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The Mental Component of the Earth System

W. LUCHT[1] and R. K. PACHAURI[2]
[1]Potsdam Institute for Climate Impact Research (PIK), 14412 Potsdam, Germany
[2]The Energy and Resources Institute, New Delhi 110003, India

ABSTRACT

This chapter explores how the mental component of the Earth system functions and interacts with the physical and biological systems of the planet. A tetrarchical loop is used to illustrate the four elements of the mental component:

- GeoScope (the interplay between observation and theory),
- GeoGraphy (the reintroduction of generalized knowledge into social contexts),
- GeoMind (aspects of identity), and
- GeoAction (interplay between governance and representation).

The ability to transfer understanding from local to global levels, e.g., through macroscopes, is a central challenge in managing the future of the Earth system. Management goals should be identified through a continuous process, based on the awareness that a multiplicity of global realities and situations exist, that there is partiality of knowledge, that observation is often influenced by theory, and that an empirical basis is needed for a science of sustainability.

SUSTAINABILITY

Humankind faces the challenge of managing our planet in a sustainable manner. To meet this challenge, management goals need to emerge that reflect the practical dimension (How can society and its institutions evolve in such a way so as to address questions of global sustainability?) as well as the systems theoretical dimension (How can interactions in the Earth system be studied and made conscious so that human actions can be purposefully guided in more sustainable directions?). For a discussion of the political and social sciences dimension, the reader is referred to Gallopín (1999), ICSU et al. (2002), Juma (2002), Martens and Rotmans (2002), and Parris and Kates (2003). Here, we focus primarily on the systems dimension, as it offers a broad framework of mental reference to regional developments. This view is useful when discussing management goals, since solutions for sustainability will most likely not emerge from simple extrapolations of current practice (Martens and Rotmans 2002). In addition, understanding the interconnections between different components of the Earth system, including the dimension of human actions, requires novel insights at the systems level. Acknowledging the seminal paper by Schellnhuber (1998), we propose some ideas that will hopefully contribute to the kind of systems understanding needed to formulate management goals for sustainability.

Scientific knowledge about the Earth system has been gained through observations and generalizations, often via formalized theories. For purposes of this discussion, we distinguish three more or less distinct spheres:

1. the physical world, or the world described by chemistry and physics;
2. the biological world, which contains the element of the living;
3. the mental world, which introduces the element of consciousness.

These three spheres (Figure 17.1) are the evolutionary products of the Earth system whereby, through coevolution, the biological sphere emerged from the physical sphere. The recent advent of the mental sphere of human consciousness, characterized by culturally acquired syntactical language and the ability to imagine the future, has enabled human beings to intervene and impact the Earth system on all scales (Crutzen and Steffen 2003). Although this has occurred throughout human history, the past few hundred years have witnessed a dramatic rise in the anthropogenic impact on core elements within the Earth system. This era has been called the Anthropocene (Crutzen and Stoermer 2000).

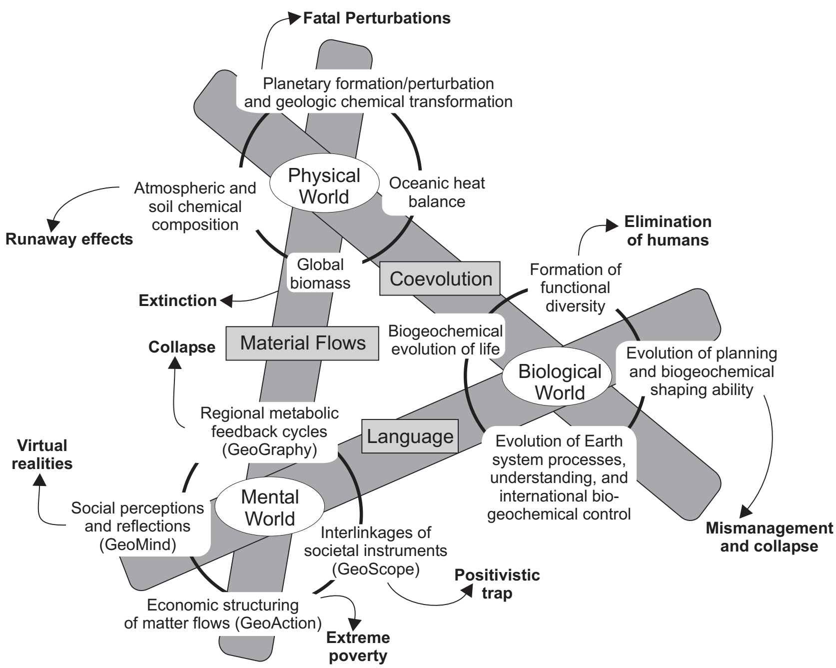

Figure 17.1 The mental component of the Earth system as related to its physical and biological components.

Our awareness that undesired or catastrophic outcomes may result from a continued, uncontrolled coevolution of the mental, physical, and biological spheres has increased over the last decades, substantiated by evidence from the environment and via scientific analysis. Still, we lack information as to the boundary conditions and dynamics through which the Earth system is evolving (Schellnhuber 1998). "Sustainability" refers to the goal of avoiding undesired effects in the Earth system, particularly those states that are deemed unacceptable in terms of human values (Lubchenco 1998; Kates et al. 2001; Tilman et al. 2002; Clark and Dickson 2003). A similar value may also be accorded to pre-industrial properties of the biological and physical systems ("nature").

Can the mental sphere evolve quickly and purposefully to a point where the future evolution of the system can be managed consciously toward a state of dynamic sustainability of the whole system? If so, how? Schellnhuber (1999) refers to the evolution of the associated global, but heterogeneous and distributed, consciousness as the *emergence of a global subject*. In this chapter, we discuss non-economic aspects of the workings of the human world and its interactions with the physical and biological spheres. In doing so, we hope to elucidate some of the processes by which goals of global management toward sustainability might be established.

EQUITY

In a largely theoretical discussion aimed at providing ways to address interconnections within the Earth system, it is easy to lose sight of the problems that seriously affect people in many parts of the world. In addition to the legitimate concerns of the Earth system, the goal of achieving sustainability is inseparable from improving the prospects of ordinary people by increasing equity across cultures and societies (Lubchenco 1998). The World Summit on Sustainable Development, held in Johannesburg in 2002, represents a milestone in the international debate on global management. It focused on issues related to the Millennium Goals set by the United Nations (UN 2000), in particular the widespread problem of poverty, which despite efforts by national governments as well as by multilateral and bilateral development assistance organizations remains excessively common and acute.

To highlight one example, the urgent need of meeting the basic requirement of clean water was identified prior to and at the summit. Currently, one billion people do not have access to safe drinking water, and about four million people die annually from drinking contaminated water. Present estimates indicate that 300 million Africans live in water-scarce environments; by 2025, 18 countries in Africa, with 600 million inhabitants, will have shifted to a water-stressed status. In Asia, as well, water demands have increased significantly, and this trend is expected to continue over the next 25 years, putting many areas at risk. Thus, the goal of reducing by half the proportion of people without access to safe drinking water by 2015 represents a significant challenge. Others of similar magnitude exist with respect to living conditions, provision of food, education, gender equity, security, and environmental quality around the world.

Whether the present global system can be sustained should also be questioned on the basis of the enormous disparities that exist between the rich and the poor. Continuing and widening disparities of wealth are likely to create acute frustration and anger in the minds of those living in poverty. It is no longer possible to insulate the poor from images of material wealth and prosperity that exist in the richest parts of the globe. This, in turn, is likely to threaten not only the maintenance of law, order, and peace in the world but may also impact the sustainability of current human and biophysical systems.

In its Third Assessment Report, the Intergovernmental Panel on Climate Change (IPCC 2001) clearly stated that "the impacts of climate change will fall disproportionately upon developing countries and the poor persons within all countries, thereby exacerbating inequities in health status and access to adequate food, clean water and other resources." The inequities in the global system are, therefore, likely to become more acute as a result of climate change.

EARTH SYSTEM KNOWLEDGE AND PREDICTABILITY

Management of the Earth system requires an understanding of how its components function and implies mental images of potential futures. These may be language based, as cultural products or formalized scientific arguments, or may exist in the realm of values and images of the self. Our ability to predict the future varies with respect to the physical, biological, and mental spheres that constitute the Earth system. This variance has implications for predicting the future of interactions between the coevolving components of the Earth system.

The physical system can largely be described by laws identified within the natural sciences. These laws are also applicable to predicting its future; however, limitations can arise in such predictions from (a) processes still unknown, (b) interactions across temporal and spatial scales associated with strongly nonlinear or chaotic behavior of subsystems, (c) unknown values of variables that result from a lack of initialization and validation data, and (d) interactions arising external to the physical system. Although these limitations may be severe in some cases, we can nonetheless expect reasonably well-founded results from a scientific analysis of the physical sphere.

Consider, for example, the science of climate change. Uncertainty in projecting climate change and its impact on various parts of the world has been greatly reduced, as evidenced by IPCC's Third Assessment Report. A large source of uncertainty that remains concerns the future direction of human actions. This uncertainty obscures the exact nature and magnitude of climate change and constrains mitigation efforts. Thus, the current challenge is to address uncertainty in a methodologically sophisticated manner.

In the biological system, the situation is less clear. The biosphere thrives within the conditions of the physical system out of which it evolved. It has partially developed the capability of modifying and adapting the physical conditions within which it exists (e.g., through the buildup of atmospheric oxygen or the formation of soils), leading to a coevolution of both spheres (Vernadsky 1926; Huggett 1999; Samson and Pitt 1999). Some aspects of the physical system are substantially altered through the introduction of pathways in chemical cycles that lead through biological and human systems as they strive to maintain and reproduce.

Although some elements of the nonhuman part of the Earth's biological system may perhaps be described mechanistically, we still lack essential understanding of many important biological processes. Large gaps in available data exist, for example, concerning the reason and role of functional diversity as well as the allometric and metabolic laws governing the division of matter and energy between individuals and between species. We lack a full theory of ecology. Although we have a theory to explain the evolution of species, it is not clear whether this evolution can be described without reference to a mechanism for filtering avenues of change, possibly through as yet undiscovered self-organization at the system level in the form of a system-wide chemical or other capacity for coordination in complex living feedback loops (cf. Lovelock 2003; Kirchner 2002; Samson and Pitt 1999). If discovered, the associated laws gained would be of a most fundamental nature, not only with respect to the evolution of the Earth system. Diversity and the properties of the individual would emerge to be more than simply the product of mutational selection. What was once called "survival of the fittest" would be replaced by a principle that optimizes (as of yet unknown) factors across the system. Whether these would also include the recent rise of mental self-awareness in humans or whether it is an accidental by-product of evolution is impossible to determine at this time; however, even as we engage in speculating on these issues, our actions increasingly intervene in the evolutionary process (Western 2001).

The mental component of the Earth system depends fully on biological reproduction yet emerges as a separate entity. Conscious planning alters established biogeochemical and evolutionary pathways (Vitousek et al. 1997). Today, even simple observations of the physical world, such as temperature readings or the chemical composition of river sediments, can no longer be explained without reference to human interference. The human economy is a system for directing flows of matter and energy through societal infrastructures that encompass our bodies. By endangering biodiversity and considering genetic manipulation, the mental world severely impacts the biological world in which it is physically situated.

An element of unpredictability of the future, fundamental by nature, accompanies the mental sphere as it emerges as a global player to be developed into a reflective agent capable of global management. This unpredictability has its roots in the reflective properties of the feedback cycle between the analytical, speculative, and observational dimensions of the mental system. As the mental world shapes reality through action and reacts to experiences, it alters its own contents. The mental world is a construct that evolves out of its interactions with its own projections, which in turn are reactions to the perceived, possibly altered, physical and biological worlds. It cannot solely be described by its own inherent laws but is dependent on the functions of the entire system, a process that has been investigated in studies of learning and the cultural encoding of experiences. This openness, however, also serves as the basis for hoping that the human mind may develop into a successfully reflective agent within the system.

Even though economics comprise the most formalized part of the social sciences, we still lack a convincing formal theory of socioeconomic evolution that will allow more substantial predictions than are possible today. Theories of financial development, rule, and value evolution exist and are rendered plausible by detailed scientific arguments. Still, they are partially contradictive in their fundamental assumptions and are almost impossible to verify due to a substantial lack of relevant data. Despite considerable progress, this condition also prevails in the political and social sciences. Regardless of our efforts to stabilize the human reproductive systems, our socioeconomic material metabolism, and monetary turnover to avoid dangerous economic crashes, we lack the ability to plan on timescale of decades.

It is impossible to know whether the advent of reflective consciousness in the Earth system is an integral part of the general evolution of a complex system that forms a biosphere. Arising out of the biological system, the feedback loop exhibits properties that are somewhat stable. We call this empirical pattern culture, and it includes political and institutional cultures. Whereas lifestyles and perceptions change over time, underlying principles (e.g., modes of analytical thought, political theory, and cultural heritage) appear to be somewhat more persistent. Distinctions in thought and tradition can be mapped geographically and are not likely to disappear altogether, in spite of increasing effects of cultural globalization. Contemporary historians do not generally believe that there is, or will be, a theory of history; history and the evolution of societies are not perceived to be mechanistic. Experience shows that predictions of the future routinely fail. There is thus only a very narrow formal basis upon which to build theoretical concepts of the mental aspects of global management. Although there is a growing literature that explores this domain and a large body of highly relevant practical experience, our continual inability to predict on a daily basis societal or even market developments is evidence that the mental world is not a deterministic process.

The attempt to unravel the workings of the mental world is an ongoing project of the human mind. Elements of this process reflect the patterns and principles of language, mental images such as mythological prototypes, as well as the relationship between observation, judgment, logic, science, and so on. It is a broad field, not to be covered here, and for our own future, we should be prepared to encounter surprises as well as a host of failed predictions and expectations. Planning for the future is an enterprise that entails the risk of being wrong. Despite all we do know, the future remains fundamentally uncertain.

Given the uncertainty in predicting the physical, biological, and mental domains of the Earth system, managing efforts toward sustainability should be characterized as a process of constant re-evaluation, re-investigation, and re-definition of goals. Since first-order interactions between components are the key feature of the Anthropocene, rational scientific planning in the traditional sense is not possible on the Earth system level. Science is and will remain a central part of the process of managing efforts toward sustainability; however, it clearly cannot be the sole method involved. To identify goals and set courses of action requires the collective input from the whole of human knowledge and experience, beyond the purely scientific domain. The Earth system, which extends beyond the physical into less mechanistic domains of the biological and mental worlds, is far more complex than the possibilities offered by positivistic scientific inquiry.

This, however, should not be surprising: Every day we routinely encounter situations in which we do not know in advance that which may be of importance. Often, society addresses issues even when a strictly formal theory of identifying missing knowledge is unavailable. We do not know, for example, whether cures exist for important diseases, whether the dangers of nuclear technology can be harnessed, what consequences genetic engineering may bring, or what politics, markets, and consumers will prefer in 10 or 20 years. Nonetheless, substantial resources are constantly allocated to advance knowledge and practice in these fields. A similar approach can be taken to identify ways toward sustainability. Decisions must and are being made, often without hesitation, in the face of uncertainties. Actions that appear logical when viewed retrospectively were frequently not at the time they were made (Feyerabend 1975).

This is not to imply that important problems cannot be reasonably analyzed, predicted, and used to base future actions. Not all is uncertain: delivering food to regions where the harvest has failed will prevent starvation; curbing CO_2 emissions will reduce the increase in global temperatures. Failure to act will negatively impact the poorest members of our global society, who neither possess the physical infrastructure, institutional strength, nor early warning systems to withstand or adapt to detrimental developments in the Earth system. The need for coordinated action has been the message of many international meetings over the last two decades. This call should be heeded and action taken without hesitation on many fronts.

FOUR COMPONENTS OF THE MENTAL WORLD

Possible goals of global management toward sustainability and the process by which they are identified are not issues to be considered within the physical or biological systems. They must be approached through human reasoning, that is, within the mental world. Solutions are only possible when the complex interlinkage of observation, analysis, preference, and action is considered. Yet can this be accomplished? If we wish to go beyond a mere optimization of current practice, we should strive to understand the inherent interrelationships at work. By identifying new dimensions of inquiry into the Earth system and its functioning, possible goals can be generated, evaluated, and negotiated in the mental world; this, in turn, will enable a better understanding of the coevolution at work within the Earth system. Such knowledge should be gained in concert with concrete and extremely important practical efforts that are currently underway to develop societal processes in positive directions.

Figure 17.2 depicts the mental world as a circular pattern, subdivided into a tetrarchy of four elements:

- GeoScope refers to the interaction between observation and theoretical formalizations from which a description of a world perceived arises. Observation and theoretical concepts are mutually interdependent.
- GeoGraphy relates to the discourse associated with this knowledge and its localized transformation into patterns of local thought, practice, and images. It is the cultural practice of a science that transforms theories and observations into other, for example, more accessible domains of knowledge. Issues of complexity, scale, and translation between different domains of language are central to this process.
- GeoMind refers to a complex of fundamental questions: Who are we? What do we want to be? These questions are closely linked to issues of place and are deeply enmeshed within the formation and evaluation of identity. The additional question "What do we want?" follows and is a predominant driver in our world that is not normally a result of technical analysis.
- GeoAction refers to measures that are taken which affect the world, e.g., implementing policies or decisions. It is associated with issues of governance, which give order to larger social entities, and representation, which relates to various forms of legitimacy of action. Finally, as action alters the observable and the debatable, the effects of action may be observed through a geoscopic process.

The use of the prefix "geo" signifies a relationship to the Earth system but it does not necessarily imply a global dimension, as it is readily applied to personal and local situations. In the tetrarchical loop, the interplay of all four elements constructs — equally and complementary — the progress of perceived reality in the mental world and its interaction with the physical and biological worlds. Neither science, theory, observation, nor action predominates. Whereas non-governmental organizations and international institutions may focus on the sphere of GeoAction and science may perceive itself as offering an analytical key to finding solutions, it is the stream of thought arising from such sectoral

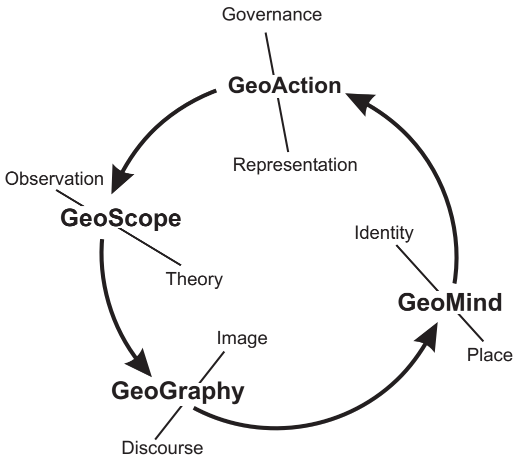

Figure 17.2 Elements of the mental component of the Earth system in the Anthropocene.

contributions and carried into the midst of society that strongly shapes individual identities and creates a GeoMind, which in turn serves as a key source for subsequent decisions. The circle can also be interpreted as consisting of the elements of generalization (GeoScope and GeoGraphy), concretization (GeoGraphy and GeoMind), interpretation (GeoMind and GeoAction), and implementation (GeoAction and GeoScope).

GeoScope: Observation and Theory

Observation can be viewed as an entry point into the functioning of the mental world. When it is not possible to predict the future entirely, observation provides important feedback about developments and consequences of action. Similarly, formalized models require data for their development, initialization, operation, and validation. With respect to a science of sustainability, observation may provide an empirical basis upon which theoretical progress can be made. Observation also entails a fundamental willingness to initiate a mental process by looking, listening, and being open to perceptions. Observation, after all, inherently has the power to surprise us.

Whereas theoretical formalizations may be viewed as universalizations of observations, observation in turn depends on the theoretical concepts and modes of thought of the observer with respect to its nature and meaning. This has been called the theory-ladenness of observation. Observations depend on the social and intellectual context in which they are made. Current images of the globe are produced through a mentally filtered mode and interpreted in culturally laden contexts, be they scientific, economic, political, or otherwise.

One may doubt whether we already possess the means of generating views and concepts of the world suitable to considering sustainability issues (Parris and Kates 2003). From the standpoint of Earth system analysis, viewing the entire system requires a "macroscope" to observe system-order variables and to produce an image of the whole (Schellnhuber 1998, 1999b; Lucht and Jaeger 2001). The principles upon which such a macroscope can be constructed are still under discussion. Large methodological challenges remain to be resolved, particularly with respect to observing social systems.

Despite the immense stream of information generated around the globe each day, we still lack an observational system capable of systematically generating images that can be strictly associated with theoretical concepts of the coevolution of the mental, biological, and physical spheres of the Earth system. Currently, the best systematic global observation instruments available address the physical world and financial aspects of national economies. These include the instrument networks of the natural sciences, which span the globe from Earth-orbiting satellites to ground stations and buoy systems, and the international system of statistical economic reporting, by which quantities such as gross domestic products, inflation rates, or stock market values are observed. Still, these networks provide only a partial view of the world.

Despite international research efforts and the resultant progress on biodiversity and habitat conservation, the Earth's biological systems are not currently under extensive coordinated observation. Considerable gaps in knowledge exist, particularly at the systems level, due primarily to the high degree of complexity and diversity in these systems. A similar situation applies to the mental sphere. Reporting scientifically on the social and political dimensions of the world has increased considerably, especially in areas of education, health care, values, preferences, and political structures. Much of the data, however, are regional, not intercomparable, and unavailable as longer time series. There are notable exceptions, but in comparison to the cost and effort expended in the natural sciences or the statistical offices serving economic planning, observation directly relevant to the many socioeconomic dimensions of sustainability is still poorly developed. Key processes (e.g., the magnitude and distribution of material and energetic exchanges between the environment and human societies or the time and space budgets of people) are not being monitored in a defined and continuous system.

The scientific community faces the challenge of creating a macroscopic instrument suitable to the task (Lucht and Jaeger 2001). If we are to direct the Earth system toward something resembling a sustainable state, a macroscope (i.e., a geoscope in terms of the tetrarchical loop) must consist of a coordinated interplay between relevant, possibly rival, theories and associated select, but deeply meaningful, observations. Such observations must be chosen to allow innovative formulation and evaluation of theories and progress in the discourse between competing ideas by providing a suitable observational reference.

The need for a geoscope is exemplified by the state of debate on sustainability indicators, which are designed to measure progress, or lack thereof, with respect to sustainability, or on the quality of life and the environment (Moldan et al. 1997; Moffat et al. 2001). At present, the theoretical basis and available data upon which such indicators are drawn remains largely unsatisfactory. Despite an increase in their importance, indicators are still based primarily on various degrees of plausibility, rather than on solid theoretical foundations, and are dependent on the available types of data, which were often collected for other purposes.

A suitable observation system is crucial to identify potential goals of sustainability, how they might be achieved, and whether measures advised by our current thinking have the desired effects in this very complex system. We suggest that such a system should initially provide data for comparative regional case studies of concrete measures affecting sustainability. These data can be used to produce time series of key variables that are justified by their relevance to identified theoretical discourse.

It is likely that an initial geoscope will consist of a combination of synoptic-scale observations (e.g., from remote sensing or aggregated statistics) and in-depth, on-the-ground data for selected regions. It could provide spatial realization of information connecting people and pixels across nested scales in domains where such data are not currently available — an effort comparable in time and cost with that of traditional economic statistics or space observation programs. A geoscope will have to be constructed through a cumulative process of learning-by-doing, as it appears impossible to produce a full blueprint at the outset. Elements of what could be called an emerging geoscope are already moving forward as the result of various initiatives. We note that macroscopes may also potentially be used by the security apparatus of global dominant powers. Issues related to the appropriate means of information gathering, ownership, and sharing are therefore highly relevant to the proposition of a geoscope, whose purpose must structurally oppose the implied dangers of total digitization of the globe and the associated potential for political control.

GeoGraphy: Partial and Situated Knowledges

GeoGraphy refers to a scientific practice that goes beyond the acts of observation and formal consideration of theory formulation. It is the process of translating formal knowledge and data into other forms of knowledge by returning them into the complexities of real-world situations (e.g., into localized contexts).

Epistemologically, macroscopic knowledge can either take the form of scientific knowledge (i.e., encoded in a formal structure expressed by rational linkages) or social knowledge (i.e., embedded in social, cultural, and psychological contexts and which may, e.g., be communicated as symbolic mental images expressed visually or through language). When scientific theory and observation meet the multitude of social situations and all of their intricacies, these forms of knowledge are constantly transformed into one another.

Today there is a tendency to move social sciences, such as geography, sociology, or the political sciences, in the formalized direction of the natural sciences. However, the usefulness of the social sciences is most evident when knowledge is translated between systems of reference, structure, and expression. Since mental language varies according to cultural, geographical, and temporal location, this is an ongoing process of exploring adequate expressions for scientific knowledge, expressions that are meaningful in social reference systems. In terms of translating the world into science, generalization and universalization are tasks to be achieved. In terms of translating science into situational meaning, the challenge is to provide a wide array of opportunities for translation. This is the task of GeoGraphy.

Neither a positivistic interpretation (in which the world is but a concrete realization of universal laws) nor a particularistic approach (which negates any relevance of abstract deductions) is productive. Instead, an interplay between generalizing mental analysis and situational complexity, where concepts offered by the mind interact with possibilities of the physical to construct a joint reality, is necessary to describe the dynamics of the Earth system in the Anthropocene as well as the coevolution of the mental, biological, and physical worlds of which it is comprised. In terms of a systems analysis, dynamics of this system are determined by feedback loops between the mind and the physical world.

Central to the process of GeoGraphy is an understanding that the information emerging from observation and formalized into theoretical systems does not have a unique meaning in social reality. Its meaning is tied to the cultural practice of the recipient society. Multiple realizations are possible. Across all scales — from an emerging collective global identity to the particularities of personal opinions — the meaning, interpretation, and importance of specific knowledge varies. Knowledge in all its forms is thus partial and situated (Haraway 1991).

Knowledge is partial in two respects. First, it is not complete in the sense that knowledge gained from within a cultural practice does not necessarily comprise knowledge arising from other cultural practices, nor is it usually possible to unite, without at least some difficulty, knowledge from different cultural practices because of the inherent association of such practices with language, patterns of thought, and identity. Second, knowledge aligns with the cultural preferences of the originator. This does not mean that measurements or results, e.g., of a numerical model simulation are necessarily a construct, rather that the practical meaning of the results is subject to interpretation. This has implications for the interface between science and politics. Science is not a comprehensive prescription for action, although action can react and refer to science.

Knowledge is situated in that it exists under actual conditions that are inseparable from the meaning of that knowledge. Such lines of thought are a product of an increasing realization in our societies that there is a multiplicity of systems of reference with increasing spatial and temporal overlap. Globalization and technology contribute to make this multiplicity of simultaneously existing mind frames more prevalent than in the past.

Understanding the particular generated in such frames in relation to a wider whole is specifically a task of science. The interplay between observation and theory is an instance of relating the particular to the generalized. The associated discourse, firmly anchored in the cultural practice of science, produces knowledge in various forms, both fundamental and as applied to particular problems. Today, however, the search for principles to be generalized is no longer the primary goal, as was the case in classic disciplinary science. Instead, the challenge is to interlink knowledge and its application to highly particular circumstances; most importantly, the task is to return the generalized back into the context of social situations.

GeoGraphy is the cultural practice of a science organizing and creating such partial and situated knowledges of the Earth system. It is likely to be one of the leading sciences of the twenty-first century, taking over the prominent position of physics. The multiplicity of realities as well as the partial and situated natures of knowledge do not mean that the world is merely a sum of many overlapping parts, rather, from a systems point of view, that the world is an internally differentiated whole. Early on, Heraclitus expressed this as the formula "*hen kai pan*," the one and all, which describes the principle that the world unfolds from one entity and dissolves back into it. Unity then is both the universal whole as well as the sum of the individual parts; that is, it is geoscopic and geographic at the same time. One is limited without the other.

GeoMind: Identity and Place

When we view the lands that surround us, we also include ourselves in this purview and, in doing so, we touch or even transform the lands in one way or another (Cosgrove 1984; von Droste 1995). There is a connection between body, self, and place that is relevant to how we consider ourselves and the world. If observation is one entry point into the mental subsystem of the Earth system, then issues of identity and will are another.

Consider, for example, the extensive transformation of the American continent over the last 500 years: Europeans perceived this expanse of land as being available to them. The South Sea illustrates this attitude as well: it served as an important object of British imperial fantasies about nature in the nineteenth century. Today, when we view the continents from space, what is it that we perceive? What do scientists observe? It is common to think that data flow is simply a digitized stream of photons, but the cultural history of imaging landscapes makes us aware of a substantial body of political, aesthetic, and cultural subtexts. Together, they shape our identity in relation to place (Mitchell 1994). This identity and the willingness to shape the future, which likely includes shaping the land, is a core driver of global transformations.

GeoMind is this contribution of individual and collective identities and wills to making sense of the world. The category of identity is not well recognized in global change science. The dominant assumption is that results of an applied, user-oriented science can feed directly into the process of political decision making. In practice, this is rarely the case. The world of decisions and actions looks toward science for input, but the process is not a formal one. Decisions are made on the basis of intuitive experience and examined in light of available knowledge. Success is measured by outcome. However, it is questionable whether international debate about possible goals of coordinated global management will get far if it does not stem from the self-image of the people participating as well as the people affected; human choice should be accorded a position of departure in the process.

Science neither provides, nor can it provide, answers that encompass all aspects to consider. It also does not, and cannot, serve as the primary motivator for action. Science, however, can play a considerable role when embedded into a larger system of cognition. Knowledge serves to direct decisions into promising directions or to challenge them when made. Scientific analysis has a stimulating and a controlling function, but not usually a creative function per se. Science is a tool that the mind employs to produce analytical challenges to thought patterns.

GeoMind may appear to be an abstract construct, but it is easy to observe in the real world. The United Nations was not founded on a scientific analysis of potential next phases in organizational structures, but as the result of a political will to move in a direction of increased collective checks and balances. Democratic institutions did not emerge from a rational analysis but from the primary desire of people to increase their freedom. Similarly, the goals of sustainable management are unlikely to arise directly from a scientific analysis of the Earth system, but from the mental world, whose questions (who we are and what we want to be) occupy us. For this reason, normative questions about minimal humanitarian standards, the role of equity principles, and intolerable domains have been included into the scientific program (e.g., Schellnhuber's "Hilbertian Programme for Earth System Science"). One question of central importance reads: "What kind of nature do modern societies want?" (Sahagian and Schellnhuber 2002, p. 9).

As we investigate more carefully the subtexts of our images of the world, which co-shape the world despite their often semi-virtual quality, we also have to become more aware of the dangers and possibilities of these new world views that are being created. The self-referential nature of constructed surroundings and cultural settings can either frighten or interest us. At the same time, the real-world consequences of images projected and actions taken are all too real. As Parris and Kates (2002) state: "Defining sustainability is ultimately a social choice about what to develop, what to sustain, and for how long" (p. 8068).

GeoAction: Managing Toward Sustainability

Several vocal parties involved in the debate on action for sustainability are discernible. There are the scientists who analyze the Earth system and consider the dangers of destabilizing the global biological and climatic systems. There are the technologically affluent and optimistic who stress that shifts in associated values are required (e.g., Raskin et al. 2002). There are the materially and ethically oriented critics of the econo-political world of capitalism who champion the perceived aspirations of the poor (e.g., Sachs 1999). There are also the believers in global markets and the technological solutions assumed to spring from them, to which that large part of the development community belongs, which strives to industrialize the as yet unindustrialized parts of the world.

How can we reconcile limits of the environment with the consumption demands of the developed world? How can we balance the justified hopes of poor nations for an increase in material goods with obvious limitations in supply? What principles of equity and minimal humanitarian standards should be applied? These questions remain unresolved.

It is striking not only to study the voices participating in this debate but to consider that large portions of the world population strongly affected by these issues are not currently being heard. This includes members of the technologically and economically less-advanced regions, many indigenous groups, women, and young people. These groups may add other scenarios and mechanisms to the debate beyond markets, technologies, and rationalized values.

The issues under debate are far-reaching in their consequences and are not close to being resolved. For example, does technological innovation have the potential to provide unexpected ways of moving forward without regret? In an extensive study of possible scenarios for the future, Raskin et al. (2002) view such innovation as a key factor in enabling the shifts in values, lifestyles, and modes of organization required to facilitate a "great transition" to sustainability, as opposed to leading the world into less desirable states. Sachs (1999) follows a line with somewhat different implications. He questions whether the imagery of multifaceted global unity, communication, and organization behind some such scenarios is realistic. Observing that "some inhabitants on this Earth of ours are more global than others," Sachs reports (1999, p. ix–x) a "nagging suspicion" that "the Western development model is fundamentally at odds…with sustainability (truly conceived)," which may in the end turn out to be "incompatible with the worldwide rule of economism." Issues of advised action toward sustainability remain contested. On one occasion a western journalist asked Mahatma Gandhi whether he would not want India to reach the same level of affluence as Britain. Gandhi's answer was that it required Britain to conquer half the planet to reach its existing level of affluence. He asked how many planets would India have to conquer to reach the same level.

We only vaguely know the overall shape of possibility space for the Earth system. We have achieved an increased understanding of this space in terms of the stability of natural systems and of resource limitations, but not with respect to ethical and evolutionary questions addressing existing and possible future global and regional structures, goals, and ambitions (Schellnhuber 1998). Not only do we need to list the possible good goals of global management, revise them continually, and discuss their contradictions, we need to focus on the investigations of this process — how goals may be identified and adapted — and position it equally at the center of research (Kates et al. 2001; Martens and Rotmans 2002). Such research necessarily has a strong institutional and political dimension (Juma 2002). Questions about institutions, organizations, process, legitimacy, information, science, participation, and representation immediately emerge (ICSU et al. 2002).

Theories of GeoAction entail social and political theories of action that accept a multitude of realities, the partial and situated natures of knowledge, as well as the theory-ladenness of observation. In such a situation, institutions can rarely have a rationalistic normative character (Finnemore and Sikkink 1998). Rather, they serve as flexible networks of exchange points for knowledge, as providers of frameworks for negotiations, and as stimulators of needed developments. As in GeoGraphy, where formal knowledge is actively brought back into situational contexts to produce applicable social forms of knowledge, GeoAction is charged with producing social forms of action where insights about the evolution of the systems within the Earth system are brought into regional political and economic contexts. Distancing knowledge from politics will not achieve these goals nor will an orthodox normative system of decision making. Only through a living exchange between generalized abstractions and concrete realities, that is, between Earth system considerations and regional necessities, can goals of sustainable management evolve to avoid the pitfalls of adherence to any particular strand of interpretation.

The complexity of the issue prevents the rapid appearance of convincing solutions. A process of learning by doing is unavoidable. A system of adaptive management expressed as GeoAction requires an infrastructure encompassing all facets of the tetrarchical loop (ICSU 2002). The global subject (preferentially to be seen as a web of multiple subjects), which acts consciously in managing the Earth system of the Anthropocene, emerges from a complex process full of contradictions, compromises, and disputes. Indeed, Schellnhuber (1999a, b) describes it as "emerging from the world-wide web of socioeconomic relations and discourses supported by advanced technology" (p. 13), where "one key to its emergence is world-wide communication" (p. C22), and as "a cooperative system generating values, preferences and decisions as crucial commonalities of humanity online" (p. C22). He concludes: "The global subject is real, although immaterial" (p. C22). Nonetheless, the cultural embedding of action is reflected in the remaining, though possibly transformed, place-based geographic nature of global identities.

IPCC is currently involved in one of the most extensive efforts to consider systematically, on a global scale, scientific knowledge upon which action to control global change may be founded. Founded in 1988 by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO), the IPCC has a threefold mandate: to assess the state of existing scientific knowledge on climate change; to examine the environmental, economic, and social impacts of climate change; and to assess response strategies.

IPCC is responsible for producing periodic assessment reports on scientific issues relevant to climate change. Additionally, Special Reports and Technical Papers are produced to address specific scientific needs that arise out of the international negotiations process dealing with climate change and to meet requests received from the United Nations Framework Convention on Climate Change (UNFCCC). The scientific objectivity, transparency, and credibility of these reports are ensured through a rigorous review process, which consists of three steps: the research assessed has already been published in peer-reviewed scientific and technical journals; the resulting draft assessment report is peer-reviewed by a large and diverse group of experts; and finally, the draft report is reviewed by governments.

To produce its reports, the IPCC attracts experts from all over the world. Since its inception, the reports have evolved in their perspective. The IPCC has progressively moved from viewing the problem of climate change, its impacts, and mitigation in isolation to adopting a more holistic approach. In its most recent assessment, the Third Assessment Report (IPCC 2001), the IPCC has presented climate change in the larger context of sustainable development. It recognized the various synergies that exist between climate change and other environmental issues and the opportunities that these synergies present in developing more effective and comprehensive response options. The Fourth Assessment Report (AR4), due out in 2007, will continue exploring these options and delve deeper into the interlinkages. In doing so, it will present an evolving model of systematic global discourse on a scientific, nonprescriptive but politically highly relevant level.

THINKING ABOUT SUSTAINABILITY: A TIMELY TASK

Each generation considers the challenges and opportunities that result from its particular position in history. Questions of Earth system management, formulated in response to a growing scientific basis reflecting a world of increasingly globalized images, are highly characteristic of our particular time.

As we approach these challenges, we must avoid abstract generalizations as well as the anti-analytical preference for only local phenomena. Equally, we should not succumb to the temptations of presuming to possess the perspective of a scientific "sage," with all of our available global imagery, and we must avoid the predominance of segregative systems of organization (e.g., in the form of spatial or temporal segregation of people or a purely disciplinary science).

As Kates et al. (2001, p. 641) write: "The sustainability science that is necessary to address these questions differs to a considerable degree in structure, methods, and content from science as we know it." By integrating observations, theories, places, identities, and actions, and by forging new dialogues across the temporal and spatial dimensions of the mental component of the Earth system, new knowledge can emerge as an epistemologically new type of science

(Gallopín et al. 2001). Through a process such as described by the tetrarchical loop (see Figure 17.2), management goals toward sustainability can be negotiated and continuously revised. This process reflects the current evolutionary state of the Earth system in the Anthropocene.

Ultimately, we are left to reflect upon fundamental questions: Who are we? Who do we want to be? In what kind of world do we want to live? If we attempt to understand the workings of the entire Earth system and not just its physical components, we stand a chance to address these questions. If we continue impacting the Earth in an unsustainable and ill-understood fashion, we (as well as future generations) may well jeopardize the future coevolution of the physical, biological, and mental spheres that comprise it. Harsh realities serve to remind us that our current task is not an academic exercise (Petschel-Held et al. 1999).

Our co-construction of a future, or rather, of futures as perceived in a multitude of perspectives, must be a carefully negotiated enterprise. A common vision should not be assumed in a world of many cultures. Limitations will arise from the workings of the physical and biological systems; dangers will emerge from the association of mental models with very strong political subtexts and fantasies. We must be aware of the many pitfalls present in mental processes and of the uncertainties inherent to projections of the future and its complex interrelated processes. Since we are embarking on an experimental journey — one which may reveal that directions taken are not necessarily those intended — feedbacks from observation into thought and action are essential.

Science is likely to play a decisive role in shaping our understanding while concurrently going through a fundamental reconsideration of its own nature (Lubchenco 1998). One of the most striking outcomes of the Rio Earth Summit of 1992 are local Agenda 21 groups throughout the world. To function, these groups rarely require scientific knowledge to act, as the most pressing problems of a local area and potential courses of action are well known to its inhabitants. Science plays its role when the local action is brought into a global framework of integrated Earth system management. Thus, the practical feasibility of our visions for the future depends on our ability to analyze the workings of a very large and complex system, which evolves while being shaped by our actions. Still, the conclusions drawn will remain ineffective unless they are re-inserted into the complexities of the many real-world situations that make up the planet.

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APPENDIX: FOUR STORIES AS FOOD FOR THOUGHT

Li Bai: Poet

In one of the most famous poems of Chinese literature, the eighth century poet Li Bai speaks of a journey through the Three Gorges of the Yangtze River: "Traveling to Jiangling: Leaving Baidicheng at dawn in clouds, / I've sailed through canyons a thousand li in a day. / The river banks are loud with monkeys. / Passing behind me, a myriad of peaks falls away."

The Three Gorges are known outside China today mainly for the gigantic new dam that is beginning to submerge them. It is a technocratic, industrial-style project in response to China's increasing demand for energy, and its costs are high. The environmental impacts of the dam are thought to be considerable. Losing this landscape cuts deeply into the heart of Chinese culture and mental makeup by eliminating what is at the core of a very old tradition. However, the dam produces neither radioactive waste nor burns greenhouse gas-emitting fossil fuels. To leave industry and homes without additional energy would also impact the outlook and limit the ambitions of millions of people who are justified in expecting increased prosperity and better basic services. Whether the hopes will be fulfilled and the dam will be manageable instead of causing endless problems, as critics suspect, remains to be seen.

Viewed from the perspective of sustainable management, supporters and critics of particular measures often create too easily the impression that advisable directions of action are known and can readily be identified. In reality, things are usually much more complicated. The dam, positioned at the crossroads of economic, environmental, cultural, and political issues, all of which run deep, is a problematic example of the dilemmas encountered when discussing the future as it evolves out of historical conditions.

The same poet Li Bai wrote of a journey going in the opposite direction: "Attempting to go up Three Gorges: The blue sky jammed between the mountains; / we will never reach it with the water rushing down / so strongly. Three mornings we started up the gorge, / at night find we've gone nowhere. For once, / I truly forgot the hair on my brow is turning white." In his life, Li Bai traveled to the region above the Three Gorges also to flee political turmoil further downstream. Returning, he never quite found rest again. Legend has it that he drowned when he fell from his boat while drunk, trying to embrace the moon.

Petrarca (Petrarch) and von Humboldt: Poet and Scientist

On April 26, 1336, the poet Francesco Petrarca ascended to the peak of Mont Ventoux, the highest mountain of the Provence. In the cultural history of Europe this event is regarded iconographically as the beginning of a conscious perception of landscape.

"The highest mountain of this region, which with reason is called Ventosum, 'the windy one,' I have ascended today, led only by the desire to see what so great an elevation has to offer," Petrarca writes the same evening in a letter. After a tortuous ascent, he reaches the summit and is overwhelmed: "At first, moved by the unfamiliar breeze of the air and the whole unhindered view around, I stood as if dazed.…I looked back down: Clouds lay at my feet….The Alps themselves, rugged and snow-capped, seemed to rise close by, although they were really at a great distance….I could see with the utmost clearness, off to the right, the mountains of the region about Lyon, and to the left the bay of

Marseilles and the waters that lash the shores of Aigues Mortes, although several day's journey distant. Under our very eyes flowed the Rhone."

But then Petrarca decides to take his eyes off of the landscape and to open a copy of Augustine's Confessions that he was carrying, to whatever he'd happen to find: "I call God as a witness and him who was there, that where I first fixed my eyes, it was written: 'And men go about to wonder at the heights of the mountains, and the mighty waves of the sea, and the wide sweep of rivers, and the circuit of the ocean, and the revolution of the stars, but themselves they forget'." This text gives him cause to admonish himself for having fallen to admiring worldly grandeur when "nothing is admirable except the soul, compared to which nothing is great." And so the story continues: "Then, in truth, I was satisfied that I had seen enough of the mountain. I turned my inward eye upon myself, and from that time not a syllable fell from my lips until we reached the bottom again."

There is justified doubt whether this ascent actually took place as described, though no doubt Petrarca did climb Mont Ventoux at some point in his life. Aside from practical aspects, the whole setup and timing is too ideal and the allegorical nature of the story too obvious to be true exactly as told. It is really a story of attaining the heights of spiritual maturity in the face of obstacles and temptations encountered. As Petrarca ascends the physical mountain, he looses sight of the spiritual mountain, which he returns to remorsefully as he leaves behind him the view of the landscape. However, the fresh exhilaration of his view of the landscape is telling. Emerging from medieval patterns of thought, but barely, Petrarca constructs an opposition of the spiritual realm to the enticement of physical reality in form of the landscape. A beginning was made of entering into a dialogue between these two worlds.

The point here is twofold. First, viewing is elementary. Without gaining a vantage point from which to view the world, the land cannot be perceived as a cohesive whole. Second, observation is closely associated with the mental makeup of the observer. It leads to questions of where one stands and what the important things should be. It causes reflection. There is no reason to believe that before global management toward sustainability can be dealt with as a task, observation of this sort is necessary. Vantage points for viewing the Earth have to be found and the view taken with an open mind, leading to an evaluation of what it is that we should or might do. This vantage point cannot only be the literally highest mountain of modern time, a satellite in low orbit, though it is interesting how many of the very technical personnel that have flown into space have reacted with similarly emotional statements about seeing the Earth. The metaphorical peaks of our time have to permit views of the mental world as well. Thereafter, we should also be ready for some unexpected sights and for some unexpected conclusions as we contemplate, standing at that place, what it is that we really want. At the same time, Petrarca's story may serve to consider the dangers of withdrawing too strongly into the inner perspective, when the view encountered challenges the mind so fundamentally.

In 1802, almost 500 years after Petrarca, the explorer and pioneer of geosciences Alexander von Humboldt ascended a mountain in the South American Andes (Humboldt 1802). He did not come, as had Petrarca, to contemplate the world spiritually, but as a scientist carrying instruments. After much expectation and many disappointments, his party finally reached its goal: "When after many undulations of the ground we had reached on the sheer mountain ridge the highest point of the Alto de Guangamarca, the heaven's dome that had been veiled in haze for so long cleared up….The whole westerly flank of the Cordilleres near Chorillo and Cascas, blanketed by immense blocks of quartz from 12 to 14 feet in length, the plains of Chala and Molinos up to the ocean shores at Truxillo lay, as in miraculous closeness, before our eyes. We saw the Southern Sea now for the first time; we saw it clearly: near the littoral a huge mass of light reflecting back, ascending in its infinity against the barely discernible horizon."

As had Petrarca, von Humboldt then turned to the main purpose of his trip, i.e., the scientific mission, but he confessed: "The joy, which my companions Bonpland and Carlo Montafur vividly shared, let us forget to open the barometer on the Alto de Guangamarca. According to the measurement that we made nearby, but lower than the peak, in an isolated dairy farm in the Hato de Guangamarca, the point at which we first saw the ocean must have been only 8800 to 9000 feet high." As was Petrarca, so the scientist is also affected in his purpose by the impression of the view. His scientific mission is embedded in the whole of his experience as a human being exploring the world.

Buckminster Fuller: Inventor

The American Robert Buckminster Fuller, inventor and mastermind, in his book *Education Automation* (1962) made the following proposal: "The new educational technology will probably provide also an invention of mine called the Geoscope — a large two-hundred-foot diameter (or more) lightweight geodesic sphere hung hoveringly at one hundred feet above mid-campus by approximately invisible cables from three remote masts. This giant sphere is a miniature Earth. Its entire exterior and interior surfaces will be covered with closely-packed electric bulbs, each with variable intensity controls. The lighting of the bulbs is scanningly controlled through an electric computer. The number of the bulbs and their minimum distance of one hundred feet from viewing eyes, either at the center of the sphere or on the ground outside and below the sphere, will produce the visual effect and resolution of a fine-screen halftone cut or that of an excellent television tube picture. The two-hundred-foot geoscope will cost about fifteen million dollars. It will make possible communication of phenomena that are not at present communicable to man's conceptual understanding. There are many motion patterns such as those of the hands of the clock or of the solar system planets or of the molecules of gas in a pneumatic ball or of atoms or the earth's annual weather that cannot be seen or comprehended by the human eye and brain relay and are therefore inadequately comprehended and dealt with by the human mind."

Fuller suggests that "the Geoscope may be illuminated to picture the Earth and the motion of its complete cloud-cover history for years run off on its surface in minutes so that man may comprehend the cyclic patterning and predict. The complete census-by-census of world population history changes could be run off in minutes, giving a clear picture of the demographical patterning and its clear trending. The total history of transportation and of world resource discovery, development, distribution, and redistribution could become comprehendible to the human mind, which would thus be able to forecast and plan in vastly greater magnitude than heretofore. The consequences of various world plans could be computed and projected. All world data would be dynamically viewable and picturable and relayable by radio to all the world, so that common consideration in a most educated manner of all world problems by all world people would become a practical event."

A child of his time, Fuller had great hopes with respect to technological solutions to the world's problems, a vision we are no longer able to share with quite the same enthusiasm. Certainly, his hope that television would usher in a revolution by providing the world with remote access to education has not been fulfilled. He did, however, understand that contemplating the future requires observation, comprehensible images as a means of mental access, ways of communicating, and a connection to politics, if science is to be able to contribute. He wrote: "During one-third of a century of experimental work, I have been operating on the philosophic premise that all thoughts and all experiences can be translated much farther than just into words and abstract thought patterns. I saw that they can be translated into patterns which may be realized in various physical projections by which we can alter the physical environment itself and thereby induce other men to subconsciously alter their ecological patterning. My own conclusion is that man has been given the capability to alter and accelerate the evolutionary transformation of the *a priori* physical environment, that is to participate objectively, directly, and consciously in universal evolution.…If he does not do so consciously, events will transpire so that he functions subconsciously in the inexorable evolutionary transformations."

Fuller clearly saw the political dimension of such an undertaking. He says: "But realize, at back of the UN Building in New York in the East River is [an island]. And what I wanted to do was build, then, a miniature earth, mounted from those rocks…[It] was going to be 200 feet in diameter [and] would be mounted 200 feet above the water, so…the height would be 400 feet, …[which is also] the height of the United Nations building. So, it would be a miniature Earth really out confronting the representatives of the world." He summarizes his proposal as follows: "This 200-foot-size Geoscope would make it possible for humans to identify the true scale of themselves and their activities on this planet. Humans could thus comprehend much more readily that their personal survival problems are related intimately to all humanity's survival."

He did build several experimental miniature Earths, or geoscopes, but a full-fledged realization of the idea was never achieved. Today, outgrowths of the basic idea can be found in computer model animation, data visualization, and public displays. However, uniting these capabilities in a single instrument available for everyday use is still lacking.

Mahatma Gandhi: Human Ecologist

One of the major highlights of the 2002 Johannesburg World Summit on Sustainable Development was the reference made to sustainable production and consumption. Attempts to focus on this subject at past meetings and conferences have generally been met with determined opposition from some developed countries, who felt that any discussion of production and consumption patterns would threaten the prosperity they had attained after a century and a half of industrial development. The World Summit agreed to encourage and promote development of a ten-year framework of programs to accelerate the shift toward sustainable consumption and production. Implied in this decision was acceptance of the fact that current levels of production and consumption were not sustainable.

Seven decades ago a visionary and enlightened leader, Mahatma Gandhi, highlighted these issues, conscious as he was of the persistent exploitation of the poor by the rich, within and across nations (Khoshoo 1995). Gandhi was once asked whether he would like to have the same standard of living for India's many millions as prevailed in England. He responded, "It took Britain half the resources of the planet to achieve this prosperity. How many planets will a country like India require?" He also sounded a warning to the developing countries to chart out a very different path of development when he said, "God forbid that India should ever take to industrialization after the manner of the West." However, any system that is based on continuing prosperity and high levels of consumption in one set of countries and a substantially lower level of consumption in other nations is not a sustainable solution.

For this reason, commenting on industrial countries, Gandhi said: "The focusing of targets by them for population stabilization in the developing countries must now be backed by their willingly fixing targets for controlling and bringing down resource use in their own countries." Gandhi shunned the idea of developing countries emulating the culture and consumptive lifestyles of the developed countries. The British writer Edward Thompson once mentioned to Gandhi that wildlife was fast disappearing in India, to which Gandhi's response was, "Wildlife is decreasing in the jungles but it is increasing in the towns." He emphasized the fact that a society can be judged by the way it treats its animals. Environmentalists discovered the truth of this saying only toward the end of the twentieth century.

Gandhi's thinking was neither pompous nor based on abstract philosophy. His actions throughout life, including, for example, cleaning the primitive toilets of poor people and inducing them to do the same, emphasized a practical reality. At the Johannesburg Summit, clean water and sanitation were seen as twin challenges necessary to meet if the need for clean water is to be satisfied. Gandhi once said, "Sanitation should occupy the foremost place. There is a fine Latin proverb which says that 'a healthy mind is possible only in a healthy body'." The importance of Gandhi and the articulation of his beliefs underlines the need for leaders who have mass appeal to influence thought and action toward sustainable development. Methods of measuring sustainable development, the deployment of technologies to attain it, and policy initiatives to bring this about will remain incomplete unless human beliefs and values progress in the same direction. Although the Johannesburg Summit developed a ten-year framework, this has to rest on the changing of value systems and a movement away from consumptive lifestyles and a preference for production systems that clearly protect the environment and ensure the efficient use of natural resources.

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