Available online at www.sciencedirect.com
SCIENCE DIRECT
Global Environmental Change 15 (2005) 177–180
Global Environmental Change
www.elsevier.com/locate/gloenvcha

Editorial

Conditions for sustainability of human–environment systems: Information, motivation, and capacity

1. Sustainability transition or collapse

Managing a transition toward a more sustainable development path at a global scale is one of the great challenges facing humanity for the decades to come. Sustainable resource use refers to the use of environmental resources to produce goods and services in such a way that, over the long term, the natural resource base is not damaged, and that future human needs can be met. The time horizon of the concept covers several generations. Human-environment research is expected to contribute in a major way to this endeavour (Clark and Dickson, 2003). The scientific literature is rich on insights on the factors that have allowed societies or communities to innovate successfully to avoid a severe deterioration of their natural environments, but also on the causes of collapse of some ancient societies. The understanding of historical experiences can help to forge and test theories of human–environment interactions, which can then be used to guide future actions.

The collapse of societies has been explained by factors such as abrupt climate change (Weiss and Bradley, 2001), ecological vulnerability (Diamond, 1994), diminishing returns to socio-political complexity (Tainter, 1988), sunk-cost effects in human-decision making (i.e., decisions based on past investments rather than on expected future returns) (Janssen and Scheffer, 2004), and growth of organizational structure in urban societies such that higher level decision makers are no longer in close contact with productive situations or with the changing aspects of the environment it relies upon (Redman, 1999). More recently, a vulnerability framework for the assessment of coupled human–environment systems has been proposed, to better explain the degree to which a system is likely to experience harm due to exposure to a hazard, either an exogenous perturbation or an endogenous stress or stressor (Turner et al., 2003).

Even more work has been dedicated to understanding processes of adaptation and innovation in the face of environmental challenge and perturbations (Berkes et al., 2003). Human societies have deployed a variety of strategies to survive and develop despite natural and anthropogenic environmental catastrophes. Wilkinson's (1973) ecological model of development postulates, after Boserup (1965) for agricultural change, that technical progress arises from resource scarcity. Development is viewed as a process of solving a succession of problems that threaten the productive system. In a co-evolutionary perspective, Rindos (1984) argues that changes in human–environment systems are not the product of intentional decision-making, but rather a process of symbiotic community evolution, in a gradual evolution based on unconscious selection of strategies. This perspective is in stark contrast with environmental economics' account of decisions on resource exploitation, which are explained in terms of seizure of economic opportunities provided by markets and as influenced by various policies that provide incentives to exploit or conserve natural resources.

Ecologists have analysed the adaptive capacity of complex systems in the face of perturbations and shocks using the concepts of resilience—the ability to experience change and disturbance without catastrophic qualitative change in the basic functional organization (Holling, 1973)—and robustness—maintenance of a system performance either when subjected to external, unpredictable perturbations or internal stress (Anderies et al., 2004). Some general principles on what makes socio-ecological systems resilient or robust have been identified. In the concept of panarchy (Gunderson and Holling, 2002; Berkes et al., 2003)—which means the process by which ecological and social systems grow, adapt, transform and, in the end, collapse, at different scales—the stages of adaptation and collapse of large systems are not viewed as alternative routes but rather as part of a cycle driven by fast and slow, small and big events that can cascade up the scales.

The concept of transition is receiving much attention in the context of sociology, technological change and complex system theory (Rotmans et al., 2001; Martens and Rotmans, 2002; Berkhout, 2002; Geels, 2002;

doi:10.1016/j.gloenvcha.2005.06.002

Raskin et al., 2002). Transitions are broad societal structural changes that require system innovations by a variety of actors and in multiple sectors of society. New research projects explore changes in production and consumption systems that will be associated with a significantly smaller burden on the environment on a global scale (Vellinga and Herb, 1999).

Beyond these various theories, one finds in the recent literature much more specific insights on factors that are playing a key role at the (broad and fuzzy) bifurcation between a path leading eventually to societal collapse by environmental degradation and a path of successful transition toward sustainability. This includes studies concerned with individual and community capacity to adopt sustainable resource management practices in the rangelands (Gordon et al., 2001); failures of information, market failures, and intervention failures that cause ecosystem degradation despite the overall benefits of these natural ecosystems for society (Balmford et al., 2002); characteristics of institutions that facilitate or undermine sustainable use of environmental resources, and in particular of a class of resources that is referred to as the commons (Dietz et al., 2003; Ostrom et al., 1999); failures of group decision-making to the point that some societies destroy themselves and collapse (Diamond, 2005); historical studies of forest transitions (Mather, 2001); land-use change studies on regions at risk (Kasperson et al., 1995); and a political ecology approach to land degradation (Blaikie and Brookfield, 1987). Most of these studies have adopted a comparative perspective, seeking to identify patterns in sets of case studies that cover distinct regions or issue areas but are designed to answer similar questions, e.g., by conducting meta-analyses of a large number of cases (Geist and Lambin, 2002, 2004).

These studies tend to converge in their assessment of conditions for a sustainable use of environmental resources. This convergence becomes a complementarity when comparing results from different academic traditions in the social sciences, in particular those based on rational-choice, collective-action models, that interpret decisions by actors in terms of utilitarian calculations, or social-practice models, that emphasize the role of culture, norms, and habits as sources of behaviour (Young, 2002).

2. Information, motivation, and capacity

A wealth of scientific evidence produced by the above studies show that the success or failure in resource management by human societies is controlled by three components of human–environment interactions: information on the state of the environment, motivation to manage sustainably the environment, and capacity to implement a sustainable management of the environment (Gordon et al., 2001). These categories bear resemblance to the core actor characteristics which are thought to determine the course and outcome of a policy process (information, motivation, and sources of power, Bressers, 2004). To use a metaphor: for any displacement, one needs a map to know where we are and where else one could go (information), a goal to stimulate movement (motivation), and a vehicle with devices to control direction and speed (capacity). These three components are influenced by the multiple dimensions of the organization and dynamics of societies—their culture, social institutions, economic system, and policies. The information–motivation–capacity classification therefore largely intersects with these dimensions.

The *information* component relates to the understanding by decision-makers of resource degradation and of alternative management practices, as driven by knowledge, information, and communication (Gordon et al., 2001). For sustainable resource management, agents need to access necessary information about the resource systems being governed, as well as about the human–environment interactions affecting those systems, at a scale that is congruent with environmental events and decisions (Dietz et al., 2003). This *information* component involves: (i) a temporal dimension—anticipation and early perception of the current state of the environment via reliable environmental indicators and monitoring systems; (ii) a historical dimension—detecting the signal of (human) perturbation from the background noise of natural variability in environmental conditions, which requires a deep knowledge of ecosystem functioning; (iii) a social dimension—recognition of the importance and relevance of the change in environmental attributes; (iv) an economic dimension—a proper valuation of services provided by natural ecosystems (Balmford et al., 2002); and (v) a socio-political dimension—ability to communicate the environmental information from local land managers to higher-level decision makers, avoiding delays and distortions in the transmission of information which are often associated with large, complex and hierarchical societies (Redman, 1999; Scheffer et al., 2003). This component is largely about dealing with uncertainty, understanding natural variability, and being able to make an accurate diagnostic on the causes of and solutions to environmental change. This requires making use of and combining different knowledge systems (Berkes et al., 2003).

The *motivation* component relates to the sources of behaviour of agents. It has also multiple dimensions: (i) a cultural dimension related to local environmental attitudes, deeply held values and knowledge, clashes between short-term and long-term motives, or psychological denial of the existence of the problem (Diamond, 2005) that can create ideological barriers; (ii) an economic dimension—balance of risk-adjusted benefits and costs, taking into account the time horizon of managers and the fraction of real costs of resource management practices that appear as nonmarketed externalities and are therefore ignored by private decision-makers (Gordon et al., 2001; Balmford et al., 2002); (iii) a policy dimension when perverse subsidies and tax incentives result, over the long term, in both economic inefficiency and the erosion of natural services (Myers and Kent, 2001); (iv) a dimension related to conflicts of interest between various stakeholders which affects the willingness of decision-makers to intervene, given private interests, short-term or long-term stakes in resources by different agents, divergence of objectives between social groups, and governance issues; and (v) an institutional dimension, related to the fit between ecosystems and institutional systems—the closer the congruence or compatibility between, on one hand, the rules, decision-making procedures and social practices that assign roles to agents in the management of ecosystems and, on the other hand, the specific configuration of that ecosystem, the better the relevant institutions will perform in terms of sustainability (Young, 2002). This component is largely about how agents evaluate response options to environmental change.

The *capacity* component is about resources (in the broadest sense) to implement change in environmental management. It is related to the provision of appropriate physical, technical and institutional infrastructure necessary for a sustainable management of natural resources (Dietz et al., 2003). It has also multiple dimensions, related to: (i) policy—capacity to rapidly modify rules governing access to and use of resources, and to implement new policies throughout a territory; (ii) technology—availability of a diverse portfolio of skills and new technologies to manage natural resources; (iii) institutions—a high level of social capital between resource users to deal with conflicts between stakeholders and reconcile varying perspectives, interests and attitudes, and an institutional system that induces compliance with rules, based on a good balance between incentives and sanctions (Dietz et al., 2003); (iv) resource constraints—availability of a production (and labour) surplus to allow for the capital investments which are required to experiment with new solutions; and (v) culture—a readiness to change and adapt, as stirred by inspiring leaders. Other contextual factors associated with a successful transition toward sustainable resource management are a relative stability in external conditions—both climatic and political—during the transition phase, to avoid the perturbing effects of abrupt biophysical or socio-political changes that can push a vulnerable society into a spiral of degradation; geographic and social diversity with social networks that allow mobilizing key resources and sharing experiences; communication and other infrastructure; and moderate rate of environmental change, that should be lower than the rate of innovation.

These three sets of factors—information, motivation, and capacity—may form the broad outline of a theory of human–environment interactions in the context of sustainability science. These factors should not be treated in isolation but should rather be taken as a whole, recognizing their interdependence and synergetic interactions. For example, individual behaviour is not just a response to individual incentives created by markets, taxes and subsidies, but is also conditioned by cultural values (Gowdy, 2005). The set of factors described above may be applied to the analysis of contemporary challenges in achieving a transition toward sustainability. When one of the above factors is severely deficient, a sustainable management of natural resources is likely to be compromised.

Environmental problems differ considerably in their cause and solution. Our ability to design effective response strategies in the face of rapid environmental change, to reverse the course of unsustainable development paths, depends on our understanding of key factors of success at the threshold of sustainability transitions. For every particular resource management situation, one should conduct an in-depth analysis of what factors may cause environmental degradation and impede the adoption of more sustainable management practices. Most human–environment studies do not consider thoroughly all the factors listed above, given the level of data collection and multidisciplinarity required by such an integrated approach. However, a comprehensive understanding of sustainability should address issues related to environmental perception, information processing and transfer; determinants of decision making and individual behaviour with respect to resource management; and portfolios of available and feasible responses to environmental change for the different categories of agents. Moreover, interactions and synergies between these factors need to be considered. This calls for a broader, more pluralistic, and more integrated approach to coupled human–environment systems than what is found in many past studies.

Acknowledgements

This paper has benefited from ideas developed within the Land-Use and Cover Change (LUCC) project of the International Geosphere-Biosphere Programme (IGBP) and the International Human Dimensions Programme (IHDP) on Global Environmental Change. I am grateful to Mark Stafford Smith for insightful discussion and to Helmut Geist and Bill McConnell for useful comments on the manuscript.

References

Anderies, J.M., Janssen, M.A., Ostrom, E., 2004. A framework to analyse the robustness of social-ecological systems from an institutional perspective. Ecology and Society 9 (1), 18 (online).

Balmford, A., Bruner, A., Cooper, P., and 16 co-authors, 2002. Economic reasons for conserving wild nature. Science 297, 950–953.

Berkes, F., Colding, J., Folke, C., 2003. Navigating Social-Ecological Systems. Cambridge University Press, Cambridge.

Berkhout, F., 2002. Technological regimes, path dependency and the environment. Global Environmental Change 12 (1), 1–4.

Blaikie, P., Brookfield, H.C., 1987. Land Degradation and Society. Methuen, London.

Boserup, E., 1965. The Conditions of Agricultural Growth. Allen and Unwin, London.

Bressers, J.T.A., 2004. Implementing sustainable development: how to know what works, where, when and how. In: Lafferty, W.M. (Ed.), Governance for Sustainable Development: The Challenge of Adapting Form to Function. Edward Elgar, Cheltenham, pp. 284–318.

Clark, W.C., Dickson, N.M., 2003. Sustainability science: the emerging research program. Proceedings of the National Academy of Sciences 100 (14), 8059–8061.

Diamond, J., 1994. Ecological collapses of past civilizations. Proceedings of the American Philosophical Society 138 (3), 363–370.

Diamond, J., 2005. Collapse: How Societies Choose to Fail or Succeed. Viking, New York.

Dietz, T., Ostrom, E., Stern, P.C., 2003. The struggle to govern the commons. Science 302, 1907–1912.

Geels, F.W., 2002. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. Research Policy 3 (8/9), 1257–1274.

Geist, H., Lambin, E.F., 2002. Proximate causes and underlying driving forces of tropical deforestation. Bioscience 52 (2), 143–150.

Geist, H., Lambin, E.F., 2004. Dynamic causal patterns of desertification. Bioscience 54 (9), 817–829.

Gordon, J., Vincent, D., Haberkorn, G., MacGregor, C., Stafford-Smith, M., Breckwoldt, R., 2001. Indicators within a decision framework: social, economic and institutional indicators for sustainable management of the rangelands. National Land and Water Resources Audit, Canberra, http://audit.ea.gov.au/ANRA/rangelands/docs/project.html

Gowdy, J., 2005. Sustainability and collapse: what can economics bring to the debate? Global Environmental Change, doi:10.1016/j.gloenvcha.2005.06.001.

Gunderson, L.H., Holling, C.S., 2002. Panarchy: Understanding Transformations in Human and Natural Systems. Island Press, Washington, DC.

Holling, C.S., 1973. Resilience and stability of ecological systems. Annual Review of Ecology and Systematics 4, 2–23.

Janssen, M.A.J.M., Scheffer, M., 2004. Overexploitation of renewable resources by ancient societies and the role of sunk-cost effects. Ecology and Society 9 (1), 6.

Kasperson, J.X., Kasperson, R.E., Turner, B.L., 1995. Regions at Risk: Comparisons of Threatened Environments. United Nations University Press, Tokyo.

Martens, P., Rotmans, J. (Eds.), 2002. Transitions in a Globalising World. Swets & Zeitlinger, Lisse.

Mather, A.S., 2001. The transition from deforestation to reforestation in Europe. In: Angelsen, A., Kaimowitz, D. (Eds.), Agricultural Technologies and Tropical Deforestation. CABI Publishing, Wallingford, New York, pp. 35–52.

Myers, N., Kent, J., 2001. Perverse Subsidies. How Tax Dollars Can Undercut the Environment and the Economy. Island Press, Washington, DC.

Ostrom, E., Burger, J., Field, C.B., Norgaard, R.B., Policansky, D., 1999. Revisiting the commons: local lessons, global challenges. Science 284, 278–282.

Raskin, P., Banuri, T., Gallopin, G., Gutman, P., Hammond, A., Kates, R., Swart, R., 2002. Great transition. The promise and lure of the times ahead. A report of the Global Scenario Group. Stockholm Environment Institute, Boston.

Redman, C.L., 1999. Human Impact on Ancient Environments. University of Arizona Press, Tucson.

Rindos, D., 1984. The Origins of Agriculture: An Evolutionary Perspective. Academic press, San Diego.

Rotmans, J., Kemp, R., van Asselt, M., 2001. More evolution than revolution. Transition management in public policy. The Journal of Future Studies, Strategic Thinking and Policy 3 (1), 1–17.

Scheffer, M., Westley, F., Brock, W., 2003. Slow response of societies to new problems: causes and costs. Ecosystems 3, 493–502.

Tainter, J.A., 1988. The Collapse of Complex Societies. Cambridge University Press, Cambridge.

Turner, B.L., Kasperson, R.E., Matson, P.A., McCarthy, J.J., Corell, R.W., Christensen, L., Eckley, N., Kasperson, J.X., Luers, A., Martello, M.L., Polsky, C., Pulsipher, A., Schiller, A., 2003. A framework for vulnerability analysis in sustainability science. Proceedings of the National Academy of Sciences 100 (14), 8074–8079.

Vellinga, P., Herb, N., 1999. Industrial transformation. Science Plan. IHDP Report No. 12, International Human Dimensions Programme on Global Environmental Change, Bonn.

Weiss, H., Bradley, R.S., 2001. What drives societal collapse? Science 291, 609–610.

Wilkinson, R.G., 1973. Poverty and Progress. An Ecological Model of Economic Development. Methuen & Co Ltd, London.

Young, O.R., 2002. The Institutional Dimensions of Environmental Change. Fit, Interplay and Scale. MIT Press, Cambridge, MA.

Eric F. Lambin
Department of Geography,
University of Louvain, Place Louis Pasteur 3,
B-1348 Louvain-la-Neuve, Belgium
E-mail address: lambin@geog.ucl.ac.be