Economic Pathways to Ecological Sustainability: Challenges for the New Millennium

by

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1. Introduction

There is a growing consensus among a broad spectrum of scholars that, as we enter the new millennium, the scope and magnitude of the environmental problems we face threaten the sustainability of our life-support systems (see, e.g., Lubchenco et al. 1991, Vitousek et al. 1997). This has long been argued by ecologists (e.g., Ehrlich and Ehrlich 1981), but they are now not alone. For example, the United States President's Committee of Advisors on Science and Technology (PCAST), an interdisciplinary body, has recently expressed concern that the composition and scale of economic activities in the USA are changing the chemistry of the nation's land, water, and atmosphere so dramatically that some of these changes are adversely affecting her natural capital and her ecosystem services to support the population sustainably (PCAST 1998). Earlier, the 1992 World Development Report of the World Bank summarized and recommended a number of methods developed by economists in recent years by which the protection, promotion, and use of environmental natural resources can be brought into the orbit of economic reasoning (see World Bank 1992).

If the core problems of the environment are in great measure ecological, their causes are largely anthropogenic. This means that appropriate solutions need to involve partnerships, not only between ecologists and economists, but also among scientists from a broad range of disciplines. Individuals from all branches of science have long recognized this challenge, but a deep chasm seems to have separated many of them. To be sure, different disciplines have frequently different lxicon, different ways of thinking, and different mindsets. For this reason, it has taken time to build bridges. In the last few years, however, there has been a virtual phase transition, in that an increase in trust and mutual respect has led to widespread cooperation and collaboration among natural and social scientists engaged in the study of environmental problems. New institutions, societies and journals have been established (1). Indeed, the points drawn in the PCAST report on the economics of the environment are a natural outgrowth of the findings of natural scientists (e.g., Ehrlich et al. 1977, Wilson 1992, Cohen 1995, Daily 1997), social scientists (e.g., Kneese et al. 1972, Mäler 1974, Baumol and Oates 1975, Dasgupta 1982, Dasgupta and Mäler 1991) and, more recently, of partnerships between them (e.g., Arrow et al. 1995, Daily et al. 1998, Levin et al. 1998). Although much has been accomplished, a great deal more needs to be done.

Individuals and groups make use of the environmental resource base for large numbers of reasons. Their rates of use depend on the costs and benefits people perceive or, indeed, face for availing themselves of the resources. In other words, the costs and benefits give rise to the incentives people have for protecting, or promoting, or destroying the various forms of natural capital. But these costs and benefits depend not only upon the size and composition of the resource base, they depend also upon the institutional structure within which people operate. So, for example, if economic transactions are carried out exclusively in markets and if, for whatever reasons, prices for the use of ecosystem services are low, people would be expected to be profligate in their use of such services. And so on. It follows that the overarching environmental problem is this: what kinds of social institution would be expected to best protect and promote the environmental resource base upon which life depends and thrives?

Progress in our understanding of the problem has been made in recent years only because investigators recognised that there are several distinct sets of sub-problems which need to be studied first. In this article we sketch those we believe to be of particular importance. Although closely related, we discuss them in turn for pedagogic reasons.

The plan of the paper is as follows: In Section 2 we set the scene by reporting a few global statistics on global food availability and prospects and show that, as they involve different considerations, global environmental concerns need to be contrasted from local environmental concerns. The point is that a study of local environmental problems brings to light the wide variety of institutional structures that are currently in operation and which need to be understood.

In Section 3 we show in which way the prevailing structure of prices and standard-of-living indices in common usage are both deficient. In particular, we show how they mislead decision-makers, be they households, private firms, or the government. As we have already noted, this is a key issue, for it gives rise to the structure of incentives people have in making use of the environment around them. However, the relative economic values of different natural resources depend also on the extent to which such resources can substitute for one another in economic activity and, more crucially, in preserving life itself. So, in Section 4 we comment on the notion of substitutability among natural resources. In Section 5 we return to our central theme, that environmental problems in the modern world are a symptom of institutional failure. Section 6 offers some general remarks on the agenda for future research.

2. Local vs. global constraints

Although environmental degradation at the geographically localised level has occurred from time to time since even before recorded history, their global reach is a more recent phenomenon. Ecologists' findings suggest that a near-50 percent increase in world population, allied to a doubling of gross world product per head, by year 2040 or so, would create substantial additional "stresses" in both local and global ecosystems (e.g., Vitousek et al. 1997, Matson et al. 1997, Chapin et al. 1997, Botsford et al. 1997). For example, global "demand" for food could easily double over the period 1990-2030, with two-and-a-half to three-fold increases in the poorest countries. Of particular concern are Asia and Africa where, over the next fifty years, plant-derived food-energy requirements are expected to increase by a factor of 2.3 and 5, respectively, with a more-than-sevenfold increase expected in some countries (Pinstrup-Andersen 1994, Crosson and Anderson 1995, FAO 1996).

And these figures do not include the inevitable increases in the demand for non-food commodities which would accompany increases in GNP. This is why much attention has been devoted in recent years to global-scale environmental problems.

The prospects for a suitable response to the predicted increases in the scale of the human enterprise depend on our ability to manage constraints on the supplies of production inputs and on the environmental consequences of the use of these inputs. These constraints are not present uniformly across the globe. Moreover, local problems of production and distribution can be difficult to counter even when global supplies are adequate, because many are too poor. To ask merely whether global production of goods and services can be increased to meet future demands in a sustainable way misses much of the question. For example, food scarcity manifests itself locally, so efforts to alleviate it must be tailored to local circumstances. To do otherwise is akin to doctoring a sick person on the basis of global health statistics. A related problem involves the growing inequities related to access to human services (e.g., due to an increasing variance in the distribution of income and wealth).

Correct diagnosis of the problems which lie at the population-consumption-environment nexus is usually a local matter, even though appropriate treatment may require regional and global support. For example, soil erosion may not currently be a serious threat to global agricultural capacity, but at local levels in various parts of the world it presents major problems to the people affected. Similarly, decisions concerning fertility, education, child-care, food, work, health care, and the use of local environmental resources are, in large measure, reached and implemented within households which face constraints that are shaped, in part, by national and international policies and the state of the local environment. The influence of household decisions are felt through local interactions (e.g., intra-village and village-town trades), and thence "upward" globally. Recent work has identified a variety of circumstances that are shaped by positive-feedback mechanisms, driving poverty, hunger, high fertility, resource degradation, and civic disconnection at the local level, even while national (and not merely global) income is rising (see, e.g., Dasgupta and Mäler 1991, Dasgupta 1993, 1995, 1998, Cleaver and Schreiber 1994). This suggests that, if we are to obtain reliable projections of global economic prospects, we need to adopt local, contemporary perspectives. It also reminds us that environmental problems go beyond those that are aired during international negotiations; there are myriad local environmental problems in constant need of attention by local people. It reminds us too that to say, as development economists frequently do (see, e.g., Bardhan 1996, Ray 1998), that current-day environmental and population problems in poor countries are only a manifestation of poverty, is misleading: since each of the problems influences the others, none is a prior cause of the others. It also reminds us that in malfunctioning institutions the prices households face for the use of various services don’t reflect the latter’s social scarcity values.

3. Economic valuation of ecosystem services

But then why is there a special need to value ecosystem services? Why can we not rely on markets to guide decisions, be they global or local, in the way we do for so many other goods and services? Or to put the matter in another way, why aren’t markets an adequate set of institutions for protecting the environment?

The reason is that for many environmental resources markets simply do not exist. In some cases they do not exist because the costs of negotiation and monitoring are too high. One class of examples is provided by economic activities that are affected by ecological interactions involving long geographical distances (e.g., the effects of uplands deforestation on downstream activities hundreds of miles away); another, by large temporal distances (e.g., the effect of carbon emission on climate in the distant future, in a world where forward markets are non-existent because future generations are not present today to negotiate with us). Then there are cases (e.g., the atmosphere, aquifers, and the open seas) where the nature of the physical situation (viz. the migratory nature of the resource) makes private property rights impractical and so keeps markets from existing; while in others (e.g., biodiversity; see Perrings et al. 1994), ill-specified or unprotected property rights prevent their existence, or make markets function wrongly even when they do exist. In short, environmental problems are often caused by market failure (but see Section 5).

Problems arising from an absence of forward markets for "transactions" between the present generation and the distant future are no doubt ameliorated by the fact that we care about our children’s well-being and know that they, in turn, will care for theirs, in an intergenerational sequence. This means, by recursion, that even if we don’t care directly about the well-being of our distant descendants, we do care about them indirectly. However, there is a distinct possibility that our implicit concern for the distant future via such recursion is inadequate. This is why many economists have argued that market rates of interest do not reflect social discount rates (see, e.g., Lind 1982, Arrow et al. 1996, Portney and Weyant 1999). In short, market failure involves not only misallocation of resources in the present, but also misallocation across time.

Since markets cannot be relied upon to provide us with prices which would signal true environmental scarcities, there is a need for techniques which would enable us to do so. A great deal of work in environmental and resource economics has been directed at discovering methods for estimating <u>notional</u> prices, often called <u>accounting</u> prices by economists, that could be used by decision-makers. But for the most part practical methods have been developed for estimating the accounting prices of <u>amenities</u> (see, e.g., Mitchell and Carson 1989), relatively few for the multitude of ecosystem services which constitute our life-support system. There is a great deal to be done in the development of valuation techniques for different categories of resources and in different institutional settings.

However, this much is clear. Indicators of social well-being in frequent use (e.g., gross national product per head [GNP], life expectancy at birth, and the infant survival rate) do not reflect the impact of economic activities on the environment. In particular, such indices of the standard of living as GNP per head pertain to commodity production; hence, they don't fully take into account the use of natural capital in the production process. So statistics on past movements of gross product tell us nothing about the resource stocks which remain. They do not make clear, for example, whether increases in GNP per head are being realized by means of a depletion of the resource base (for example, if increases in agricultural production are not being achieved by "mining" the soil). Over the years environmental and resource economists have shown how national accounting systems need to be revised so as to include the value of the changes in the environmental resource-base that occur each year due to human activities (see, e.g., Mäler 1974, Dasgupta and Heal 1979). We should be in a position to determine whether resource degradation in the various locations of the world has yet to reach the stage from which their current economic activities are unsustainable. But the practice of national-income accounting has lagged so far behind its theory, that we have little idea of what the facts have been. It is, therefore, entirely possible that time trends in such commonly used socio-economic indicators as GNP per head, life expectancy at birth, and the infant survival rate give us a singularly misleading picture of movements of the true standard of living.

To state the matter succinctly, current-day estimates of socio-economic indicators are biased because the accounting value of changes in the stocks of natural capital are not taken into account. Because their accounting prices are not available, environmental resources on site are frequently regarded as having no value. This amounts to regarding the depreciation of natural capital as of no consequence. But as these resources are scarce goods, their accounting prices are positive. So, if they depreciate, there is a social loss. It means that profits attributed to projects that degrade the environment are frequently greater than the social profits they generate. Estimates of their rates of return are higher than their true rates of return. Wrong sets of investment projects therefore get selected, in both the private and public sectors: resource-intensive projects look better than they actually are. It should be no surprise, therefore, that installed technologies are often unfriendly towards the environment. This is likely to be especially true in poor countries, where environmental legislations are usually neither strong nor effectively enforced.

The extent of such bias in investment activities will obviously vary from case to case, and from country to country. But it can be substantial. In their work on the depreciation of natural resources in Costa Rica, Solorzano et al. (1991) estimated that in 1989 the depreciation of three resources—forests, soil, and fisheries—amounted to about 10 percent of gross domestic product and over a third of gross capital accumulation.

One can go further: The bias extends to the prior stage of research and development. When environmental resources are underpriced (in the extreme, when they are not priced at all), there is little incentive on anyone’s part to develop technologies which would economize their use. So the direction of technological research and technological change are systematically directed against the environment. Consequently, environmental "cures" are sought once it is perceived that past choices have been damaging to the environment, whereas "prevention", or input reduction, would have been the better choice. To give an example, Chichilnisky and Heal (1998) compared the costs of restoring the ecological functioning of the Catskill Watershed ecosystem in New York State, to the costs of replacing the natural water purification and filtration services the ecosystem has provided in the past by building a water-purification plant costing 8 billion US dollars. They have shown the overwhelming economic advantages of preservation over construction: Independent of the other services the Catskill watershed provides, and ignoring the annual running costs of 300 million US dollars for a filtration plant, the capital costs alone showed a more than 6-fold advantage for investing in the natural-capital base.

It is worth emphasizing that the purpose of estimating environmental accounting prices is not to value the entire environment; rather, it is to evaluate the benefits and costs associated with changes made to the environment due to human activities. Prices, whether actual or merely notional, have significance only when there are potential exchanges from which choices have to be made (for example, when one has to choose among alternative investment projects). Thus, the statement that a particular act of investment can be expected to degrade the environment by, say, 1 million dollars annually has meaning, because it says, among other things, that if the investment were not to be undertaken, humanity would enjoy an additional 1 million dollars of benefits in the form of environmental services. The statement also has operational significance: the estimate could (and should) be used for calculating the rate of return attributable to the investment in question.

Contrast such an estimate of the value of an incremental change in the environmental resource base with the one which says that, world-wide, the flow of environmental services is currently worth, in total, 33 trillion US dollars annually (Costanza et al. 1997). The former is meaningful because it presumes that humanity will survive the incremental change and be there to experience and assess the change. The reason the latter should cause us to balk is that if environmental services were to cease, life would not exist. But then who would be there to receive 33 trillion dollars of annual benefits if humanity were to exchange its very existence for them? This is a case where the value of an entire something has no meaning and, therefore, is of no use, even though the value of incremental changes to that same something not only has meaning, it also has use.

4. Non-convex processes, biodiversity and substitution possibilities

In fact there are further reasons why markets can't be expected to function well for environmental resources. A major achievement of modern economics has been to show that there are many virtues in a competitive market mechanism in economies where the transformation of goods and services into further goods and services is governed by linear processes. But when one talks of "stress" and "positive-feedback mechanisms," as we did in Section 2, one refers to systems characterized by non-convex processes. (A process is said to be convex if, given any two time paths that are feasible under the process, all time paths that are weighted averages of the two (with positive weights), are also feasible. Non-convex processes are, therefore, non-linear. Koopmans 1957 is the classic reference on the subject.) It is as well to emphasize that such processes can govern both global and local systems. Indeed, even if a large-scale ecosystem were not to show signs of stress, local ones could, and often do, display such signs. There are also extant records of local ecosystems having collapsed in the past.

The assumption of linearity in economic transformation possibilities is related to the idea that for every commodity that can be transacted, there are close substitutes lying waiting. The latter assumption, if true, would imply that even as constraints increasingly make their presence felt on any one resource base, humanity could move to other resource bases. The enormous additions to the sources of industrial energy (successively human power, animal and wind power, timber, coal, oil and natural gas and, most recently, nuclear) that have been realized are a prime historical illustration of this possibility.

The assumption of linearity continues to be reasonable in many spheres of activity, but it becomes sorely stretched when applied to those that encroach upon ecosystems on a greater spatial scale. The services provided by an ecosystem are dependent on the composition of biota and the abiotic processes at work. Here it is important to distinguish among the resource base that comprises an ecosystem (its structure), its functioning, and the services the ecosystem provides. (So, in concentrating on functional, as opposed to structural, characteristics, we are taking an entirely utilitarian view of ecosystems.) Degradation of the resource base (e.g. destruction of native populations of flora and fauna) not only affects the volume and quality of those services; it also challenges an ecosystem's "resilience," which is the capacity of the system to absorb disturbances, or perturbations, without undergoing fundamental changes in its functional characteristics. (Recovery from disturbances can be costly, in some cases impossible. In short, such flips can in many cases be regarded as irreversible. The mathematics of "relaxation phenomena" offers a formal account of what the intuitive notion of irreversibility amounts to. On this, see for example, Levin 1999.) If a system loses its resilience, it can flip to a wholly new state when subjected to even a small perturbation (see, e.g., Wilson 1992, Holling et al. 1995, Walker 1995, Levin et al. 1998). One way to interpret an ecosystem's loss of resilience is to view it as having moved to a new stability domain, thereby being captured by a different attractor. Sudden changes in the character of shallow lakes (e.g., from clear to eutrophied water), owing to increases in the input of nutrients (Scheffer 1997, Carpenter et al. 1998) and the transformation of grasslands into shrublands, consequent upon non-adaptive cattle-management practices (Perrings and Walker 1995) provide two examples. Human populations have on occasions been unable to avoid suffering from unexpected flips in their local ecosystems because of this. Fishermen on Lake Victoria and the nomads in the now-shrublands of southern Africa are examples from recent years.

Closely related to non-convex processes is the concept of biodiversity. Even today it is a popular belief among some segments of society that the utilitarian value of biodiversity is located mainly in the potential uses of genetic material (e.g., for pharmaceutical purposes). Preservation of biodiversity is seen as a way of holding a diverse portfolio of assets with uncertain payoffs. But it is increasingly being appreciated by ecologists that biodiversity, appropriately conceived, is essential for the maintenance of a wide variety of services on which humans and, indeed, the resiliency of our very life support systems depend (UNEP 1995, Daily 1997). This has the important corollary that, to invoke the idea of substitutability among natural resources in commodity production in order to play down the utilitarian importance of biodiversity, as people frequently do (e.g., Simon 1981, 1994), is wrong intellectually. Biodiversity, indeed, is necessary for substitute ecosystem services to be available. It follows that its importance cannot be downplayed by the mere hope that there are substitutes lying in wait. Recall the famous analogy in Ehrlich and Ehrlich (1981) relating species in an ecosystem to rivets in an airplane: One by one, perhaps, species may disappear and not be missed. Eventually, however, the cumulative effect of loss of biodiversity will lead to the crash of ecosystem functioning, just as the cumulative loss of redundant rivets will lead to the crash of an airplane.

5. Institutional failure and ecosystem destruction

These observations tell us why markets cannot be relied upon to generate correct signals of resource scarcity. This being so, we shouldn't expect markets to generate those signals that would alert us to impending shifts in the stability regimes of ecosystems.

In fact, of course, traditional societies have rarely depended upon markets for allocating environmental resources. The study of local environmental problems has revealed the wide variety of institutional structures which have evolved in different locations, in part in response to environmental scarcities. To give only one example, both domestic energy- and water-use in urban USA are based on monetary transactions with commercial suppliers and local authorities, while in rural sub-Saharan Africa and the Indian sub-Continent it is widely based on communally-owned resources, such as woodlands, rivers, water-holes, and wells. The structure of incentives in the former is based on prices, while in the latter it is built on social norms (Jodha 1986, Ostrom 1990, Dasgupta, 1993). But just as markets can fail to operate effectively, giving rise to wrong prices, so too can social norms erode under changing circumstances, thus removing the incentives people in a given location previously have had for nurturing their resource-base (Dasgupta, 1995).

Ecosystem degradation can occur also because of bad government policies, for example, because of wrong tax policies. (Binswanger 1991 has argued that government policies in Brazil regarding agricultural income and land ownership have in the past provided incentives for deforestation in the Amazon basin.) We may, therefore, put the matter more generally: an underlying cause of environmental degradation is institutional failure. Indeed, the various types of institutional failure pull in different directions and are together not unrelated to an intellectual tension between the concerns people share about such matters as mean global warming and acid rain, which sweep across regions, nations and continents; and about those matters (such as, for example, the decline in firewood or water resources) that are specific to the needs and concerns of the poor in a small village community. Environmental problems present themselves differently to different societies. Some individuals identify environmental problems with population growth, while others identify or associate them with wrong sorts of economic growth. Others view them through the spectacle of poverty. Each of these visions is correct. There is no single environmental problem; rather, there is a large collection of answers and challenges, some global, some regional, many local.

For years, environmental and resource economists have responded to this interrelationship by identifying desirable institutional reforms in a case-by-case manner. Alterations to prevailing structures of property rights, the imposition of environmental and resource taxes, environmental regulations and policies, local-community control, and various other devices that change individual and group incentives have been much discussed and implemented. Contrary to what is frequently suggested in popular writings on environmental matters, the tools of modern economics are not restricted to the study of convex systems. Many of the lessons drawn have been put into use, most especially in the western industrial countries.

However, less research has been conducted on the economics of local ecosystems in poor societies. There is a reason for this. Because economic systems often do not generate signals that would alert the public of growing resource scarcity (a case of institutional failure), it can be a very difficult matter for those who suffer from the economic consequences of the scarcity to get an environmental problem placed on the agenda of public discourse. In poor countries, for example, there are strong links between household poverty, local environmental deterioration, and a weak political voice (see, e.g., Dasgupta 1993). As in many other aspects of life, the political economy of the matter, and in particular governance, is at the heart of many environmental problems.

6. Conclusion

The challenges of sustainability cannot be the province of ecologists or economists alone, but must involve collaboration among diverse disciplines. We must understand better the linkages between Nature and the services it provides society. This will involve a deeper understanding of how biodiversity and ecosystem functioning are coupled. We must find ways to translate this knowledge into economic terms, and to utilize that information to build strategies for achieving sustainability. This program is in part political, and in part scientific. These are, however, interconnected; the successful implementation of political solutions must be informed by knowledge not only of the dynamics of ecosystems, but also of the dynamics of humans and their societies.

The roots of global environmental problems are at the local level, and linking local with global perspectives is essential to their solution. Furthermore, global indicators commonly in use fail to represent declines in environmental resources and, consequently, the true costs to societies. Institutional reforms are essential to make the system work, reforms that will tighten feedback loops, creating incentives for individuals and groups to operate in the common good.

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(1) Examples are Resources for the Future, World Resources Institute, and the Heinz Center for Science, Economics and the Environment - all based in Washington, D.C.; and the Beijer International Institute of Ecological Economics of the Royal Swedish Academy of Sciences, Stockholm. There are now two professional associations engaged in this field of activity: the International Association of Environmental and Resource Economics and the International Society for Ecological Economics. Prominent journals include the Journal of Environmental Economics and Management, Ecological Economics, and Environment and Development Economics.