A systems perspective on the interrelations between natural, human-made and cultural capital

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In recent years substantial progress has been achieved in the field of ecological economics for clarifying human-nature interrelations. The fundamental role of the life-support functions of the environment (Odum, 1975) for economic development and sustainability has entered from ecology into economics, and has started to be theoretically as well as empirically analyzed. This has, in part, given rise to the terminology of *natural capital and human-made capital.* In contrast to the assumptions of standard economic theory, ecological economists regard human-made capital and natural capital as fundamentally complementary. Natural capital and its derived goods and services are the preconditions or the basis for economic development. It is not possible for human ingenuity to create human-made capital without support from natural capital (e.g. Daly, 1990). Moreover, it is not possible to approach sustainability by only focusing on these two factors, natural capital and human-made capital interrelations. We need a third dimension, what we refer to as *cultural capital,* as well. From a systems perspective, we emphasize that the three types of capital are strongly interrelated and form the basis for guiding society towards sustainability.

THREE TYPES OF CAPITAL

Human-made capital is capital generated via economic activity through human ingenuity and technological change; the produced means of production. This is a common definition of capital in economics textbooks.

Natural capital consists of three major components: (1) non-renewable resources such as oil and minerals that are extracted from ecosystems, (2) renewable resources such as fish, wood, and drinking water that are produced and maintained by the processes and functions of ecosystems, (3) environmental services such as maintenance of the quality of the atmosphere, climate, operation of the hydrological cycle including flood controls and drinking water supply, waste assimilation, recycling of nutrients, generation of soils, pollination of crops, provision of food from the sea, and the maintenance of a vast genetic library. These crucial services are generated and sustained by the work of ecosystems (Odum, 1975; Folke, 1991). Only through maintenance of an integrated, functional ecosystem can each environmental good and service be assured; such goods and services cannot be managed one by one as independent commodities.

Cultural capital refers to factors that provide human societies with the means and adaptations to deal with the natural environment and to actively modify it: how people view the world and the universe, or cosmology in the sense of Skolimowski (1981); environmental philosophy and ethics, including religion (Leopold, 1949; Naess, 1989); traditional ecological knowledge (Johannes, 1989); and social/political institutions (Ostrom, 1990). Cultural capital, as used here, includes the wide variety of ways in which societies interact with their environment; it includes cultural diversity (Gadgil, 1987).

We have used the term 'cultural capital' for the lack of a better term. As an alternative term, we considered using 'adaptive capital' to emphasize that we are referring to all of those factors important to ecological economics from an evolutionary, mainly cultural evolutionary, sense (Costanza et al., 1991). But the term would be inadequate to capture the systems perspective that we present here, in which organisms not only adapt to, but also actively modify their environment. (This concept is referred to as autopoiesis by Varela et al., 1974.) Daly (1980) has used the term 'moral' to refer to some of the same social factors; Daly and Cobb (1989) have distinguished between moral capital and physical capital in reference to ethics and community.

No doubt all of these terms are insufficient, but it would be difficult to find a term that would adequately cover all aspects of human societal evolution. The areas mentioned above fall into a number of different fields of social sciences and humanities; there is no common technical literature that binds them. Yet from a systems point of view. they are clearly interrelated as they all pertain to adaptations to deal with the natural systems of which human systems are a part, and on which the long-term sustainability of human systems depend. Together they shape the way in which society interacts with its environment, and defines and uses natural capital.

SYSTEMS ECOLOGY AND CULTURAL ADAPTATIONS

First, consider the systems view of the environment. The structure and function of the ecosystem is sustained by synergistic feedbacks between organisms and their environment. The physical environment puts constraints on the growth and development of the biological subsystem which, in turn actively modifies its Physical environment to enhance its chance of survival. The evolutionary perspective focuses on the incessant process by which organisms adapt to and co-evolve with their environment. The ecological system as a whole is seen to be in a dynamic process of self-organization and self-maintenance (homeostasis). Solar energy drives the use of matter for self-organization, and complex, interdependent hierarchical structures evolve. It is this self-organizing ability, the resilience, organization, and vigour of the ecosystem that generates and sustains the goods and services which form the necessary material basis for human societies.

Now consider the systems view of the human-environmental relationship. The structure and function of the ecosystem is sustained by synergistic feedbacks between human societies and their environment. The physical and biological environment places basic physical constraints on the growth and development of the human subsystem. For

example, the population growth in a certain area would be limited by the carrying capacity of the environment. The human subsystem, in turn, actively modifies its physical and biological environment; carrying capacity of an area may be decreased through the degradation of life-support systems, or increased by organizing differently or using new technology that works with the environment (e.g. Mitsch and Jogensen, 1989). The self-organizing ability and homeostasis of the ecosystem is paralleled by the self-organizing ability and homeostasis of the human subsystem. These adaptations, in turn, shape the way in which society defines and uses natural capital.

The systems view of the human-environment interrelationship in human ecology is not nearly as well developed as the systems view in ecology. It is a relatively new field, but one in which impressive new evidence has been accumulating rapidly in recent years on co-evolution in human-nature relations, traditional ecological knowledge, and self-organizing ability for the sustainable use of resources. We deal with each in turn.

HUMAN ECOLOGY AND CULTURAL CAPITAL

(1) Human-environment interactions may be viewed as a co-evolutionary interrelationship in which the two sides change one another continuously by mutual feedback. This is the logical extension into the human subsystem of an evolutionary concept that has been in common use in ecology at least since the 1960s (Ehrlich and Raven, 1964). Yet many ecologists have been reluctant to extend mutually interactive relations to the study of human ecology, concentrating instead on other species or on the impacts of humans on the environment.

Historically, the world can be seen as consisting of a "mosaic of co-evolving social and ecological systems" (Norgaard, 1987). In each part of the mosaic, the human subsystem selected for species that fulfilled its needs, and itself evolved under the selective pressure of having to use natural capital sustainably. "Co-evolution is a local process," Norgaard (1987) pointed out, "specific to local cultural knowledge, technology and social organization." Thus, these local human subsystems are a significant starting point for discussion of evolution in ecological economics.

(2) A great deal of information has been compiled in recent years on traditional ecological knowledge. From subarctic Amerindian hunters and Pacific Island fishermen to Scandinavian herders and Amazon horticulturists, generations-old adaptations and knowledge help various groups survive in the long-term (e.g., Johannes, 1989). These adaptations constitute a reservoir of human knowledge that could guide us to a sustainable society. Gadgil (1987) observed that human cultural diversity and biological diversity go hand-in-hand as prerequisites to long-term societal survival. Too great a diversity within a small area can also lead to ethnic strife, as in the Middle East. But the point we wish to make here is that with only a limited number of dominant world views, the chance of finding sustainable patterns will be diminished. Diverse cultures hold the key not only to diverse adaptations to the environment, but also to a diversity of world views, philosophies, and ethics that underpin these adaptations (Gadgil and Berkes, in press).

Different human societies have elaborated a startling diversity of ways in which traditional resource use practices were organized and natural capital used without depletion (Berkes, 1989). This diversity represents a pool of social system adaptations spanning many millennia, a 'library' from which a new science of sustainable resource use can be synthesized from the best of traditional and scientific knowledge. The conservation of this rapidly diminishing pool of experience is as pressing as the conservation of biological diversity.

(3) The most convincing body of evidence for human self-organizational ability may be found in the literature of common property resources (McCay and Acheson, 1987; Berkes, 1989; Ostrom, 1990). The common property literature focuses on *institutions* rather than co-evolution or traditional ecological knowledge, but all three are no doubt interrelated toward the solution of the vexing common property dilemma. Considering that conventional wisdom predicts the demise of any resource held in common (Hardin, 1968), a surprising number of cases exist in which users have been able to use shared resources such as grazing lands, forests, fish, wildlife and water, sustainably (Feeny et al., 1990).

A number of long-enduring, self-organized and self-governed common property institutions have been analyzed by Ostrom (1990). Examples include communal land tenure in high mountain meadows and forests in Torbel, Switzerland; common land management in Hirano and area villages in Japan; and the huerta irrigation system in the Valencia area and elsewhere in Spain. From these and other cases, Ostrom (1990) has derived a set of conditions that lead to success (sustainability) in commons management, as opposed to the "tragedy of the commons."

Perhaps the main lesson from the common property literature is that, given a resource management problem, a group of people often organize themselves to deal with it in a manner similar to the formation of a 'bucket brigade' to put out a fire in a rural neighbourhood. The evolution of rules and self-regulatory mechanisms within the group has adaptive significance for sustainability and survival. These common property institutions are found with all resource types, many of them non-traditional, covering a wide range of regions and cultures throughout the world. Specific institutions can arise in less than ten years, and may endure over centuries (but evolve constantly).

In these institutions, one of the critical variables is the number of functional units. Many simple common property systems involve on the order of one hundred users. More complex systems function with thousands, if organized hierarchically as in some irrigation systems (Feeny et al., 1990; Ostrom, 1990). Conceptually, it is not surprising that we find such self-organizing capabilities in human systems, similar to those in ecosystems, because human systems are subsystems of ecosystems. But in practical terms, the adaptation of common property institutions for the solution of regional and international resource management problems is going to be challenging indeed.

CONCLUSIONS

There exists a fundamental interrelation between natural capital, human-made capital, and cultural capital. Natural capital is the basis, the precondition, for cultural capital. Human-made capital is generated by an interaction between natural and cultural capital. Cultural capital will decide how we will use natural capital to 'create' human-made capital. Therefore, human-made capital is never value-neutral. Technologies that we develop are not simply tools we can put to good or bad use - they reflect our cultural values.

Costanza et al. (1991) state that "humans have a special place in the system because they are responsible for understanding their own role in the larger system and managing it for sustainability." A necessary condition for sustainability is that processes and functions of natural capital are supported, rather than disrupted, by feedbacks from society. Many resource use problems that currently exist can be traced in part to some of the same elements that we assign to cultural capital, e.g., differences in religion, ethics, cultural diversity, and social institutions.

We need to integrate human resource flows with ecosystems in a synergistic fashion. Combining knowledge of cultural self-regulatory patterns, such as those discussed in this paper, with improved understanding of self-organizing principles in ecosystems (Mitsch and Jorgensen, 1989), could lead us towards sustainable solutions. Important measures for understanding the role of the dominant Western-oriented culture in the larger system are to increase the general awareness of the fundamental dependence of culture on its environment, the humans-as-part-of-nature view, and the need to preserve and learn from a diversity of cultural experiences how to relate to the resource base in a synergistic fashion. Such measures would stimulate social-environmental self-regulatory patterns for sustainability.

In summary, we alert ecological economists to the cultural capital dimension and to cultural-ethical-institutional issues. From a policy point of view, we wish to highlight the importance of *institutions* and the lessons available from the common property literature - after all, the global sustainability dilemma is a common property dilemma writ large. Institution-building, collective action (Ostrom, 1990), cooperation (Axelrod, 1984), and social learning (Milbrath, 1989) may be some of the ways in which we can self-organize and adapt rapidly enough to meet the constraints of sustainability.

Can we use the great creative activity of the current energy-rich world and the pervasive information network that we have developed to find 'a prosperous way down' to sustainable steady-state societies (Odum, 1973, 1988); to rethink and reconstruct a new science that is better adapted to deal with the interdependencies among natural capital, human-made capital, and cultural capital? By taking a systems perspective, the field of ecological economics has great potential to take on this challenge.

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