THE WORLD SYSTEM AND THE EARTH SYSTEM

GLOBAL SOCIOENVIRONMENTAL CHANGE AND SUSTAINABILITY SINCE THE NEOLITHIC

ALF HORNBORG &
CAROLE L. CRUMLEY, Eds.

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The Human–Environment Nexus: Progress in the Past Decade in the Integrated Analysis of Human and Biophysical Factors[1]

EMILIO F. MORAN

I. Introduction

The Earth continues to be treated with little thought for the future. More and more species are going extinct. Wetlands are disappearing at a rapid rate, endangering the migration routes of birds. Even our closest primate relatives are finding less and less of their habitat left standing to ensure their survival. The story goes on. There is little concrete strategic policy that incorporates the development of a sustainable Earth system as a practical objective. Yet, that is exactly what we must establish. Without a conscious exercise dedicated to the objective of ensuring the sustainability of the world's ecological systems, our days on this planet are numbered.

Humans, as a distinct species, have been on this planet a very long time. What is not widely recognized is that in the past fifty years we have changed nearly every aspect of our relationship with Nature. Yes, the Industrial Revolution began some three hundred years ago, and we have been gradually increasing the effects we have on the Earth since then (Turner et al. 1990). And, in the past 10,000 years, in various times and places, we have had considerable effect on the local and the regional scale (Redman 1999). But never before has our impact had planetary-scale consequences, and that is what we are having trouble understanding. As a species we tend to think and act locally; however, for the first time in human evolution we have begun to have a cumulative, global impact.

Our impact in the past fifty years has no equivalent in our entire history as a species (see Figure 1). In the past fifty years we have seen not only an exponential increase in carbon dioxide but also ozone depletion and nitrous oxide concentrations in the atmosphere, losses in tropical rainforests, frequency of natural disasters, and species extinctions. The same can be said for fertilizer consumption, damming of rivers, water use, paper consumption, the number of people living in cities, and the number of motor vehicles. Although we see a few cases of nations and regions with a growing middle class and improved

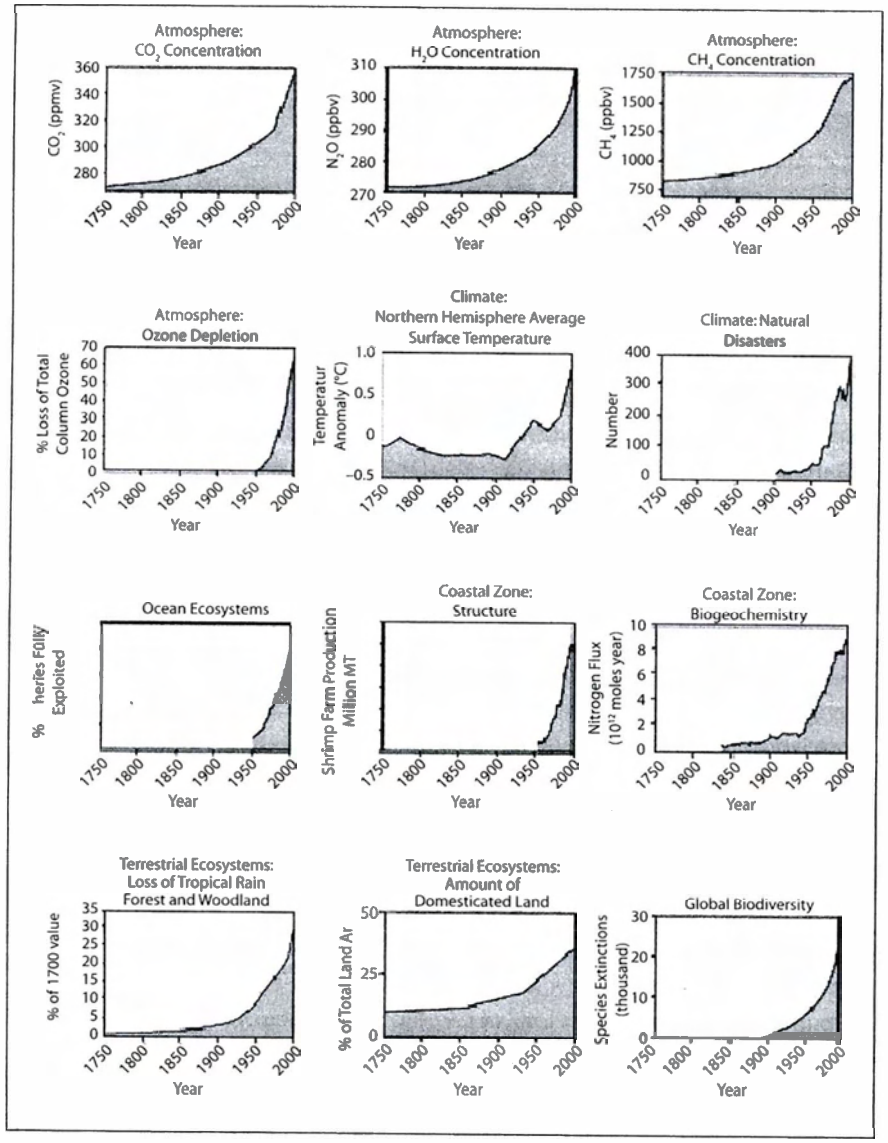

Figure 1 • Biophysical changes in the past fifty years (Steffen et al. 2004).

living standards, more often than not in the past twenty years we have seen a decline in the living standards of the poor and the middle class, with the gap growing and the concentration of wealth becoming as pervasive as the loss of species.

The exponential increase in environmental change is tied to two factors: the increase in human population and changes in consumption habits. Indeed, one must think of these two factors in tandem. One Euroamerican citizen consumes twenty-five times the resources that one average citizen from India, Guatemala, or other less developed countries does. So, while birth rates have declined to replacement level or even below in developed countries, these populations continue to impact the Earth's resources far more than do the billions of people in developing countries. Both "the North" and "the South" have a huge impact on Nature, and if we want to leave an Earth worth living in to our children, both the North and the South will need to change how they go about their business. Yet, changing business-as-usual— "culture," worldview, and such—is easier said than done.

Whether in the North or the South, specific societies have deeply ingrained cultural and historical traditions that have both positive and negative elements that facilitate and hinder our capacity to respond to the current crisis in the Earth system. Looking at North American and European society, we can speak positively of the democratic institutions that are in place, which provide an effective mechanism for citizens to respond to information provided to them, whether about schools, politics, or the environment. This is all to the good. Yet, how do we explain the lack of responsiveness in the United States to the growing evidence for a global environmental crisis? Side by side with our democratic institutions, the United States has a culture of individualism, with a much greater value given to capital accumulation as a measure of a person's worth than in almost any other society. These cultural values tend to sway a great portion of the citizenry against environmental regulations, seeing them as costly and thus likely to increase taxes on individuals, and to raise the cost of environmental goods and services. Even the promotion of public transportation as a response to reducing fossil-fuel emissions is opposed by many on the grounds that it limits personal freedom, despite the costs to the country (in terms of dependence on foreign oil supplies) and the globe (in terms of emission of Earth-warming gases).

This example can be paralleled by many other countries. Each will have a slightly different twist to it: a product of the historically contingent nature of human affairs. Other countries may lack, for instance, democratic institutions with a capacity to mobilize the populace, but they may have enlightened rulers who respond quickly to evidence for environmental crisis: witness the rapid reforestation of China in the past twenty years, following decades of deforestation. The pace of the reforestation has been without equal in the world, despite the many economic constraints faced by China and its vast population. In short, there is no one answer to finding environmentally appropriate

solutions to the current global environmental crisis. Human agents in specific places need to work within the constraints and opportunities provided by their physical, social, economic, and cultural setting. We are all responsible for the condition of our planet, by our action and by our inaction.

II. Can One Conceive of Ecosystems without Human Agents?

Ecologists have a tendency to blame human agents for our current crisis. However, doing so does not begin to move us toward solutions. Human agents are part of the problem, but they are the only ones who can alleviate the current crisis. Fortunately, we know one thing: human agents are eminently self-interested and capable of amazing self-organization when properly motivated and led. So, if we are so capable of looking after ourselves, and to organize to achieve our goals, why are we in the current crisis? I think the answer lies in our evolutionary tendency to think primarily of local territories, even though our contemporary capacity to use resources from far and distant places has grown enormously. We still have not been able to internalize the consequences of our contemporary consumption of environmental resources from throughout the world, and we have not developed effective ways to get information and feedback on what the impact of our consumption has been. In other words, economic globalization has been very effective at using global resources but not in giving consumers the information they need to make a decision on whether they want to have that kind of impact. This is a systemic failure that must be corrected if we are to begin to be able to respond to our current environmental crisis. Without feedback from our consumption actions, we will continue to act irresponsibly. That has not always been the case in how we use resources.

In the past, human agents went out from their communities to gather needed resources to sustain their population at a very local level. We must recall that for most of our experience as a species, we were hunter-gatherers. The range of hunter-gatherers was fairly limited, and when they overused resources they were forced to move considerable distances until they could find another territory, not occupied by others, to sustain them. As hunter-gatherer populations increased, they found themselves running into other bands, and perhaps experiencing conflict with them. In short, it was preferable in many cases to limit the group's consumption to sustainable levels, rather than face a very uncertain future access to distant and possibly dangerous territories.

Even with the advances in control made possible by domestication of plants and animals, human agents could experientially understand how the local land and water responded to their agricultural management. What was happening in China was of no interest to those living in Europe or Africa. Products came from relatively close distances and anyone could assess whether they were putting themselves at risk.

Those familiar ways of adjusting our behavior to existing resources are now completely changed for much of the human populations on Earth. Today, whether in China, Germany, Argentina, or the United States, human agents are provided with coffee from Brazil; bananas from Honduras, Philippines, or Gabon; fish from oceans on the other side of the world; and powdered milk from places unspecified on the can labels. The human consumer has no way to know how much forest was cut to grow that coffee, which people were displaced to make room for those banana plantations, which fish stock was depleted, or which smallholder was displaced for that dairy farm. In short, we have a disconnection between what we use on the Earth and the consequences of that use for people and nature (cf. Moran 2006).

If we are to begin to move toward a sustainable Earth system, we must begin by building an awareness of what we do—no matter where it might be—and to reflect on whether that is an impact that we want to have. Just as consumer movements have, after much effort, succeeded in having many products labeled by corporations as to their nutritional and caloric content, we need to begin to require that products indicate where they come from and to post, in public sites on the Internet, environmental impact statements that show the products' ecological consequences.

III. Human Agency: Individuals Making a Difference

A fine line exists between endowing individuals with agency, or the ability to take decisions and actions, and ignoring actual people altogether. Ecologically, we have tended to do the latter. In many major texts and popular books, we read about how people do this to the environment, or degrade that landscape, or pollute these rivers. Just as the socialist literature treated the workers as *Lumpenproletariat*, or an aggregate proletarian mass, so does modern analysis deal with how people treat the environment, not recognizing the diverse ways that people in fact act toward their physical surroundings. But in giving individuals the attention they deserve, and in trying to understand their actions, we can also fail to see the patterns in their actions. After all, human agency takes place within an environmental and social matrix, and individuals are members of social groups with shared economic, cultural, and political interests. Thus, in ensuring that we give individual human agents their due, we must balance this attention with a concern for how many other agents share similar values and make similar decisions with given cumulative impacts.

It is appropriate to consider how human agency can make a difference, and how social movements can make an even greater difference. Individuals, as members of given societies, do not represent the entire society but some segment of it characterized by a specific economic position, education, and political linkages. When individuals act they commonly represent the interests of those parts of the social fabric within which they are embedded, but on occasion they rise above those contexts and represent wider interests. Time and again we see evidence of how an individual through his or her actions can change how we think about the world and how we can act on it.

In short, human agency does make a difference, whether expressed as ideas or in action. Until 1985 there were hardly any stories in major magazines or newspapers about Amazonian deforestation, even though there had been a growing discussion of it in scientific journals and plenty of research attesting to the rapid rates of forest destruction. But the appearance of an interview with Tom Lovejoy in the *New York Times* in 1985 overnight mobilized the considerable resources of the press and other media, and over the next decade there was an exponential growth in the number of stories in major newspapers and magazines, which resulted in considerable international pressure on Brazil to stop the subsidies that were fueling the deforestation.

So, it seems that we need to have an accumulation of information over an extended time, gradually shaping into a picture that instigates concern in some quarters and action by some individuals. When such action is associated with some notable event or overwhelming evidence, it appears that public response can result in remarkably rapid and effective mobilization. But this will not happen if individual agents do not take the considerable risks involved in trying to change business-as-usual and to advocate a significant shift in how we do things. Change is resisted by all complex systems largely in self-defense and because it can be very costly if the change proves unnecessary or wrong-headed. Thus, human political and economic systems, like ecological systems, resist changing their basic patterns until there is overwhelming evidence that something fundamental has happened that requires a shift in the structure and the function of the system, if it is to survive. Are we there yet? Do we have overwhelming evidence?

IV. Overwhelming Evidence

Figure 2 illustrates what is happening in terms of demographic variables, which should be reason for concern. Population has been increasing rapidly since 1750, but it is really only since 1950 that the exponential nature of this growth has become manifest, showing very little sign of subsiding in the next thirty to forty years. By that time the human population will be in excess of

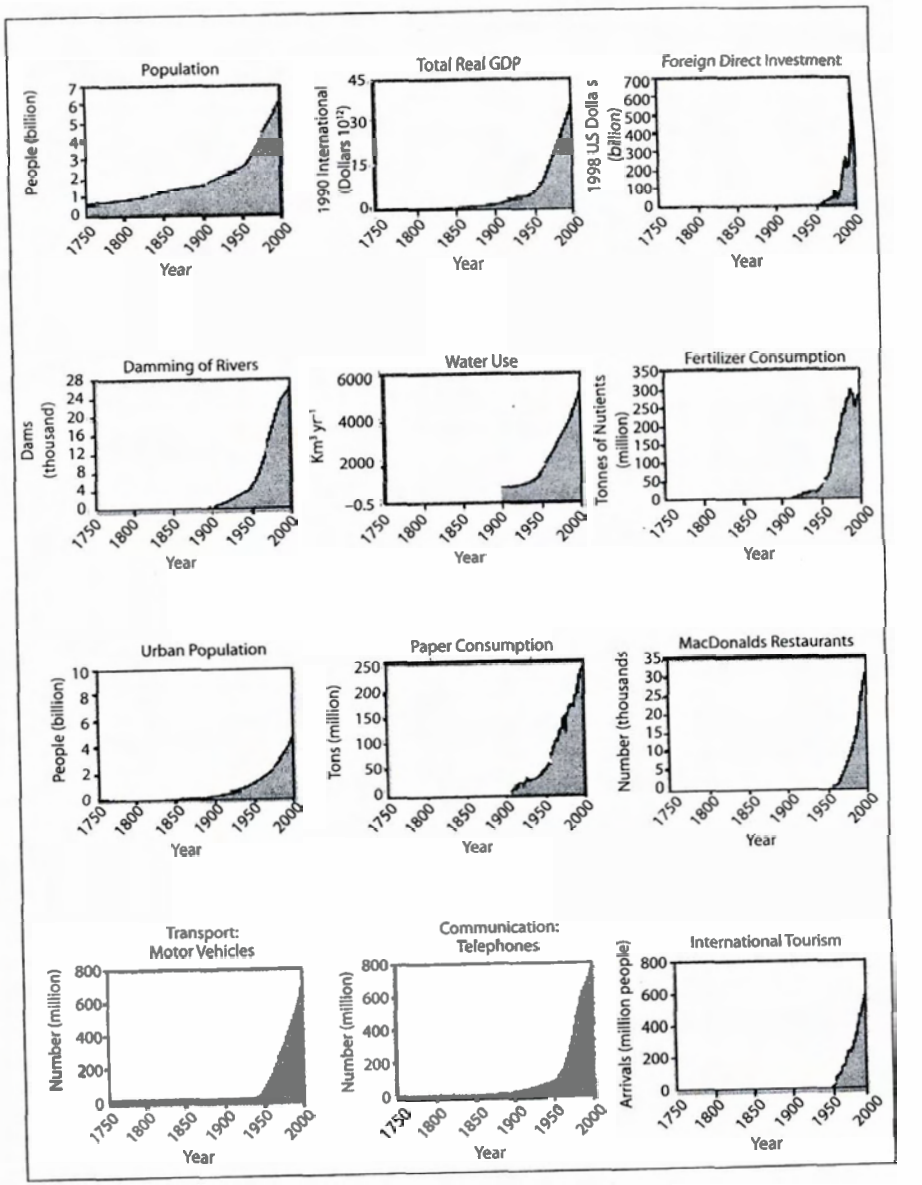

Figure 2 • Population changes in the last fifty years (Steffen et al. 2004).

10 billion (it is now about 6 billion). Total Gross Domestic Product, foreign direct investment, damming of rivers, water use, fertilizer consumption, urbanization, paper consumption, the number of motor vehicles, and the number of telephones have also all jumped exponentially since 1950.

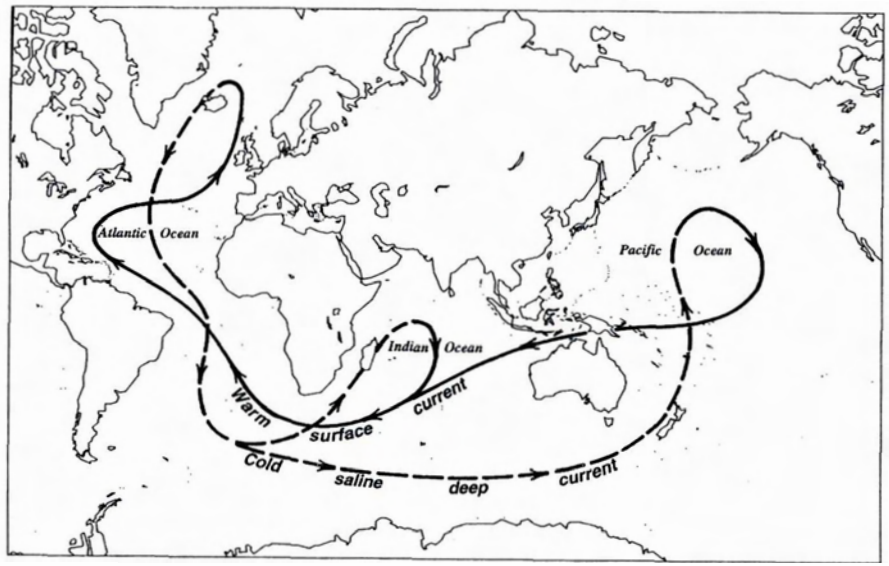

Figure 3 • Oceanic conveyor belt (adapted from Broecker 1991).

Similarly synchronous trends can be observed on the Earth-system side (see Figure 1): CO_2 concentrations, N_2O concentrations, CH_4 concentrations, ozone depletion, northern hemisphere average surface temperatures, the number of natural disasters, loss of fisheries, increase in nitrogen fluxes in coastal zones, loss of tropical rain forests and woodlands, amount of land dedicated to cultivation, and number of species gone extinct have all jumped exponentially since 1950.

In short, the simultaneous and interconnected nature of these changes in human ecological relations since 1950 suggest that human activities could inadvertently trigger abrupt changes in the Earth system. The most troubling of all would be the triggering of a disruption in the oceanic conveyor belt, which regulates the world climate (see Figure 3 and Broecker 1991). Simulations show that increases in greenhouse gases can trigger changes in the North Atlantic circulation, yielding scenarios resulting in rather dramatic collapses. We know already that the Atlantic thermohaline circulation (THC) reorganization can be triggered by changes in surface heat and in freshwater fluxes, and that crossing thresholds can result in irreversible changes of ocean circulation (Rahmstorf & Stocker 2003). Our current situation with regard to CO_2 alone, not to mention all the other gases, is well above the recorded experience of the past 500 million years as recorded in the Vostok Ice Core (see Figure 4).

Once we begin to operate well above any recorded levels, not just for one but for many measurable parameters, the question has to be asked if we

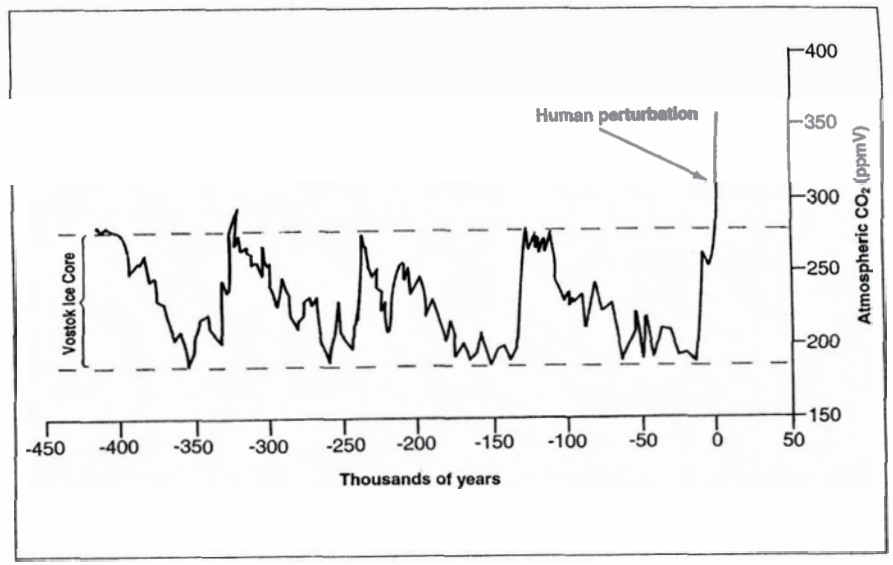

Figure 4 • Vostok ice core (adapted from Steffen et al. 2004).

have begun to play a game with the survival of our species on planet Earth. Do we recognize that business-as-usual is a sure guarantee of the end of life as we know it? Do we recognize our own contribution to it? Or are we so self-satisfied in our own material success that we cannot recognize overwhelming evidence when we see it? In the answer to these questions lies the likelihood of our having a future in a world worth living in.

V. Progress in the Integrated Study of Human–Environment Interactions

Over the past decade a series of international efforts have made considerable contributions to understanding the dynamics of coupled human–environment systems. The International Geosphere Biosphere Programme (IGBP) constitutes a network of scientists who have focused their attention on Earth-System Science, first by addressing global atmospheric circulation and climate change, then terrestrial ecosystems, hydrology, and modeling. These scientists in 1988 approached the social sciences community to engage their interest in addressing questions of the human dimensions of such global changes.

The science of global environmental change has, arguably, been responsible for the discovery of the rapid and large-scale accumulation of CO_2 in the atmosphere and the concern that this process will trigger global climate changes whose consequences could threaten the planet. Research

quickly identified land-use and land-cover changes as a major element of the global carbon cycle, both as source and sink (Houghton et al. 1983; Moore et al. 1981; Woodwell et al. 1983). This turned research interests toward the human alteration and conversion of landscapes, especially forests, agricultural lands, and grasslands, which increased or reduced carbon in the atmosphere. In addition, suggestions on how to balance the carbon cycle identified land cover as a candidate for helping explain the so-called missing carbon sink, with recent evidence pointing to such land changes as the regeneration of forests on abandoned agricultural lands as well as changes in ecosystem production owing to longer growing seasons and fertilization by CO_2 and nitrogen (Goodale et al. 2002; Schimel et al. 2001). Using these questions as points of departure, global environmental change research subsequently expanded to include a broad array of human-induced changes in the structure and the function of the Earth system, including ecosystems and their services and biodiversity (Daily et al. 2000; Lubchenco 1998; Raven 2002), in which land change plays a fundamental role. Recent evidence points to the importance of regional-to-local climate change as driven by land change (Kalnay & Cai 2003), and the emergence of sustainability science (Schellnhuber et al. 2004; Kates et al. 2001) represents yet another strong interest in land change, with strong policy implications (Turner et al. 2001).

A crucial element in the past decade has been the land-use and land-cover change program. Land-cover changes are complex processes that are discontinuous rather than smoothly even over time and space. Change is often triggered by sudden shock events that cascade throughout vast areas. Land cover will follow different temporal trajectories of change as a result of the differential uses to which the land is put, and we see evidence for high spatial heterogeneity in patterns of land use at the local level. We can see both land-use intensification and extensification occurring side by side in the same region, which makes it wrong-headed to suggest simple trajectories from extensive to intensive use, as we had done earlier in the social sciences.

Researchers on land use and land cover have focused a lot of their effort in the past decade on identifying the "drivers" of land-use and land-cover change. Examination of 152 studies of tropical deforestation indicated complex interactions and contradictory conclusions. Simple answers that we have turned to, such as the roles of population growth, poverty, and other drivers of land degradation, prove to be affected by other factors, such as social institutions, in ways that are at times surprising. Population proves to be important, but less so than national objectives for agricultural development and the expansion of roads, technology, and infrastructure. The comparative study of these cases shows that we have dealt rather simplistically with demographic factors. Demographic

change is not necessarily a shift from high to low mortality and fertility regimes (referred to as the demographic transition) but is more likely associated with the breakdown of extended families into a greater number of households and the consequences of more households for consumption behavior.

The study of a large number of cases also shows that there are distinct regional pathways to tropical deforestation and other land-use and land-cover changes. In Latin America, especially Amazonia, a phase of colonization is followed by infrastructure improvements, logging, and the expansion of ranching and pasture development. In contrast, changes in Africa and Asia are driven more by timber concessions and large-scale plantations, and in the case of Southeast Asia by intensive, high-density migration projects focused on commercial cultivation displacing native peoples.

Cross-cutting these pathways are the many processes of globalization that amplify or reduce the impact of such forces. Rapid land-use changes tend to be associated with the incorporation of regions into global markets and capital and information flows. When such incorporation occurs, local processes and relationships can be eclipsed by external drivers that bring about devastating impacts on local social and political processes. It can also change the biodiversity in a region by forcing a market-driven specialization of production to fit global standards or expectations. Yet, we know that this does not always happen: witness the recent expansion into urban-industrial areas of products previously restricted to the Amazon hinterland, such as the consumption of *açaí* (*Euterpe oleracea*) in Rio de Janeiro and São Paulo, and soon also in Europe (Brondizio In press).

Significant interest exists in improving our understanding of the drivers of land change and recognizing their complexity and variation beyond the general factors of demand for resources from increasing population and levels of consumption. Significant headway has been made, including the social causes of deforestation and arid land degradation (for example, Archer 2003; Indrabudi, de Gier, & Fresco 1998; Moran 1993; Reynolds & Stafford Smith 2002; Robbins 1998; Sierra & Stallings 1998; Walker et al. 1999); the role of institutions in land-use decisions (for instance, ıooster 2003; Lam ın et al. 2001; Ostrom et al. 2002; Turner et al. 2001); and understanding the reciprocal relationships between population and land change (for example, Crews-Meyer 2001; Döös 2002; McCracken et al. 1999). Significan gains have also been made in how to link social with physical processes using remotely sensed data and in nesting data and studies from local to regional to global scales (for instance, Fox et al. 2002; Turner et al. 2001; Moran & Brondizio 2001; Walsh & Crews-Meyer 2002), including a means of comparing different land classifications used in various studies (Di Gregorio & Jansen 2000; McConnell & Moran 2001).

Our understanding of the role of population growth has also changed. From thinking that more people always meant less forest, a growing number of cases suggest that forests can persist under high population densities (for example, Moran & Ostrom 2005; Ostrom et al. 2002). The role of communities and institutionalized rules of management plays a critical role in such cases, emerging from a variety of sources, among them scarcity of the valued good (Laris 2002). Studies have shown how political and economic structures constrain individual choices about management of land resources (for instance, Archer 2003; Robbins 1998). Cultural traditions and land tenure rules are critical in influencing how land can be used and by whom (Tucker 1999). A notable advance has been the growing use of orbital Earth-observing satellites linked to ground research to address regional to local issues of land change (Fox et al. 2002; Liverman et al. 1998; Walsh & Crews-Meyer 2002; Wood & Porro 2002), contributing novel insights to the interpretation of land-cover change on topics rarely addressable with any accuracy at global or regional scales, for instance, land change in areas undergoing urbanization (Seto & Kaufmann 2003) and stages of secondary succession and their management (Brondizio et al. 1994, 1996; Moran et al. 2000).

In short, research over the past decade on land-use and land-cover change is making increasingly productive use of case studies by linking them to regional and global modeling exercises that challenge past simplifications, and in more nuanced regional and global understandings of pathways of change that not only capture the complex socioeconomic and biophysical drivers of land-use change but also account for the specific human–environment conditions under which these drivers operate. But none of this will matter if we fail to imbue all of it with a stronger sense of why it matters.

Note

1. I wish to thank the Lund conference organizers for the opportunity to present these views before a superb audience and for the comments received since then. The first part of this chapter is elaborated into a full-length book, *People and Nature*, published by Blackwell Publishing in 2006. The work reported in the second half of the chapter reflects the collective efforts of many people in the global-change community (see Gutman et al. 2004). It also reflects many years of field research by me and my colleagues, made possible by numerous funding agencies: NSF, NOAA, NASA, and NIH. None of these colleagues or funding agencies, however, is responsible for the views expressed herein. They are the sole responsibility of the author.

CHAPTER 16

In Search of Sustainability: What Can We Learn from the Past?[1]

BERT J. M. DE VRIES

> Concepts of past cultures have probably changed as much in the last thirty years as have ideas of the earth system. The two massive data sets await reconciliation. (Gunn & Folan 2000:227)

Over the last decade, the idea of *sustainability* and *sustainable development* has gradually become a modern equivalent of, and complement to, the Declaration of Human Rights, which inspired so many people shortly after the devastating Second World War. Respected business and government leaders have embraced the concept and hailed it as the foremost challenge for the twenty-first century. Inevitably, this concept has been widened to the extent that it now accommodates a large variety of interpretations, objectives, and proposals. These are intertwined with personal and collective values and perceptions, which are in turn rooted in millennia of developments that shaped human experiences, knowledge, technical skills, social arrangements, and psychological traits.

It seems logical to ask whether we can learn something from the past in our search for the roots of unsustainable human–nature interaction.[2] Moreover, in the past few decades a large amount of new scientific research results have become available, in particular from undertakings such as the IGBP PAGES and the BIOME 6000 projects. There is need for an overview. In addition, novel insights and tools exist for a more in-depth, model-based understanding of the past that can help to synthesize various disciplinary data, concepts, and theories into a more coherent and transdisciplinary framework.

In this chapter, I reflect on some of the lessons learned from a three-year project sponsored by the *Hollandsche Maatschappij der Wetenschappen in Haarlem* in celebration of its 250th anniversary (de Vries & Goudsblom 2002).