APPROACHING SUSTAINABLE DEVELOPMENT FROM DIFFERENT ANGLES

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Summary

Taking a historical perspective, this article comes to the conclusion that human beings are causing the life-support system to deteriorate, and addresses sustainable

development from the economics, biogeochemical, and social approaches. Then it refers to the international coordination now under way. Finally it summarizes the details of sustainable development.

1. Introduction

The expression sustainable development was coined to demonstrate that economic growth and environmental protection can be compatible. Many definitions have been provided for this expression. At the most basic level, dictionaries give some of the meanings of the verb sustain as “to give support to, nourish, keep up/prolong” and define development as “the improvement of human welfare and the quality of life.” Development is therefore not entirely synonymous with economic growth, which focuses mainly on real incomes.

A narrow definition of sustainable development would indicate that per capita income or well-being is constant or increasing over time. The wider concept of sustainable development is less precise and embraces a set of indicators of well-being (including income) that could be maintained or increase over time. The World Bank, in its *World Development Report 1992*, states that sustainable development means basing developmental and environmental policies on a comparison of costs and benefits and on careful economic analysis that will strengthen environmental protection and lead to rising and sustainable levels of welfare.

The practice of sustainable development involves making choices. Any given development activity will inevitably advance some interests while prejudicing others. In order for informed choices to be made, economic, ecological, political, social, and cultural factors all needed to be considered and presented to decision makers in an unambiguous and unbiased fashion.

Different disciplines place varying interpretations on the concept of sustainability. While economists emphasize the maintenance and improvement of the living standards of humans, ecologists and scientists have broadened the meaning to express concern about preserving the adaptability and function of entire ecological and biophysical systems. At the same time, geographers and anthropologists have focused on the viability of social and cultural systems.

Understanding sustainable development in turn requires that the competition for resources be placed in a historical context, in order to identify and describe the social and economic underpinnings of environmental degradation. By examining how underlying processes have evolved in the past, it becomes easier to understand the goals of various types of development activities and institutional arrangements.

2. A Historical Perspective

Throughout the course of human evolution, the populations that survived were by definition those that had a sustainable relationship with their environment; that is, unsustainable behavior led to displacement or extinction of the population or to a change in behavior. This does not mean that early human populations did not have significant ecological impacts or modify their environments to suit their needs better. Indeed, coincident with the first arrival of *Homo sapiens* in North America, some thirty-four genera of large mammals became extinct, and the first arrivals of humans into Australia, New Zealand, and Madagascar were accompanied by significant losses of species of large animals that were easily harvested by the new and sophisticated predator. Presumably, hunters missed at least some of these easily hunted species once they were gone, while local cultures based on the harvesting of large mammals necessarily adopted other means of earning a living or became extinct themselves.

The unsustainable pressures of human activities on the environment greatly increased as the domestication of animals and the cultivation of crops became common. Thus traditional nomadic pastoralism is generally accepted as being more environmentally benign than agriculturalism, given that agriculture deliberately transforms nature and ecosystems by altering soils and growth patterns and through deforestation.

Sociological changes acted as a catalyst for the first known large-scale anthropogenic disruptions to the biogeochemical environment. In Mesopotamia, the need for food surpluses to support a growing nonproducer class of bureaucrats and soldiers led to an intensive, irrigated agricultural system; the consequent waterlogging and salinization of the fields destroyed the basis for Sumerian society, around 2370 B.C.E. In the Indus Valley of India and the Mayan lowland tropical jungles of Mesoamerica, large-scale deforestation and the resultant soil erosion precipitated a similar collapse of society, caused by the inability of fragile ecosystems to support a massive, complex infrastructure. In a somewhat different manner, the demands of rapid population growth on the environment during the heyday of the Roman Empire led to long-term environmental decline in the Mediterranean caused by deforestation and soil erosion from overgrazing.

A similar picture comes from many, if not most, individual civilizations of the past. The process of civilization could be more broadly defined to include not only the rise and fall of individual societies but also their progressively increasing levels of organization and complexity. The future sustainability of this broader evolutionary process will depend on the ongoing search for paths of long-run sustainable development.

3. Human Activities and Global Environmental Changes

That the current level of human activity alters many features of the earth's system on regional and global scales is beyond dispute.

3.1. The Changing Atmosphere

The atmosphere mixes more rapidly than the other great spheres of the earth's system, and it is not surprising that global changes have been detected most readily in the atmosphere. Measurements of carbon dioxide concentrations have been carried out since 1957; during that time, concentrations have increased more than 10%, from 315 to over 355 parts per million, and the rate of increase has accelerated. This rapid increase results from a fortuitous interaction between people's relatively brief record of measurements and a natural fluctuation in carbon dioxide concentrations will certainly increase, because measurements of carbon dioxide concentrations in air bubbles trapped in Greenland and Antarctic ice show that concentrations were stable near 280 parts per million for at least 1000 years before the ongoing exponential increase began.

There is no doubt that the ongoing increase is a by-product of human activity, primarily the combustion of fossil fuels and, secondarily, changes in land use. The amount of carbon released from the burning of fossil fuel is more than sufficient to account for the global increase. More convincingly, the relative atmospheric abundance of the carbon isotopes $_{13}C$ and $_{14}C$ have decreased over time in a pattern and magnitude that demonstrate that their concentrations are being diluted by carbon released from fossil fuel combustion (which is $_{14}C$-free and $_{13}C$-depleted) and to a lesser extent loss of terrestrial biomass.

This human-caused increase in carbon dioxide is already substantial (more than 25% of the initial value), and it is the major factor driving anthropogenic enhancement of the greenhouse effect. Moreover, increased concentrations of carbon dioxide are likely to affect terrestrial biota directly by increasing growth rates of some but not all plants and by increasing the quality of food available to many animals and decomposers. Elevated carbon dioxide could also have direct effects in marine ecosystems.

Anthropogenic increases in concentrations of a number of other stable gases also have been documented. These include the industrially produced chlorofluorocarbons (CFCs), methane, and nitrous oxide. The increase in methane is believed to be due to a combination of agricultural activities (particularly the growing of paddy rice and the maintenance of domestic ruminants) and industrial processes. The reasons for increasing nitrous oxide are less certain but are believed to relate to changes in tropical land use and the massive alternation of the global nitrogen cycle brought about by intensive agriculture.

All of these gases can enhance the greenhouse effect: in addition, CFCs and nitrous oxide break down in the stratosphere and cause a breakdown of stratospheric ozone. The ability of CFCs to affect stratospheric ozone was identified in 1974, and their importance as an agent for global change was debated actively at that time. Nevertheless, everyone was surprised by the discovery of a springtime hole in the Antarctic ozone in the mid 1980s, though perhaps not by the subsequent proof that CFCs cause this depletion as a consequence of a previously unsuspected set of interactions.

Not all of the human-caused changes to the atmosphere involve stable, globally distributed gases. Anthropogenic increases in concentrations of chemically reactive gases have led to decreased tropospheric concentrations of the hydroxyl radical, the major oxidizing agent in the atmosphere. The resulting decrease in the ability of the atmosphere to cleanse itself leads to an increased atmospheric lifetime, and hence increased concentration, of methane.

At the same time, a syndrome of elevated tropospheric ozone concentrations, acidic precipitation, and elevated nitrogen deposition occurs over most of the economically developed regions of the earth, and similar changes are now being observed seasonally in developing tropical regions. High application rates of nitrogen fertilizer, intensive animal husbandry, and the production of nitrogen oxides and sulfur oxides by internal combustion engines and other industrial processes all contribute to these changes; biomass burning is the most important source in many developing tropical areas. Europe, where increases in agricultural production have been most impressive, is affected particularly severely by these by-products of human activity.

3.2. Changes in Land Use

Human-caused change in land use (land clearing, agricultural intensification, urbanization, and so forth) is currently the most consequential component of global change, and its effects are already with us. However, land use can be difficult to treat as a global change because, unlike the atmosphere or oceans, terrestrial ecosystems do not mix on any time scale that is relevant to human sustainability. Consequently, it is impossible to characterize global changes in land use by measurements in one or a few locations. Any global effect must be the sum of many changes to local ecosystems. In practice, change in land use alters. Enough local ecosystems substantially enough to contribute directly to increased concentrations of greenhouse gases, to affect regional climate and atmospheric chemistry, to alter the chemistry of major river systems, and to be the most important cause of global change to coastal marine ecosystems and coral reefs. Nevertheless, its most important effect probably is simply to alter local systems; some types of major ecosystems have nearly disappeared (tall grass prairie, tropical deciduous forest), and many others have been degraded or fragmented.

The global effects of changes in land use have been summarized in two ways: in terms of the amount of land altered by people and in terms of the fraction of terrestrial productivity that people control. To the extent that these natural systems, species, and populations provide goods or services that are essential to sustainability of human systems, their shrunken base of operations must be a cause for concern.

3.3. Loss of Biological Diversity

The most permanent component of anthropogenic global change is the extinction of species and genetically distinct populations. Extinction is a natural phenomenon; under normal circumstances, an average species lasts perhaps 10 million years from appearance to extinction. Normal conditions are punctuated by episodes of mass extinction, of which five are known in the past hundreds of millions of years.

Human activity is accelerating the process of extinction dramatically. Observations of well-studied groups such as birds, together with calculations of losses based on species per area and species per energy relationships, suggest that current rates of extinction are orders of magnitude above background rates. Most of the extinctions that have occurred to date though biological invasions by exotic species have also played a significant role. Other components of global change are likely to contribute increasingly in the twenty-first century.

If these human-caused extinctions continue, the first few decades of the twenty-first century will see a mass extinction of a magnitude greater than any since the Cretaceous-Tertiary boundary 65 million years ago. This loss of diversity is by far the least reversible component of global change. The greenhouse gases have atmospheric lifetimes lasting from a decade to a little more than a century; their concentrations could return to background levels in at most a few centuries if anthropogenic forcing were removed. Climate might be a little slower to respond due to buffering by the oceans; the restoration of soil fertility on severely degraded sites could take a millennium or two. In contrast, overall levels of species diversity might recover from a catastrophic mass extinction in a million years, and the loss of particular species and their genetic information would be permanent.

4. General Ideas about Sustainable Development

Probably the best-known and most frequently quoted definition of sustainable development is provided in the Brundtland Report as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development 1987, p. 8). This definition is anthropocentric and based on the concept of intergenerational equity.

An economist's working definition of sustainable development could be "the maximization of net benefits of economic development, subject to maintaining the services from and quality of natural resources over time." This implies that renewable resources (especially scarce ones) should be used at rates less than or equal to the natural rate of regeneration and that the efficiency with which nonrenewable resources are used should be optimized, subject to how effectively technological progress can substitute for resources as they become scarce. To this could be added the requirement that waste be generated at rates less than or equal to the assimilative capacity of the environment. Three broad approaches to sustainability might be identified. Economists relate sustainability to the preservation of the productive capital stock. Physical scientists relate sustainability to the resilience or integrity of biological and physical systems. A third view relates sustainability to a concern about the adaptability and preservation of diverse social and cultural systems.

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Biographical Sketches

Kunmin Zhang graduated from Tsinghua University, Beijing, in 1963, and completed his postgraduate training in Tsinghua University in 1966 (at that time there was no degrees in the People's Republic of China). Then he became a teacher in the same university and occupied the position of vice dean of the Department of Civil Engineering and Department of Environmental Engineering. Professor Zhang was appointed vice president of the National Training College of Environmental Management in 1985. From 1988 to 1998, he was deputy administrator of the National Environmental Protection Agency (NEPA). He currently holds the positions of secretary general of the China Council for International Cooperation on Environment and Development (CCICED), senior advisor of the State Environmental Protection Administration (SEPA), vice president of the China Sustainable Development Association, honorary chair of the Environmental Literature Association, professor with Peking University, Tsinghua University, China People's University, Nanjing University, etc.

Professor Zhang has compiled nine books, translated or collated 11 books, and published over 90 papers. His *Introduction to Sustainable Development* won the Eleventh China Books Award and the State Environmental Protection Science Award.

Jiantao Zheng graduated in 1997 from Tsinghua University, Beijing, with a Bachelor of Engineering, and is currently a candidate for a master's degree in management science and engineering at Tsinghua University. His research area is energy systems engineering, sustainable development strategy, and energy economics.