Sustainability: Are Economists on the Right Track?

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ABSTRACT

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Economists commonly express the concept of sustainability using economic growth models. These models allow exploration of the impacts of technological progress, different types of natural resources, degrees of resource substitutability and inter-temporal preferences on long-term economic growth. However since such models require perfect knowledge of technologies and preferences, they are institution-free, and provide no guide to actual implementation of sustainability. In particular, since changes in complex adaptive social-ecological systems are unlikely to be gradual or linear or predictable, models that aim at better control of environmental and social outcomes are unlikely to lead to sustainability. Alternative views of sustainability, springing from philosophy and systems analysis,

suggest that institutional arrangements are likely to be better guides to implementation of sustainability. It may be better sought by creating flexible institutions that promote progressive learning and the incorporation of new knowledge into the institutions and organizations that guide human decisions

Sustainability: Information Problems

How do we achieve continued compatibility between human resource use and environmental service flows as economic activity expands? This is the genesis of the modern concept of sustainability.

Sustainability is not a precise concept, but this much is widely agreed: sustainability is about our obligations to future generations, and about how humans interact with the natural environment on which they depend. Thus it is about ethics, about balancing consumption today with investment for the future, by considering the impacts of today's resource use on the availability of resources in the future, and about balancing investment in natural assets such as fresh water with the creation of new assets such as roads and medicines and human knowledge.

Viewed in these terms, sustainability involves some very hard problems. What is our obligation to future generations, whose numbers and quality of life may depend upon today's decisions? We can know little of future economy-environment interactions and of future technologies and preferences, yet the answer to the sustainability puzzle depends upon these very things.

The idea of ‘sustainable’ management of the natural and material and social resources of the Murray-Darling Basin is an archetypical example of the hard problems involved in sustainability. Ignorance of future technologies and preferences is one barrier to sustainable resource use. Limited knowledge of the impacts of changes in land and water use on Basin ecosystems is another.

Facing unavoidable uncertainty, what is to be done? Do we try to control the evolution of combined social-ecological systems, or, accepting that control is generally beyond us, promote adjustment to circumstances as they arise?

Economists commonly express concepts of sustainability using neo-classical economic growth models. In this paper, the economic approach to sustainability is contrasted with two alternative approaches. The first part of the paper sketches economic approaches to sustainability, their information requirements, and consequent limitations as a guide to sustainability of combined social and economic systems.

Each of the alternative approaches to sustainability pays explicit attention to some of the information deficiencies that limit the economic approach. In each case, institutions are required to generate the information to chart a path to social-ecological sustainability. Thus, each case suggests that institutional arrangements are likely to be important guides to achieving sustainability.

The first of the alternatives comes from the philosopher Bryan Norton. Criticising economic modelling of sustainability, he argues that it entails specific obligations to the future, obligations that considerably reduce uncertainty about future preferences. Sustainability therefore involves creating institutions designed to determine and implement a community's chosen natural and social legacies to the future.

A second, more comprehensive, alternative approach to sustainability is based upon research into the functioning of combined social and ecological systems. Systems analysts' studies of complex social-ecological systems suggest that the promotion of learning and information exchanges throughout the community is important in achieving sustainability of such systems. The key to sustainability of such systems is resilience, the capacity to ‘bounce back’, to learn about and adapt to novel circumstances.

The paper concludes by arguing that complex social-ecological systems cannot be managed to control change, as neo-classical sustainability models may suggest. Facing unavoidable uncertainty, a society’s learning and signalling and incentive systems are probably the best indicator of its sustainability.

The Neoclassical Economic Approach to Sustainability

For most economists, sustainability is about (Solow,2000; Pezzey and Toman, 2002):

1. seeking to ensure that current economic decisions take full account of economy-environment interactions, now and in the future;

2. concern about the well-being of people in both the present and the future, involving both meeting the needs of the present and preserving the capacity for future generations to be no less well-off than the present generation.

Note that sustainability, as described, is necessarily vague. As Solow (2000, p.138) puts it:

> Sustainability…. is intrinsically inexact. … It is, at best, a general guide to policies that have to do with investment, conservation and resource use. And we shouldn't pretend that it is anything other than that.

Solow emphasises that the vagueness of sustainability does not imply that the concept is meaningless. On the contrary, it serves to remind the present generation of its obligation to invest of behalf of future generations, where the investments may take the form of natural resources, productive equipment, human skills or knowledge. It also serves to remind decision makers of the importance of considering the mix of investments the present generation leaves behind, in particular, the likely relative contributions of natural resources and created assets, including human knowledge, to people's future well-being.

Why is sustainability vague? The information requirements for decisions aimed at achieving sustainability are formidable. Information required includes, in addition to the obvious need for knowledge of the initial stocks of resources, current production technology, and the preferences of the present generation:

- The short- and long-term impacts of economic activity on the natural environment, and the impacts of environmental changes on economic activity. This will include the possibilities for substitution between different types of resources, especially the possibilities for replacing non-renewable resources with renewable resources and created assets.

- Advances in technology over time, including new input substitution possibilities.

- The preferences of future community members.

- The weighting of the well-being of present versus future community members. This is at least as much an ethical (what is the present generation's responsibility to future generations?) as an economic issue.

Each of these poses information problems for decision makers seeking sustainability. Knowledge of economy-environment interactions is imperfect, especially as they stretch into the future. Indeed, as discussed below, change in combined social and ecological systems may be inherently unpredictable. Second, Solow argues that we know almost nothing of the technology or preferences of future generations. The appropriate weighting of present versus future well-being poses a different sort of problem; without a broad community consensus about obligations to the future, community cooperation required to pursue sustainability may not be forthcoming.

While recognizing the information barriers to effective implementation of sustainability, Solow (2000) points out that the problems of defining and measuring sustainability are much reduced if (i), the preferences of future generations are unknown, and (ii), technological advances permit almost unlimited substitutability of created assets for natural capital. In these circumstances, Solow (1992) argues that sustainability is achieved not by preserving specific capital, but by maintaining a broad aggregate of natural and created capital:

> A sustainable path for the economy is thus not necessarily one that conserves every single thing or any single thing. It is one that replaces whatever it takes from its inherited natural and produced endowment, its material and intellectual endowment. What matters is not the particular form that the replacement takes, but only its capacity to produce the things that posterity will enjoy (Solow, 1992, p.15).

This is the concept of weak sustainability.

Economists have used neoclassical economic growth models to explore economy-environment interactions and sustainability issues. In this application, growth models are heuristic devices used to explore the impacts of environmental characteristics and technological changes on the path that the economy follows over time. These models allow rigorous exploration of the impacts of:

- different degrees of substitutability between non-renewable natural resources, renewable natural resources and created assets
- non-renewable and renewable natural resources
- technological progress
- the life-support services generated by natural environments

- inter-temporal preferences

on long-term economic growth and future well-being. A sustainable growth path is commonly achieved by adding an additional constraint to a growth model that maximises the present value of well-being from now into the future. A non-declining utility constraint would prevent utility from declining at any stage along the growth path. A weak sustainability constraint would require the maintenance of a broad aggregate of natural, constructed and human capital. A strong sustainability constraint would require maintenance of an aggregate of natural capital.

Krautkraemer (2004) points out that the addition of such side-constraints to achieve sustainability implies that the standard present-value-maximising growth model is incorrectly specified. For example, non-declining utility implies that this generation's utility depends not only on its own consumption, but also on that of the preceding generation. Maintenance of natural capital implies that the production technology of the model should allow for complementarity of natural and created capital.

As used to explore sustainability issues, growth models are treated as simulation tools, not as guides to actual policies. Nevertheless, if they omit crucial features of real-world societies and ecosystems, their results may hinder, rather than assist, the search for operational sustainability policies.

The Achilles heel of growth models in the search for operational sustainability policies is their assumption of costless information about future environmental impacts, technologies and preferences. Crucially, because the neo-classical models ignore information costs, they ignore the societal institutions required to generate the information required by decision makers. Yet, as explained above, information deficiencies are key barriers to implementing sustainability.

Institutions and Sustainability - I

The evolution of social-ecological systems is driven by a mixture of changes in nature and people's production and consumption choices. Those choices, including choices necessitated by unforeseen changes in the natural environment, are guided by a society's learning and signalling and incentive systems, based on social rules and the associated organisations that define and enforce them. Thus institutions, in the form of the social rules that govern how a society acquires scientific and behavioural information about the environment, technology and preferences, and how that information is communicated and applied, are crucial to the achievement of sustainability. Relevant institutions include scientific and engineering and farming cultures, markets, land and water entitlements and government boundaries and programs. Such institutions, together with the professional and community and commercial and government organizations they spawn, guide social learning and inform and motivate producers and consumers.

Recognition of the role of institutions in acquiring the information needed to chart a path to sustainability raises an important question. Institutions are almost always slow to change, indeed that is a desirable characteristic of social rules designed to reduce uncertainty and conflict in people’s dealings with others. But what if the rules that guide the acquisition and use of information about human-environment interactions cannot adjust quickly enough to keep up with emerging changes in nature and technology? Continued compatibility between human resource use and environmental service flows will be unattainable, leading to ecological and social crises (seen from an anthropocentric perspective).

Cases where rules governing natural resource use appear to have lagged behind emerging environmental knowledge include the introduction of the cane toad (Low, 1999, pp.46-54), development-driven irrigation dam construction and the early 1900s expansion of cereal cropping into arid South Australia and the western Dakotas under the belief that 'rain follows the plough' (Raban, 1997). In such cases the only solution to the resulting ecological and social crises may be a major reorganisation of societal rules and organisations.

Such ecological and social crises and reorganisations are not contemplated by economists studying sustainability. They are seen as almost inevitable by complex systems analysts; their views on the sustainability of social-ecological systems are examined below.

Norton: Community-Based Obligations to the Future

Recall that Solow argues for weak sustainability on the bases that (i), we are ignorant of future people's preferences, and (ii), substitutability of created assets for natural capital is almost unlimited. Solow's first argument eliminates obligations to maintain specific capital to provide for the well-being of future generations, and the second eliminates the need to preserve specific capital for future productive purposes. The philosopher Norton (2002) takes issue with both of these arguments.

On the substitutability argument, Norton doubts that it is possible to substitute for the life-support services of ecosystems, if ecological damage is extensive enough. However his main concern is with the ignorance argument. Norton argues that we do know something about the specific concerns of future generations, for at least two reasons. First, future preferences will not be completely different from current preferences, for genetic and physiological reasons; future preferences for unpolluted water and air are likely to be similar to today's preferences. Second, many in the present generation believe that we have a responsibility to educate the next generation to love and respect nature.

> If we could somehow learn that our grandchildren or great grandchildren will desecrate the heritage we so carefully preserved for them, I submit that we would not, as passively as Solow says, accept this as none of our business. On the contrary, we might well increase efforts to educate today's population and to build lasting institutions

> that will perpetuate our deeply held values and ideals (Norton, 2002, p.43).

Like some advocates of strong sustainability, Norton's argument points to the preservation of specific natural resources, but with the resources to be identified by the community at large, rather than technical experts.

Norton's also disagrees with the view of Solow and other advocates of weak sustainability, that obligations to the future consist solely of *individual*, as opposed to *community-based*, goods.

> Some obligations to the future are obligations to build a community and culture that lasts. We would have failed the future if we fail to develop institutions, ideas and practices that create lasting communities in real places, communities with the moral and institutional strength to protect special places as symbols of the natural history and emergent culture of the community. Failure to do so, I believe, could leave people of the future worse off than we are in an important respect, even if they are vastly wealthier than we are (Norton, 2002, p.45).

Norton argues accordingly that intergenerational morality, and hence sustainability, is not just about intertemporal tradeoffs; it is also about community commitments to continuity with its past, by preserving its natural and social history for the future. Thus sustainability involves creating institutions designed to determine and implement a community's chosen natural and social legacies to the future.

The Nature of Social-Ecological Systems

Systems analysts describe both ecosystems and linked social-ecological systems as complex adaptive systems. Recent studies indicate that such systems are constantly changing, and the change is not always gradual or linear and predictable; sometimes change beyond a particular threshold can lead to 'flips' between alternative ecological and social regimes, shifts that can be very costly or perhaps impossible to reverse (Folke et.al., 2002; Holling and Gunderson, 2002). For example, overfishing has lead to the collapse of cod populations in the northern Atlantic and Baltic Sea. Such ecosystem changes can be both the result of and the cause of major technological and social changes in communities dependent on the particular ecosystem, for example, shifts to high-tech commercial fishing leading to overharvesting and subsequently to the decline of traditional fishing communities and cultures.

Long-held views of resource management, including those underpinning economic growth models, view nature and human society as systems near equilibrium, generally responding smoothly and predictably to management changes such as increased fishing or grazing pressure or fire control. Change in complex adaptive systems is very different. Complex systems are self-organising – interactions between the components of the system create feedback that influences the further development of the system. For example, in the case of Australian rangelands, rainfall, government land management policies, the financial circumstances of graziers, grazing animals, the mix of grasses and shrubs and fire may combine in a variety of ways to produce multiple possible outcomes of management (Walker and Abel, 2002). Each component of the system is changing continuously, and the relations between them are complex and non-linear. Thus change is irregular and unpredictable - it may be gradual, it may be abrupt and discontinuous. There is no single equilibrium to which a system tends; rather complex systems tend to have multiple stable states, such as a grassland and a woody shrubland in the case of rangelands, with irregular adjustments between the two dictated by constantly evolving interactions between system components.

What recognisable patterns of change have been identified in complex adaptive systems? Typically, they go through repeated cycles that involve adaptive change to both interactions between components of the system (for example, plants' responses to animal grazing) and external pressures (for example, changes in wool prices). During the cyclical changes there is a shifting balance between forces that act to stabilise the existing state of the system (say, adjustments in sheep numbers according to pasture availability), and forces that act to upset that state (say, declining wool prices, drought and young people leaving the area for education and employment). Typically, the cyclical changes involve both slow phases of growth and accumulation, when change is relatively predictable, and rapid phases of destruction and reorganisation, when outcomes are highly unpredictable (Holling and Gunderson, 2002, pp.32-49). It appears that for any complex system to be adaptive and thus functional over the long term, it must pass through such successive phases of growth and stability and of change, variety and creative experimentation (p.47). Importantly, for ecosystems the long-term may stretch to decades or centuries (think of irrigation-induced salinity), way beyond the horizons of almost all resource managers.

The complex systems pattern of social-ecological change suggests two very different concepts of sustainability. One, kin to the traditional forestry and fishing notions of sustainable yield, emphasises efficient control of the output of a system viewed as near-equilibrium and relatively predictable. This is the view of sustainability inherent in the neo-classical sustainability models sketched above. In a complex systems context, such models may provide a good representation of system behaviour during the slow growth-and-accumulation phase of the cycle. They will seem quite appropriate whenever the growth-and-accumulation phase lasts for decades, in much the same way as resource planning models based on the long-established and apparently entrenched Soviet Communist system might have seemed quite appropriate to planning Russia’s future in the early 1980s. Yet, as in Russia, the rigidities created during growth and accumulation can make a system unsustainable in both ecological and social terms.

The complex systems view of sustainability extends over the complete cycle of a system, not just the growth-and-accumulation phase, but also the destruction-and-reorganisation phase. From this perspective, a system is only sustainable if it can not only grow and accumulate, but also adapt when faced with drastic and unforeseen change. Adaptation will involve mobilising latent biological resources and information, accepting new resources and information from outside the system, and innovating by recombining resources and human talents in novel ways. In this way a complex system can maintain its biological and social functions despite being subject to destructive change.

If the systems analysts are correct, unpredictability and discontinuities in environmental and human responses in the destruction-and-reorganisation phase rule out the idea that social-ecological systems can be micro-managed to control change. This is what would be required to implement policies to achieve economists’ weak and strong sustainability. While it may be possible to produce stable and predictable outputs for a considerable period while the systems is in the growth-and-accumulation phase, this is likely to be at the cost of reducing biological and social diversity, thereby reducing the adaptive capacity of the system when it is faced with drastic unforeseen change. For example, long-term fire suppression in forest ecosystems leads to fuel build-ups, intense fires and major ecosystem changes (Chase, 1987).

Sustainability of Complex Adaptive Systems

If long-term control of the evolution of social-ecological systems is ruled out, how is sustainability of such systems attained? Complex systems analysts prescribe policies to strengthen ecological and social resilience. Resilience is the capacity to buffer change, to learn about and adapt to novel circumstances (Folke et.al., 2002, pp.13-14). More specifically:

- *Ecological resilience* is the capacity of an ecosystem to recover or to reorganize and adapt to change after disturbance, thereby maintaining its ecological functions and biological productivity.

- *Social resilience* is the ability of communities to recover from environmental or social or economic or political shocks without fundamental changes in social relationships and economic circumstances (Folke et.al., 2002, p.71).

Loss of resilience, and hence of adaptive capacity, means a loss of biological and economic and social options, and hence of the future well-being of people, after unforeseen disturbance to the pre-existing social-ecological system.

What makes linked social-ecological systems resilient, and thus likely to be sustainable? Case studies of social-ecological systems have revealed a tight connection between ecological and social resilience and biological and social diversity. In ecosystems resilience is related to genetic diversity, species diversity and diversity of ecosystems on a landscape. Diversity provides insurance against environmental disturbance; for example, if there are four species of plant pollinators in an ecosystem, and each responds differently to environmental changes, the capacity of the ecosystem to adapt to a change that extinguishes one pollinator species is enhanced. In social systems, resilience is related to diversity of community knowledge, of economic and other social relationships, and of adjustment options that help to absorb and spread the risks of environmental and economic and social disturbances. For example, poor farm communities that cultivate a variety of crops with different ecological requirements and market demands are likely to be more resilient than those reliant on one or two crops.

The systems approach to sustainability shifts the policy focus from planning for control of the outputs of socio-ecological systems to (Folke et.al., 2002, pp.41-54):

- Promoting community learning about the interactions between people and nature.
- Promoting interactions between physical, biological and social disciplines.
- Adaptive management that treats different management policies as experiments from which managers can learn, accepting uncertainty and expecting surprises.
- Creating flexible institutions able to respond to environmental and social feedback.
- Encouraging institutions whose dimensions match the spatial and temporal scales of ecological and social processes, and which interact with institutions operating at other scales. This means sharing of information gathering and decision making responsibilities across local, regional and national organizations.

Thus the emphasis shifts from identifying and implementing centralised control strategies, to designing processes to promote learning about the connections between people and nature at all decision-making levels, and processes to incorporate that knowledge into the institutions and organisations that guide human decisions.

Institutions and Sustainability - II

Institutions can embody both commitments to societal values and guides to decision making. Both the preceding views of sustainability - Norton's view that sustainability requires institutions designed to determine and implement a community's legacies to the future, and complex systems analysts' view that sustainability requires flexible institutions that promote community learning and adaptation to change – suggest that institutions have a key role in the implementation of sustainability.

The logical conclusion is that sustainability policy should be less concerned with particular resource uses, and much more concerned with the informal and formal rules and organizations that guide societal learning and resource use choices. These include social norms, moral codes, conventions, property rights, markets, educational curricula (in particular, education about human-environment interactions), social and environmental monitoring, administrative rules and penalties, jurisdictional boundaries, elections, legislative procedures, law and legal procedures, legislatures and so on (Folke, et.al., 2002, pp.9-10).

The other lesson from the complex adaptive systems literature is that diversity of economic and other social relationships and of consequent sources of ecological and social information, promotes resilience and sustainability. The greater the variety of institutions, the greater the reservoir of information and interpersonal relationships to draw on in the destruction-and-reorganisation phase of the system cycle. Institution-rich communities are more resilient in consequence, consistent with the findings of Putnam (1993), on community functioning in Italy. Holling, Gunderson and Peterson, (2002) stress the importance of linkages between organizations operating at the local and higher levels. A variety of institutions operating at different scales can create benefits in both up and down directions: technical or institutional innovations trialled at the local level can spread to a wider population; lower-level institutions can draw on resources and knowledge accumulated at more aggregate levels.

On the other hand, at the present state of development of complex systems theory, there are dangers in readily deciding that the route to sustainability is through encouraging a wide variety of institutions. First, as Hanley (1998, pp.247-48) points out, it is not easy to define what is meant by ‘maintaining the biological and social functioning of a socio-ecological system’. No doubt this is easier to recognize ex post. What is needed is a rigorous framework for ex ante policy analysis. Second, the diversity and innovation of the destruction-and-reorganisation phase of the system cycle does not automatically lead to a desirable sustainable state. It could lead to an unproductive and socially-rigid systems that are resilient in that they persist by controlling or ejecting innovation, such as the Hindu caste system (Holling, Gunderson and Peterson, 2002, pp.95-98).

A deliberate strategy to achieve sustainability by promoting diversity of community knowledge, institutions and adjustment options is a risk-minimising strategy. Like other such strategies, this involves a trade-off between the costs of maintaining additional learning and institutional options, and the benefits of those options in circumstances of unforeseen environmental or social change. In a globalising world, received knowledge and institutions that have stood the test of time in dealing with past environmental and social changes are often under threat of extinction. Yet the costs of maintaining this information and institutions will frequently be less that the costs of replacements. From a complex systems point of view, inherited social diversity may be as valuable as inherited biodiversity.

What sorts of institutional changes are required to move Australian social-ecological systems towards sustainability? The generic nature of the literature dealing with building resilience and adaptive capacity in social-ecological systems makes it impossible to come up with a detailed prescription. Comparison of this literature (see Folke, Colding and Berkes, 2003) with existing Australian institutional arrangements suggests the following, partial, list of changes (also see Dovers, 2001):

- Long-term monitoring of environmental and social changes, including, where possible, constructing detailed records of past changes.
- Education of the general public about the long-term interdependence of humans and nature.
- Encouragement for the creation of resource management organisations at lower levels of aggregation wherever possible, with funding and decision-making responsibilities shared as appropriate to the geographic scales of problems.
- Participation of all interested parties in policy formulation and management, in order to tap experiential as well as scientific knowledge, and to increase the chances of continued cooperation in

resource management. The recent history of the Australian Fisheries Management Agency points the way.

- Changing political culture to attempt to insulate resource management decisions with long-term payoffs from the short-term political calculus (treat resource management more like emergency management or defence).
- Encourage local or regional or state decision makers to experiment with novel types of resource management and management institutions and organisations. Where the resources required are beyond those available at lower levels, senior agencies should provide assistance, on condition of careful monitoring of outcomes.
- Requiring individual, local, regional and state resource managers to live with more of the commercial consequences of their management decisions, as opposed to underwriting commercial outcomes with senior government assistance. The long history of subsidies for rural 'natural disasters' is a prime example of what not to do.

Conclusions

In economics and business management, implementing sustainability is commonly seen as requiring better understanding of environmental and social systems, followed by better system modelling and better control of environmental and social outcomes. This approach commonly assumes that complex social-ecological systems such as that of the Queensland coastal sugar and tourist belt are stable and predictable.

Unfortunately for those seeking ‘optimal’ management strategies, studies of linked social-ecological systems like those of coastal Queensland indicate that they are constantly changing, and that change is not always gradual or linear and predictable. It is unlikely that they can be managed to yield predictable long-term outputs. Thus the answer to the sustainability puzzle lies more with the development of flexible institutional arrangements than with planning for control of outcomes.

Entrenched ways of thinking in economics and business, communities and government can be a barrier to sustainability. If Australian communities have grown accustomed to waiting for governments to analyse and respond to environmental and social problems, their resilience - their coping ability - is correspondingly less when confronted with water shortages or algal blooms or coral dieback.

Norton emphasizes the importance of institutions for sustainability on the basis that society does not plan for the future starting with a clean slate. Institutions embody legacies that ensure that the historical and cultural essence of the community is preserved.

The complex systems and economics approaches to sustainability share an emphasis on learning about people-environment interactions. However the systems approach shifts the policy focus from planning for control of the environment and society to the design of adaptable institutions. Implementing sustainability then involves creating diversity and flexibility in society's learning and signalling and incentive systems.

Facing unavoidable uncertainty about changes in social-ecological systems, society's learning and signalling and incentive systems are probably the best indicators of sustainability—of ability to adapt to changing social and environmental circumstances.

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