to be in disagreement about the history of this relationship (Burkett and Foster, 2006, 2008; Foster and Burkett, 2004). Paul Burkett and John Bellamy Foster have shown that Marx and Engels were much better acquainted with ecological theory than Martinez-Alier has suggested, and that their understanding of industrial capitalism was not only compatible with, but strongly informed by, the laws of thermodynamics. The Marxian analysis of capitalism demonstrates how the abusive exploitation of labor and land are two sides of the same coin (see Moore, 2000, 2003, 2007a, 2007b). Historical materialism is profoundly concerned with ecology, yet refuses to reduce economic value to thermodynamics.

Finally, Marina Fischer-Kowalski has organized a group of scholars in Vienna working on 'social metabolism' through material flow analysis (Eisenmenger and Giljum, 2007; Fischer-Kowalski, 1998; Fischer-Kowalski and Amann, 2001;

Fischer-Kowalski and Haberl, 1993; Weisz, 2007). By translating international commodity flows into weight (i.e. tonnes), these researchers have been able to calculate the 'physical trade balances' of nations and even of the European Union. These calculations generally show that core nations import much more weight (materials) than they export, while the converse applies to nations in the periphery of the world-system. Working on trade statistics from Colombia, Mario Pérez Rincón (2006) has shown how the country's deteriorating physical trade balance over several decades can be explained by the falling prices for its primary exports. He aptly uses the notion of an 'ecological Prebisch thesis' to indicate how structural inequalities in the world-system have an ecological dimension that Prebisch (1950) and his colleagues did not fully recognize. Material flow analysis has also been used to show how core nations tend to export their most polluting industries to poorer nations (Muradian and Giljum, 2007), illustrating how the import of high-quality resources and the export of degraded materials and health risks are two sides of the same coin.

It should be possible, finally, to integrate all of these approaches into a single theoretical framework clarifying how societal relations of exchange and the material dimensions of production are intertwined in global metabolism (Hornborg, 1992, 1998, 2001, 2003, 2006, 2007a). The study of unequal exchange of embodied labor can be combined with the study of unequal exchange of embodied land, demonstrating that the birth of industrial capitalism in early 19th-century England was founded on a highly unequal exchange of both time (embodied labor) and space (embodied land) with its colonies. This basic condition of industrialized technology has been called 'time-space appropriation' (Hornborg, 2006), suggesting also that David Harvey's (1996) observations on experiences of 'time-space compression' represent the phenomenological dimension of what in terms of political economy (and political ecology) can only be understood as a process of (time-space) appropriation. The rationale of industrial technology is to save time and space, but a global analysis reveals the extent to which this is achieved at the *expense* of (underpaid) human time and natural space elsewhere in the world-system.

A further elaboration (or simplification) of this argument would be to demonstrate that even the flows of embodied labor can ultimately be converted into flows of embodied land. If the embodied hours of labor are converted into man-years (years of labor for one average laborer) and multiplied by an average ecological footprint (space requirements of consumption) for this category of laborers, commodity flows could conceivably be analyzed exclusively in terms of the exchange of space. A brief calculation indicates that such a translation of (labor) time into space would, in the case of mid-19th-century England (see Hornborg, 2006), further accentuate the unequal global exchange of embodied land, even if the per capita footprints of British factory workers in 1850 are assumed to be twice as large as those of plantation workers in the colonies. If it required about 12.8 North American man-years (years of labor for one laborer)

to produce £1000 worth of raw cotton, but about 1.6 British man-years to produce £1000 worth of cotton textiles, and the average ecological footprints of these two categories of laborers are (very hypothetically) estimated at 0.5 and 1.0 hectares, respectively, the exchange of labor embodied in these volumes of commodities would still represent an exchange of 1.6 hectares of embodied British land for 6.4 hectares of embodied American land. This conclusion presupposes that most of the land requirements of British and American laborers at this time were provided domestically (i.e. from within respective nation). Rather than a definitive conclusion, however, this exercise is simply intended as a suggestion for further methodological development.

To understand how industrial capitalism can present itself to us as 'efficiency' and 'progress', while we simultaneously acknowledge that it is bringing us closer and closer to socio-ecological disaster, we need to grasp both the material, the social, and the cultural or cognitive dimensions of this mode of production. On the material side, we certainly need to be acquainted with Georgescu-Roegen's observations on entropy, Bunker's concept of an unequal exchange of energy, and Fischer-Kowalski's analyses of the uneven flows of matter in global society. To understand the structure of this global system, we cannot do without the world-system perspectives of Frank and Wallerstein. Finally, to grasp how it has been possible for us to be so deluded by our technology for over two hundred years, we need the Marxian analysis of fetishism. But although Marx was able to expose the fetishism of money and of commodities, he never fully recognized the fetishism of the machine. Yet it, too, is a material object attributed with magical powers that mystify unequal relations of exchange.

3. 'RESILIENCE' OR COLLAPSE? THE IDEOLOGICAL DISARMAMENT OF DISASTER

In very general terms, there seem to be three possible ways of relating to the issue of global socio-ecological sustainability. The first is to deny that there are any major problems that will not be solved by the market and new technologies (e.g. Lomborg, 2001). The second is to acknowledge that current trends will lead to disaster unless major political or cultural reforms are achieved, but to continue to believe in the feasibility of such reforms (e.g. Gore, 1993). The third is to acknowledge the risk of disaster, but as yet be unable to visualize any realistic strategy for preventing it. The first two attitudes are both optimistic regarding the future of global capitalist civilization, but for different reasons. To the extent that people in the industrialized North have thought about this issue, a majority today probably lean toward the second option. The fact that Lomborg's (2001) research has been officially rejected by a Danish research council, while Al Gore in 2007 was awarded the Nobel Peace Prize, seems to reflect widespread attitudes in core capitalist nations. Gore's movie *An Inconvenient Truth* no doubt expresses the current world view of most citizens of these nations. The problems cannot be denied, they seem to concede, but solutions are within reach. In fact, the confidence in solutions may often be a prerequisite for acknowledging the

problems. Presentations of our global socio-ecological dilemma that do not offer feasible solutions will tend to be rejected, very much like Karl Marx's analysis of capitalism probably would have been by the labor movement, if he had not simultaneously articulated a vision of socialism. This is a disturbing fact, since it makes intellectual sense to distinguish between the activity of describing a socio-ecological dilemma, on one hand, and offering practical or political solutions to it, on the other. Yet, option two is undoubtedly experienced by most people as morally superior to both option one and option three.

Against this background, it is not difficult to understand why the globalized discourse on 'sustainable development' within academia and management is dominated by assumptions of consensus and a trivialization of obstacles to implementation of the requisite policies. In order to remain within acceptable discursive territory, politicians and researchers alike are expected to assume a profoundly critical stance vis-à-vis current patterns of consumption, transports, and energy use, yet continue to offer pathways to sustainability that do not seem too uncomfortable or provocative. This explains why the rallying-cry of the early 21st century is not 'revolution' (as in the early 20th century), but 'resilience'. The burgeoning discourse on 'resilience' in socio-ecological systems (e.g. Berkes and Folke, 1998; Berkes et al., 2003; Levin et al., 1998) is an ideological phenomenon worthy of study in its own right. Intellectually, it is largely founded on the epistemological traditions of systems ecology and similar, natural-science approaches emphasizing the harmonious functioning of natural systems through adaptation, wise management, and appropriate technologies. Normative notions of strategies to promote the 'resilience' of socio-ecological systems exemplify this view. These approaches, and the agencies that continue to promote them, seem oblivious to several strong research traditions in the social sciences that have persuasively shown that socio-ecological systems are historically and currently characterized by structural problems of power, conflicts of interest, and unequal distribution.

Considerable amounts of economic resources are currently being invested in the idea that modern society will be able to learn how to manage natural resources sustainably by studying the small-scale, traditional ecological practices that for centuries have been systematically eclipsed by the logic of industrial capitalism (see Berkes, 1999; Berkes and Folke, 1998; Berkes et al., 2003). In the light of the alarming current trends of global environmental change (e.g. Jackson et al., 2001; Millennium Ecosystem Assessment, 2005), this notion seems naïve and paradoxical. Many anthropologists will feel strong ambivalence about such claims. Considering the fate of traditional or indigenous societies under extractive capitalism (see p. 218 in Nadasdy, 2007), it is confounding to read that 'traditional resource management systems . . . may have potential that has hardly been tapped' (Berkes and Folke, 1998: 13). Although there is definitely something to learn from local and contextualized ecological practice about the disastrous course of capitalist extraction, the suggestion that modern

capitalist society might adopt the logic of its socio-ecological antithesis must be dismissed as mystification (Hornborg, 1996). The only circumstance that might engender a revitalization of such local practices would be the collapse of capitalist civilization (see Tainter, 1988), but we may rest assured that this is not the objective of all the research, conferences, publications, and policy statements that presently champion what Nadasdy (2007) calls the 'gospel of resilience'.

The explicit goal of the research on conditions of socio-ecological resilience is to incorporate such knowledge into 'resource management science' (Berkes and Folke, 1998: 1), yet Western resource management science is explicitly *contrasted* with 'traditional and local management' (p. 5). Here is another instance, then, of capitalism struggling to incorporate its antithesis. 'Resilience' is defined as the ability of a system to absorb disturbances before unpredictably changing its structure from one equilibrium state to another, less desirable one (pp. 6, 12). The concept has recently replaced the scientifically obsolete notion of the 'balance of nature' as the foundation of an ecological ethic (Nadasdy, 2007: 214). Although derived from the natural science of systems ecology (e.g. Odum, 1989), the concept is applied to linked 'social-ecological systems' and thus obviously considered applicable also to social systems, much as 'classical human ecology' literature such as Park (1936) did not hesitate to apply ecological theory to societies (p. 9 in Berkes and Folke, 1998). The proponents of resilience theory suggest that this dissolution of the boundary between nature and society is consistent with the way many traditional societies see their relationships with the environment, viz. human society as part of nature rather than separate from it. This is a statement that should be approached with some caution, however. Although the dichotomy of nature and society indeed seems to be absent in many traditional cosmologies (see Descola and Pálsson, 1996; Ingold, 2000), these cosmologies generally have very little in common with systems ecology. To the extent that nature and society are conceptualized within the same framework, it is the social domain that is extended into the natural, rather than vice versa. Characteristic of these traditional cosmologies is not the existence of 'pre-scientific ecosystem concepts' (Berkes and Folke, 1998: 9), but the projection of social concepts of reciprocity, harmony, conflict, and power onto relationships between humans and non-human species (e.g. Descola, 1994). To suggest that modern 'resource management science' emphasizing the resilience of socio-ecological systems is somehow cognate to pre-modern cosmologies, and sympathetic to the 'savage thought' of Lévi-Strauss (pp. 12–13 in Berkes and Folke, 1998), is thus a gross distortion. The claim to have rediscovered or reinvented indigenous ecological knowledge, legitimized as 'science', has been made repeatedly by resource administrators over more than a hundred years (pp. 211–12 in Nadasdy, 2007). The stereotype of the 'ecologically noble savage' has great symbolic power, but may here be resorted to as a way of erasing (or concealing) the historical heritage of resource management science as a means of restricting indigenous people's access to and use of the environment (pp. 212–13).

Intimately connected with the notion of resilience is the idea of 'adaptive management' (Holling, 1978). To the extent that adaptive management is defined by its capacity to handle 'surprises' or unpredictable events, it almost seems an oxymoron (see pp. 209–10 in Nadasdy, 2007). It is founded on the explicit belief that 'organizations and institutions can ''learn'' as individuals do' (Berkes and Folke, 1998: 10), but this is yet another highly problematic contention. It is one thing to observe that supra-individual knowledge systems can accumulate information in a manner analogous to individual learning, as is the case with both science and 'traditional ecological knowledge', but another to suggest that organizations and institutions (i.e. social structures) can learn. Social systems are not comparable to biological systems in this regard (p. 5 in Hornborg, 2007b). Their trajectories are generally propelled by individuals and groups struggling to maximize their power and affluence, yet there is no mention of power or contradiction in the so-called 'analytical framework' for understanding social-ecological systems (Berkes and Folke, 1998: 15). In view of the recurrent catastrophes that have historically afflicted human societies at all levels of integration, from bands to empires, it is very difficult to subscribe to this notion of societal learning. To the extent that social systems are able to draw on past experience to avoid future disaster, it is important to recognize that such 'learning' is a matter of storing information as practically useful knowledge, rather than of mystically codifying 'wisdom' into the cybernetic structure of social organization. The proponents of resilience theory are conspicuously unclear about which of these two concepts of societal learning they are advocating. In building one of three concluding hypotheses on the naively functionalist notion of 'the well-being of social and ecological systems' (p. 21), they demonstrate once again how their vantage-points in fields such as systems ecology have constrained them from seriously engaging the logic of social systems. To any modern social scientist, 'the well-being of social systems' is simply an impossible phrase.

Such socio-political ingenuousness is evident, for instance, in the assertion that high fertility rates in the Third World are 'caused in part by the absence of effective capital markets, which make it difficult or impossible for households to obtain social security except by having more children' (Levin et al., 1998: 226). Another example is the proposed analogy between the deterioration of the immune system in an individual infected with HIV/AIDS, on one hand, and the collapse of communism in Central and Eastern Europe, on the other (p. 227). A third example is the remarkable faith in 'trust' and 'reciprocal altruism' as mechanisms for environmental protection in globalized capitalism (p. 231). Fortunately, some social scientists have identified such weaknesses in resilience theory (p. 248 in Hanley, 1998; p. 253 in Lélé, 1998; Nadasdy, 2007). As Lélé (1998: 253) remarks, 'The lessons from the history of environmental policy are unambiguous: no amount of ''trust'', ''clever institutional design'' . . ., or ''epistemic consensus'' . . . can compensate for major asymmetries in the interests and powers of the different actors'. Nadasdy (2007: 216) observes that

although proponents of adaptive management 'clearly recognize that it is the economic imperatives of modern extractive and agro-industries that are the root cause of the management ''pathologies'' that lead to decreased resilience and ultimate collapse . . ., their proposed solutions do not address these larger issues at all'. Indeed, he continues, it is largely because of the exploitative dynamic of capitalism that conventional resource management even exists, and the focus on resilience 'has the implicit goal of maintaining the social-ecological relations of capitalist resource extraction and agro-industry' (pp. 217–18).

The discourse on resilience is oblivious not only of power, conflict, and contradiction, but also of culture. The institutions and knowledge systems that Berkes and Folke (1998: 6) refer to as 'cultural capital' are acknowledged as significant components in socio-ecological systems only inasmuch as they contribute to resilience, that is, in the obsolete and functionalist sense in which culture was conceived in mid-20th-century schools of anthropology such as cultural ecology and cultural materialism. There is no discussion of the role of cultural idiosyncrasies (e.g. various versions of fetishism and consumption patterns) as autonomous driving forces propelling the ecological trajectory of a social system. It is thus symptomatic that the first major international conference on resilience, hosted in April 2008 by the Stockholm Resilience Centre (recipient of the largest single research grant ever awarded environmental research in Sweden), chose to illustrate its commitment to dialogue between science and the humanities by encouraging the participants to view an art exhibit. 'Culture' in the modern anthropological sense is obviously not acknowledged as a relevant component of socio-ecological systems. Yet, as we have seen, culture is in many ways crucial to socio-ecological processes and relations. It shapes our way of thinking and talking about sustainability and exchange, including our categories of 'technology', 'economy', and 'ecology'. It generates our specific kinds of fetishism and consumption, determining which aspects of material culture that we consider indispensable. It prompts us, in different contexts, to attribute productivity or 'value' to different factors of production. In fact, it is finally also responsible for our modern fascination with 'traditional ecological knowledge', which paradoxically has become so central to the 'gospel of resilience'.

CONCLUSIONS

In this article, I have discussed various ways in which conventional discourse on sustainability fails to acknowledge the distributive, political, and cultural dimensions of global environmental problems. Central to the argument is the phenomenon of 'machine fetishism', that is, the inclination to view the technological capacity of a given population as independent of that population's position in a global system of resource flows. Machine fetishism is an ideological illusion maintained by keeping perspectives from the natural sciences, social sciences, and humanities effectively separated, and by perceiving the operation of global market price mechanisms as tantamount to guaranteeing reciprocal

exchange. The three main ingredients in the theory of machine fetishism – the acknowledgement of ecologically unequal exchange, world-system analysis, and the concept of fetishism applied to political economy – can all be traced back to Karl Marx. The 'zero-sum game' view of technological and economic growth, which underlies all these three ingredients, had been consolidated in Marx's concepts of capital accumulation and the 'metabolic rift' already in the mid-19th century, as Europe was entering the age of fossil fuels. The current concerns about peak oil and climate change suggest that we may be in the midst of a historical transition (back) to an economy based primarily on productive land area. This prompts us to reconceptualize the unequal exchange of embodied labor and embodied land in terms of 'time-space appropriation', and to question general theories of value attempting to account for economic growth with reference to a specific factor of production, whether labor, land, or capital. Such theories (e.g. labor theories of value, Physiocracy, modernization theory, etc.) should thus be viewed as geographically and historically positioned social constructs. The illusion of machine fetishism generates a representation of socio-economic differences in geographical space as if they were differences in historical time, epitomized in mainstream conceptions of 'development'. The discourse on 'sustainable development' is thus confronted with the political challenge of representing solutions to glaring problems of global inequalities in terms of consensus, benevolent 'management', and the restoration of socio-ecological 'resilience'.

Although the bulk of the insights that we need to correctly analyze the current political ecology of the world-system can be derived from the Marxian framework, we are today in a better position to discern the pervasive logic of environmental load displacement and thus also to deconstruct the ideological faith in technological solutions.

The various epistemological challenges presented in this article can thus be viewed as interconnected illusions postponing systemic crisis and obstructing rational societal negotiations that acknowledge the political dimensions of global ecology. These challenges are nothing less than the ideological pillars of ecological modernization. They are five in number: 1) The fragmentation of scientific perspectives into bounded categories such as 'technology', 'economy', and 'ecology'. 2) The assumption that the operation of market prices is tantamount to reciprocity. 3) The illusion of machine fetishism, that is, that the technological capacity of a given population is independent of that population's position in a global system of resource flows. 4) The representation of inequalities in societal space as developmental stages in historical time. 5) The conviction that 'sustainable development' can be achieved through consensus. These five pillars of ecological modernization are serially interconnected in the following manner: 1 and 2 are prerequisite to 3; 3 is prerequisite to 4; and 2 and 4 are prerequisite to 5. The aim of this article has been to indicate some ways in which these illusions can be unraveled.

Beyond these illusions, what might truly sustainable socio-ecological relations look like? Although hardly comfortable – and likely to be dismissed by most readers as unfeasible – my conclusion is that the only way of achieving 'sustainability' would be by transforming the very idea and institution of money itself (Hornborg, 2007c). The fundamental problem is that our global social system has adopted an institution, based on the idea that *everything is interchangeable*, that continues to encourage an accelerating dissipation of resources. General-purpose money inexorably rewards such dissipation by providing access to more resources to dissipate. Only by breaking that logic will human society be able to gain mastery over its own mastery over nature.

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