SUSTAINABLE AGRICULTURAL DEVELOPMENT: THE ROLE OF INTERNATIONAL COOPERATION

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Sustainable Development: Concepts and Strategies

INTRODUCTION

There is increasing recognition that economic growth will not necessarily or automatically lead to an improvement in human welfare, in obtaining justice, or in the protection of the environment. Indeed, many critics have indicated economic growth as being exploitative of both people and the environment. However, there also appears to be considerable validity in the expression 'Wealthier is healthier' (Wildavsky, 1988). That is, throughout the world, rising standards of living have accompanied economic growth. Furthermore, the results of economic growth have been spectacular: freedom from many diseases, protection from many natural disasters, the elimination of famine for much of the world, and the freeing of people from drudgery by the substitution of machines for human labour. Thus economic growth can simultaneously be viewed as both the problem and the solution, which in itself poses a dilemma for the designing of informed economic and environmental policies.

These contradictions become apparent when exploring the concept of sustainable development. It has been defined by the Bruntland Commission as development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs (World Commission, 1987). It has evolved to mean the selection of development paths that protect ecosystem functioning as well as protecting traditional cultures.

There are many different schools of thought concerning interpretation of the concept (Batie, 1991; Colby, 1989). While differing substantially, they are for the most part united in the belief that sustainable development does not mean the *status quo*. Also, the neo-classical economics measure of gross national production as a monetized proxy for human welfare is rejected. Furthermore, if sustainable development is to have meaning, it must include consideration of the environment and of human needs and aspirations. Thus sustainable development incorporates the idea of transformations of relationships between people and between people and nature – both now and through time. There remains, however, considerable tension between those schools of sustainable development thought which draw their strength mainly from the ecological science paradigm, and those based on the economic science paradigm. Furthermore, the desires to protect the environment, to develop econo-

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mies and people, to enhance personal liberties, and to maintain a stable and just government can be, and frequently are, in conflict. Recognition of paradigm differences and the nature of sustainable development issues has implications for policy reform and institutional design. Specifically, the recognition of our ignorance and the inherent uncertainty of important future events requires the design of sustainable development strategies that prepare us for the unpredicted and unpredictable.

SUSTAINABLE DEVELOPMENT: ECOLOGY AND ECONOMICS

The two main paradigms underlying concepts of sustainable development, those of economics and ecology, incorporate substantially different assumptions about ecological and economic relationships. I explore these assumptions in depth in another paper (Batie, 1990), but I will highlight a few of the differences here. First, economics and ecological paradigms differ in their assumptions about relative scarcity. Economics incorporates a belief in the almost unlimited possibility of the substitution of man-made and human capital for natural resource capital. As one economist, Ed Schuh (1987), succinctly describes this belief:

> economic development, rather than creating economic scarcity, in its general force tends to create economic abundance. The reason is obvious ... . The engine of economic growth does not lie in physical and natural resources ... but in science and technology – [that is] knowledge. (p.373)

That is, as resources become more scarce, market prices (or shadow prices) will rise, which will induce a search for more abundant substitutes as well as for the technology appropriate to their exploitation. Because of this belief, the traditional economic model does not incorporate limits to growth, at least not in a meaningful time-frame. While recognizing that the earth is a finite collection of living and non-living systems, most economists believe that the inventiveness of the human mind and the responsiveness of institutions has, and will, avoid absolute constraints to growth for centuries.

Ecologists tend to incorporate the idea of absolute scarcity and, therefore, real limits to economic growth as a key assumption in their paradigm. The biosphere is conceived of as posing absolute limits on economic growth (but not on economic development); of particular concern is the limit of the assimilative capacity of the environment with respect to waste residuals from human activities. The foundation of this belief in absolute limits stem from the laws of thermodynamics:

> These laws guide the interaction of energy-matter on the planet and are immutable. It is ultimately the laws of nature, not of man, which determine the biospheric constraints imposed on the level of economic activity. If, for example, increasing entropy is a reality, then knowledge cannot infinitely expand the domain of human material progress at the expense of natural environment. (Underwood and King, 1989, p. 324).

The first law of thermodynamics – the Conservation of Matter Law – states that energy-matter can neither be created nor destroyed. When this law is considered with the second law of thermodynamics, or the Entropy Law, the usual conclusion is that all consumption and production ultimately increases entropy and irrevocably diminishes our future ability to use resources (Underwood and King, 1989; Daly, 1991).

Both the economists' belief in relative scarcity and the ecologists' belief in absolute scarcity can be thought of as untested. The second law of thermodynamics, on which rests the absolute limits hypothesis, applies to closed, non-living systems; its applicability to a solar energy-receiving earth which is pocketed with complex interacting, living systems remains highly debated (Zhu, Batie and Taylor, 1991). Whether the imperative for ever-increasing entropy can be applied to such a large system is not yet known[1]; there is no scientific 'high ground' for those who advocate absolute scarcity or for those who advocate relative scarcity.

The second major difference in assumptions between the traditional economics paradigm and the ecological paradigm stems from their perspectives of the economic and natural system. Neo-classical economics, like many sciences, emulates Newtonian physics (Mirowski, 1988) – a situation that more than one author has referred to as 'physics envy'. Mechanistic systems predominate in neo-classical economics. 'The neo-classical model is mechanistic in the assumption that the economic system can operate in equilibrium at any position along a continuum and move back and forth between positions.... Atomistic–mechanistic models are characterized by a range of stable equilibria and the reversibility of system changes' (Norgaard, 1985, p. 383).

The mechanistic view of the world results in most (but not all) neo-classical economists searching for optimal solutions, equilibrium positions and reversible actions (and not incidentally, developing a fetish for formal mathematical rigour and quantification). Mechanistic systems are particularly suitable for the analysis of stable, predictable systems. However, the ecologist tends to see the world as one of irreversibility, unstable systems, unpredictable system changes, disequilibria and non-incremental events; therefore an ecologist is much more likely to draw lessons from the Darwinian revolution – not the Newtonian one. The paradigm of evolution places great emphasis on the interconnectiveness of ecosystems that have coevolved as well as on ecosystems and traditional human cultures that have coevolved. As a result of these and other fundamental differences in assumptions, the meaning of the concept of sustainable development can differ substantially between the two disciplines.

'Progressives' and 'Environmentalists'

However, sustainable development advocates, no matter what their science, tend to agree that past and current development strategies are not desirable and are not sustainable in the long run. However, the foundation of their thinking – economics or ecology – tends to influence their perspective on the corrective action that should be pursued.

Norgaard (1991) draws the distinction between 'progressives' and 'environmentalists.' 'Progressives' tend to draw many lessons from economics: 'They argue that sustainability will require a significant expansion in agriculture, forestry, and other research to implement more environmental compatible technologies, significantly more environmental monitoring and assessment, and design new institutions to internalize external costs. They envision sustainability as a matter of fully optimizing people's interaction with nature' (p.11). This 'progressive' perspective on sustainable development has been termed that of 'resource management' (Colby, 1989) and leads towards discovering the 'right' incentives to produce solution-oriented technologies, implementing the 'right prices' to internalize the externalities as well as using natural resource accounting (Ahmad, Serafy and Lutz 1989; Repetto 1986). It can also involve advocacy for collective action to reduce the use of 'throughputs' in the system (Batie, 1989). Resource management policies are also those of improving imperfect capital markets, investing in education and infrastructure, health and nutrition, as well as in productivity-enhancing, pollution-controlling technologies, (Schuh, 1987; 1988; Mellor, 1988). For example, in the developed nations, there are numerous resource management strategies that can be pursued to achieve energy efficiency, to reduce agrichemical use, and to reduce pollutants (Repetto, 1990). These strategies encompass those of relating vehicle taxes to fuel consumption, eliminating 'below-cost' forest timber sales, using accurate marginal cost pricing for all energy production and reforming farm policy to eliminate incentives for surplus monoculture production (Repetto, 1990).

In contrast, 'environmentalists', who tend to draw their lessons from ecology, believe the corrective course of action should be the reduction of the overall level of economic activity. Whereas the 'progressives' goal may be to lift the poor closer to the rich through the adoption of non-polluting, efficiency-enhancing technology, the 'environmentalist' is more likely to advocate the pulling of the rich towards the poor through land tenure reform, redistribution of income and adoption of appropriate small-scale technology. While the 'progressive' is more likely to use economic incentives to achieve desired goals, an 'environmentalist's' first instincts are to regulate and to use command control institutions. This tendency stems, in part, from less knowledge of (or faith in) economic incentives. That is, the 'environmentalist' is likely to feel that the problems of protecting the environment are so complex, with numerous scientific uncertainties and with such potential for catastrophic outcomes, that no amount of tinkering with markets will suffice. However, another reason 'environmentalists' usually do not use economic incentives to achieve goals is in part their desire to stigmatize undesired behaviour as ethically, morally and legally wrong. This major school of sustainable development thought has been termed 'eco-protection' (Colby, 1989) and is preservationist in nature; it has as an objective the 'maintenance of the resource base'. That is, it is a minimization, steady-state concept that implies minimizing the use of the natural environment.[2]

In this eco-protection perspective, not only is a highly managed nature not desirable, it is not feasible. 'Environmentalists' claim that pursuit of managed environments may lead to ecosystem collapse and perhaps even the eventual

extinction of the human species. Thus eco-protection goals imply limiting human management of resources as well as use of non-solar, non-renewable energy inputs.

There is also a high level of risk aversion among the eco-protecting 'environmentalists'. There is a willingness to bear high costs in terms of bureaucracies, implementation costs, foregone income, foregone personal freedoms or other opportunity costs, in order to reduce the risk of ecological damage. When in doubt – about whether there is a risk of ecological damage or whether certain behaviours or technologies are contributing to an environmental risk – the 'environmentalist' is likely to advocate that society adopt the more risk-averse court of action. In the language of statistics, the 'environmentalist' is willing to pay high costs if necessary to avoid a Type II error. A Type II error in this case would be wrongly assuming that there be no long-lasting environmental harm from a chosen action. 'Environmentalists' are also likely to estimate unknown risks to the environment as more costly than do resource managers; that is, 'environmentalists' are more pessimistic than 'progressive' resource managers. Such differing attitudes can be seen, for example, in estimates of, and willingness to bear the costs of, carbon dioxides and other pollutants to reduce the possibility of global warming.

Norgaard (1991) further distinguishes between 'technocratic environmentalists', 'who think the new environmental scientists have reasonable answers' and 'populist environmentalists', who strive to change the world into what they desire. This attitude is in contrast to the pragmatism of the 'progressive' resource managers who work with the world and its values as they find it. Thus the 'populist environmentalists' emphasize changing peoples' values, limiting population growth, redistribution of society's income and wealth, and protecting traditional cultures.

THREE PILLARS OF A SUSTAINABLE SOCIETY

Regardless of which perspective of sustainable development is adopted, however, all have as goals a sustainable, humane and just society. There appear to be three pillars to such a society: economic stability, political stability and ecological stability. All are related; all are dependent on one another; all can be in confict. Many of the dependencies are well known; however, economists as 'progressives' tend to perceive mainly the social dependencies, while ecologists as 'environmentalists' tend to perceive mainly the ecological and physical dependencies.

For example, economists tend to recognize the social complexities encompassed in the relationships between economic stability and ecological stability with respect to rates of human population growth. They perceive the problem to be one where fertility rates outstrip death rates, owing to a variety of understandable social and economic factors. Poor families must ensure their survival. When children enhance a family's economic security through their labour and when they enhance their mother's limited social status by their existence, then families tend to be large. Large poor families, on the other hand, frequently have no choice (particularly when faced with a variety of

economic influences such as limited capital markets and no off-farm employment opportunities) other than to exploit and degrade their environment. The evidence is overwhelming that rising standards of living and enhanced status for women can reduce the birth rate. Therefore economists tend to look for ways to enhance income and/or women's status as one way to reduce environmental degradation in developing countries. Furthermore, because economic development causes population rates to decline as parents have fewer children (but provide each child with more education), ultimately there can be a decline in the demand for natural resources. Thus economic and ecological stability are perceived as being strongly linked with economic development.

In constrast, ecologists tend to see the ecological complexities in the relationship between economic and ecological stability. They recognize that there are complex linkages that result in unintended ecological damage by well-intended economic actions. For example, they were the first to call attention to the complex ecological relationships that are damaged when wetlands or forests are converted to agricultural uses. Ecologists understand that ecosystem health is important to all species including the human species, and they recognize that protecting species' diversity and habitat also protects future human choices.

While interdependencies between economic, political and ecological stability are real and common, so are conflicts. For example, in order for natural resources to be conserved and used wisely, they must not be priced too cheaply. Thus, whether one refers to the American West or the Soviet Union Aral Sea, one finds that inexpensive irrigation water, for example, can lead to serious ecological disfunctioning. In these examples, economic stability (for example, pricing resources appropriate to their scarcity) and ecological stability (such as protecting ecosystem functioning) appear to be compatible, but political stability may imply pricing food and clothes inappropriately low relative to the true opportunity costs of their production, or may mean maintaining populations on fragile lands. Thus political stability may be counter to economic ecological goals. Furthermore, there are many examples where economic and political stability are seemingly in conflict with ecological stability. The closing of old growth forests to the logging industry on which local cultures depend is such an example.

Furthermore, with environmental issues, the potential for surprise and system breaks – that is, sudden and drastic changes in the parameters of the system – is high and potentially catastrophic: 'Examples include the greenhouse effect, the hole in the ozone layer, algal bloom from fertilizer runoff, acid rain, ... all of these are relatively new phenomena, and they were all unexpected and unwelcome' (Faber, Manstetten and Proops, 1990, p. 14). As a result, there are some profoundly different issues surrounding the problems of natural resource depletion and those of ecological stability. The economic policies that apply to resource depletion may well be inappropriate for protection of ecosystem stability.

Informed sustainable development policies should incorporate appreciation of social, political and ecological interrelationships. As the past-president of the World Bank stated:

> A purely technical approach to the environmental challenge, insensitive to social, cultural, and public health considerations, results in a wide array of social problems. Profligate industrial policies assail the world's climate. The basic requirement of food for ceaselessly growing populations is met at the expense of degraded soils, making future agricultural efforts more costly. Development resting only on exploitation of nonrenewable resources leaves us poorer in the long run. All these issues and others are intertwined and must be addressed. (Conable, 1989, pp. 2–3)

Dynamic concepts

In addition, it is important to recognize that these three pillars – economic, political and ecological stability – are dynamic concepts whose definitions change with changes in culture, time and scale. The interpretation of these terms embodies value-judgements not resolvable by science. The ecological concept of carrying capacity, for example, must be defined for a certain scale of an economy, the size of its population and the available level of technology, as well as its use of finite resources. A 'slash and burn' nomadic culture may be sustainable when there are few people using a large amount of land; such practices only become unsustainable when populations grow out of proportion to the land base. Such large populations may be sustainable, however, if they adopt an alternative technology to 'slash and burn' as their agricultural production practice.

Furthermore, embodied in the concept of carrying capacity are value-judgements concerning appropriate standards of living, levels of biological diversity or limits to a managed nature. While scientists may be able to assist in identifying the ultimate limits of carrying capacity – that is, the circumstances which would be present when the entire ecosystem or social system ceases to function – the selection of the optimal carrying capacity short of these ultimate limits is not a scientific decision. Furthermore, in many cases, even the ultimate limits are subject to fierce debate, not just between social and physical scientists, but between physical scientists themselves. The current debates swirling around the reality and significance of global warming or acid rain are testament to this point. There are great uncertainties associated with many of the economic–ecological linkages: 'The sobering prospect is that most of the major public decisions about resource use and environmental management will be made in the face of large uncertainty deriving from ignorance of physical and biological systems and from evolving techniques and social values' (White, 1980, p. 183). In many cases, there are also significant political impediments to achieving ecological and/or economic stability goals.

IMPLICATIONS FOR SUSTAINABLE DEVELOPMENT POLICIES

What are the implications of these insights for economists interested in sustainable development policies? The first is simply that there will be differ-

ences in the way well-informed, well-intentioned people view the concept. Ultimately one's views depend on such factors as one's:

- faith in technological progress and institutional capacity to react to change,
- belief in the appropriate scale and relationship between humans and nature,
- estimate of the time-frame in which any physical limits to growth apply,
- concern over and belief in the potentiality of complete ecosystem collapse, and
- definition of intergenerational and intragenerational justice.

It is no wonder that debates are so common, so intense, and so unresolved.

One's view on these factors influences the answers to fundamental questions: how do we determine who and what we want to sustain and how do we organize society to achieve sustainability? Much of the literature on sustainable development presumes we know what would comprise a sustainable world and that our sustainable development goals are predetermined. Some authors directly or implicitly argue for command control policy instruments (for example, emission controls, regulation of equipment, production processes, inputs and outputs) and/or highly planned centralized decision making to achieve these goals. Others proclaim that we must rely on decentralized decision making, preferably market-based incentives (such as tradable permits, taxes, subsidies). In practice, neither of these approaches, historically, have proved totally satisfying for obtaining environmental quality or sustainability. Markets will never 'get the prices right' on unpriced resources, particularly when the non-market value of the natural functioning of the resource is unknown. Markets involve trade at the margin; any physical limits, ecosystem collapse, or future generations' needs are beyond the traders' vision. Markets thrive on disequilibrium, instabilities and uncertainties; on trial and error, not single-minded pursuit of stability goals or steady-state economics. Furthermore, the market does not encourage a sense of a global community of interests.

On the other hand, centralized decision making has proved to be exceptionally poor at providing even market goods, let alone environmental quality and ecological stability. Centralized planning does not reduce rent-seeking behaviour or uncertainty, and it tends to stifle entrepreneurship for innovative solution-providing technologies and institutional design. Similarly, command control instruments require deterministic centralized planning relating to what the environmental standards should be and how they are to be achieved. The implicit and generally wrong assumption is that we know the who, what and how of sustainability.

Sustainable development strategies need to reflect recognition of knowledge uncertainties and the potential for both market and government failures. Furthermore, there must be more knowledge sharing between the physical and social sciences as to the socio-economic, political and ecological reasons underlying both environmental degradation and poverty. Such knowledge sharing is essential if we are to adequately analyze supply and demand for unsustainable actions (Idachaba, 1987). For example, the world is replete with

examples of environmental degradation resulting, not from population pressures or economic growth, but rather from public policies. Sugar policy in the USA, for example, by artificially raising the US domestic price of sugar, encourages sugar production, encourages corn production (since corn fructose is a substitute for sugar), injures non-US producers of sugar and (without intending to) results in the pollution of southern United States wetlands as well as soil erosion in the mid-West United States. US transportation, land use and energy policies encourage the use of cars and airplanes as well as the growth of suburbs but discourages railway development and (without intending to) results in air pollution and habitat destruction.

There are a variety of socio-economic, political and ecological factors underlying these examples. Only careful examination of these factors will provide the knowledge necessary to redesign the institutions to implement sustainable development policies. Such institutional design can have as much or more social pay-off as can new production technologies (Ruttan, 1987), particularly if it addresses uncertainties and provides for non-deterministic ways of addressing trade-offs between economic, ecological and political stability.

Sustainable development requires new strategies that differ from those that emanate from strategic, rational, deterministic planning. These strategies should allow for technological progress to solve environmental problems, but not depend solely on such progress. Furthermore, any strategy should be open to revision when an unexpected 'novelty' or currently unforeseen possibility occurs.

Adaptive management

This broad, flexible strategy has been termed in environmental planning: 'adaptive management' (Walters, 1986). Adaptive management involves trial and error, monitoring and feedback in the development of alternatives, as well as the exploration of values. Rather than develop a fixed goal and an inflexible plan to achieve that goal, adaptive management recognizes the imperfect knowledge about the interdependencies that exist within, and among, natural and social systems. Furthermore, this imperfect knowledge is seen as requiring plan modifications with improved technical knowledge and changing social preferences. In effect, adaptive management is a learn-by-doing approach to decision making.

Adaptive management is capable of incorporating either market incentives or command control instruments but includes feedback and redesign as fundamental components of the policy implementation. Thus, if adaptive management is to be sustainable, it requires knowledge of ecological as well as social systems. Feedback mechanisms must include those that feedback, in a timely effect manner, information about ecological dysfunctioning (Dryzek, 1987) as well as economic and political cost. Flexibility and responsiveness of institutions to changing environmental or economic conditions is necessary as well.

Adaptive management, sustainable development strategies establish objectives through an opportunity cost decision-making approach. For example,

within the opportunity cost framework, the answer to the question 'how much environmental protection is enough?', emerges from legitimate social choice processes within governments which determine the degree of environmental protection that is desirable. Confronting the decision process with economic, ecological and political cost information elicits 'values' from that process. Continually focusing the question on whether an action is 'worth' its economic, ecological and political opportunity cost is seen as the most practical way to answer the question 'how much is enough?'

The development of institutions capable of adaptive planning is a tremendous challenge. In the United States, for example, most environmental strategies do not incorporate monitoring, feedback and re-design. For example, the 1985 Farm Bill authorized the United States Department of Agriculture (USDA) to pay farmers not to farm highly eroding lands for ten years. The bill did not include any evaluation and re-design as the programme was implemented. Subsequently some monitoring has taken place, conducted, not by the USDA, but rather by environmental groups who were suspicious that environmental goals were not being met. Re-design had to wait until congressional re-authorization of the farm bill in 1990, an awkward, slow, inflexible institutional approach. Further re-design must wait until 1994.

There are a few examples of adaptive management. One is found in the United States Chesapeake Bay programme's nutrient management strategy. The four state governments in the region initially established a goal to reduce non-point nutrient loads to the Bay by 40 per cent and agreed to a variety of approaches to achieve the goal. They also committed themselves to continuous study of the goal itself as well as the cost and effectiveness of the means to attain the goal. The 'value' of goal attainment would be discovered in relation to the cost of goal attainment. As a result, both goals and approaches are subject to revision over time. However, adaptive planning such as is incorporated in the Chesapeake Bay programme is rare, still quite imperfect, and in need of refinement.

CONCLUSION

The design of adaptive management institutions represents a significant change from the status quo and hence is a tremendous challenge. However, it appears to provide one of the more promising answers to the fundamental questions of what we want to sustain and how we organize to achieve such sustainability. Such design requires contributions from many disciplines and a willingness to experiment with alternative sustainable development strategies. Sustainable development will not become reality if the three pillars of economic, political and ecological stability are leaning in opposite directions as a result of uncoordinated development and environmental policies. Sustainable development, as implemented in adaptive planning strategies, is an imperfect and dynamic process that attempts to reflect the social–political value context necessary for systems' stability.

NOTES

[1]However, the entropy law clearly applies to the conversion of raw material ultimately to 'waste' material that is returned to an environment characterized by a finite capacity to absorb wastes. That is, there is a limit to ecosystems' ability to absorb pollutants and still continue to provide natural services such as clean air.

[2]This latter eco-protection view can include those of deep ecology 'ecocentrists' whose beliefs are dominated by concerns with rights for non-human species and systems.

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DISCUSSION OPENING – RICHARD R. BARICHELLO*

Let me open by commending Sandra Batie for the fine job she has done in pulling together the several schools of thought and lines of argument which surround the concept of sustainable development. The topic remains only vaguely defined because it is applied to a wide range of problems and has attracted an exceedingly diverse set of authors, disciplines and prescriptions. Confronted with this array of material, Professor Batie has organized it well and has extracted the key issues clearly.

The paper focuses on the two paradigms of ecology and economics, and begins with the beliefs, assumptions and implicit models which each uses to analyse the sustainability issue. Two major differences are highlighted: (a) the interpretation of relative scarcity, and (b) the question of whether the economic and natural systems are characterized by equilibria and smooth marginal changes, or by disequilibria, instability, irreversibility and non-incremental changes.

The paper goes into greater detail by discussing prescriptions for dealing with sustainability problems through the eyes of 'economic progressives' and 'environmentalists'. These characterizations show some differences in objectives, but primarily a difference in the underlying model of the way the world works.

To find common ground and policy responses to these problems, the paper emphasizes three factors or pillars underlying a sustainable society which must collectively guide us in the search for policies to help resolve the sustainability problem: economic, political and ecological stability. The paper emphasizes the interrelationships among these three factors, changes in their relations over time, recognition of where our knowledge base is weak, knowledge sharing between physical and social sciences, and a re-design of our institutions to implement more sustainable policies. An adaptive management strategy incorporating economic and ecological information, and which features monitoring and feedback, is recommended.

Let me now summarize what I think we have learned from this ongoing debate and the speaker's review, with a focus on appropriate resolution of sustainability problems.

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(1) A number of externalities, particularly relating to sustainability issues, have been much better identified and defined. This information has been largely provided by ecologists and scientists, and a continued flow of data documenting such externalities is a necessary part of an effective policy process. Dr Yadav's paper, within this section of the programme, provides a nice illustration of bringing important local data to bear on practices.
(2) The environmentalist goal of preserving certain resources or resource stocks, with the interests of future generations in mind, has been identified and emphasized anew. This may be legitimate, but requires some measurement and weighing of costs and benefits.
(3) Let me restate the importance of combining economics, ecology and politics in developing appropriate policies and strategies, although with a somewhat different emphasis than that found in Batie's paper. There are three headings:

— from scientists and ecologists, we need more information to overcome 'knowledge uncertainty' about the technical details of ecological problems;
— economic analysis is required, not only in measuring costs and benefits, but also in identifying the incentives faced by farmers or others whose actions are causing problems;
— understanding of the political economy of government action or inaction would help us to understand the interests involved, and how policies might be changed.

Above all, it should be emphasized that there is in practice a very great distance between current policies and institutions and those which would be recommended by economic analysis to provide a solution to sustainability problems. We do not live in a 'first-best' or even a 'second-best' world. The policies and institutions which are in place often do little to help solve environmental externalities; indeed, many actually create or exacerbate them. This suggests that there is a wide range of problems which are amenable to resolution with more appropriate economic instruments. For example, soil degradation problems are significantly resolved by reducing the incentive to expand production to marginal lands, and over-cutting of forest lands is reduced by improved land tenure arrangements (see below). This may sound like a repetition of familiar arguments, but when we examine a selection of particular problem areas, such as irrigation water control or sugar policy, we are so far from sensible economic policies in many areas that it is worth restating the priority of using economic tools carefully and more persuasively.

The challenge facing economists is to design incentive systems which lessen or solve our environmental problems, and to construct local institutions which can provide those incentives. Farmers' responses to the incentives they actually face, given their information base and other constraints, are not in doubt, although determining farmers' true incentives is not a trivial problem.

It is also my view that many of the problems we face are the result of local circumstances, institutions and ecological conditions. Their solution similarly requires the use of problem-specific data rather than general prescriptions.

Without this focus on specific data, one could easily be drawn into a quasi-religious approach to solving sustainability difficulties.

One example can be provided to illustrate my points; it concerns tropical deforestation, where there are key issues relating to institutional conditions. Are timber concessions awarded for 20 years when the optimal felling cycle is 35 years, giving concession-holders no financial interest in the next crop? How do taxation and royalty policies encourage logging practices? If taxation is on the basis of timber removals rather than marketable stems, one should expect high grading, increased site damage and wasted wood, lower productivity in the next crop, and lower government royalty and tax revenues. What kind of replanting policy is in place and what are the resulting incentives to replant? Are there other restrictions, such as selective felling, which may increase environmental damage and lower forest productivity? If enforcement of concession rights against localized small farmer logging or slash and burn agriculture is difficult, what do concession holders do to their forest stocks to deal with illegal harvesting and squatting? The sensible response of concession holders may be to cut the forest stock faster.

The point is that many externalities are generated by chosen government policies and existing local institutions. Attention to these details is often critical to (a) understanding why unsustainable practices are being followed, and (b) designing appropriate solutions. Last, and not least important, is the question of why the policies were designed in such a way in the first place. What are the political interests which may prevent effective policy and institutional reform? If the responsible ministry is reluctant or unable to change forest policies because of the influence of powerful vested interests, what are the reasons for opposition from those interests? Further, can other policies or regulations be put in place which would enlist interest group support?

In closing, I would hazard the guess that a large proportion of the environmental problems which have spurred the sustainability debate are not caused by irreversibilities or by an unwillingness to consider future generations: for example, the smallholders who are damaging forest stocks are often saving prodigiously to enable their children to own their land and to better their education at family expense. Rather, the problems are the result of government policies and local institutions which are serving some political interest, or which have inadvertent side-effects injurious to sustainability. Dealing with these sustainable development problems requires a mix of careful economic analysis, adequate local environmental and policy data, and an attempt to understand the political economy considerations which have led politicians to choose the policies in place.