ASSESSING THE HEALTH OF AGROECOSYSTEMS: A SOCIOECONOMIC PERSPECTIVE

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Agroecosystems are managed ecosystems. Agriculture inherently involves self-conscious attempt of humans to change or manage natural ecosystems. The fundamental purpose of agriculture is to shift the ecological balance so as to favor humans relative to other species in production of food and physical protection. Humans are unique among species in that we make purposeful, deliberate decisions that can enhance or degrade the health of the ecosystems of which we are a part. Thus, any assessment of the health of agroecosystem must take into consideration the purposeful, self-conscious nature of individual and collective human actions.

Socioeconomic Dimensions of Agroecosystems

The evolving discipline of agroecology provides the scientific underpinning for evaluation of agroecosystems. Agroecology represents an integration or fusion of ecology and agricultural sciences. However, disagreements continue regarding whether agroecology should include the social as well as the natural sciences. For example, in a recent book review, Anderson chides the authors of two new books on agroecology for their "confusion" in including social sciences in agroecological analysis. Gleissman is quoted as promoting a vision of agroecology that is "more than just ecology applied to agriculture (in that) it takes on a cultural perspective as it expands to include humans and their impacts on agriculture environments" (page 369). Anderson points out that "Human culture requires very different methods of analysis than ecological phenomena. Ecology's methods were designed to study organic processes and the behavior of organisms that lack most forms of intentionality. Human capacity for intentional action -- our abilities to use indirect strategies, to learn from mistakes, to delay gratification, to persuade others to work collectively -- imposes a layer of complexity that is qualitatively different from that of the naturally occurring 'societies' that ecological methods can study" (page 41). She concludes that we should "prune back the aims of agroecology to understanding what makes the tangible aspects of agricultural systems work, rather than trying to tackle cultural systems as well." (page 42).

On the other hand, Allen contends that "Agriculture does not exist and cannot function except at the intersection of society and nature" (page 2). She states that "In our Western conception of nature, the environment is usually considered to be a physical space and set of laws that exist and operate external to and independent of us (humans). While there is a 'nature' that preexisted

human beings, and we are subject to natural laws such as gravity, nature (as related to) agriculture is a humanly reconstructed nature" (page 3). Allen points out also that "problems do not arise from only the interface between society and external nature but also from contradictions within society itself." "Natural" disasters, such as flood and drought, may actually result from, or at least be "disastrous" because of, past collective actions of humans. She concludes, that "it is important to understand that we are working in a situation in which both nature and society have been developed, produced, and reproduced by the ideas and activities of human beings" (page 3).

The debate will continue as to whether social sciences and physical sciences should be integrated under the disciplinary umbrella of agroecology. However, if agroecology is to provide an intellectual foundation for study of the health and sustainability of agroecosystems, it must include the socioeconomic as well as the biophysical.

Agroecosystem Health and Agricultural Sustainability

Much of the current interest in agroecosystem health arises from the issue of agricultural sustainability. A universally accepted definition of sustainable agriculture is yet to be found. Allen, et al. suggest that the efforts to forge such a definition should continue, in spite of feelings on the part of many that we should spend less time talking about sustainable agriculture and more time implementing it. Not only is there no single definition, "there is no generally accepted set of goals for sustainable agriculture and little agreement even on what and who it is we intend to sustain" (Allen, et al., page 34). Lacking explicit goals and objectives it is difficult, if not impossible, to assess sustainability. Sustainability is an important facet of ecosystem health. Any assessment of agroecosystem health must be prefaced with an explicit definition of agricultural sustainability, while recognizing that a different definition might well lead to different conclusions.

Allen, et al. offer the following definition: "A sustainable agriculture is one that equitably balances concerns of environmental soundness, economic viability, and social justice among all sectors of society." While this definition provides an appropriate set of objectives, it does not define the overall goal of sustainability. It does not answer the question; what is to be sustained and for whom? An appropriate preamble may be added, however, resulting in the following definition: *A sustainable agriculture is one that is capable of providing everlasting value to society. A sustainable agriculture, so defined, must be ecological sound, economic viable, and social just.* This definition makes clear the anthropocentric nature of agricultural sustainability. We are concerned about sustaining agriculture for the benefit of humans, both now and into the indefinite future. However, the definition is also ecocentric in that it explicitly recognizes the critical interconnectedness of humans with the other biophysical elements of the natural environment and with each other. Ecologic, economic, and social sustainability are all recognized as necessary conditions for agricultural sustainability. This definition makes clear the necessity of including economic and social indicators in any assessment of agricultural sustainability, and thus, in any assessment of health of agroecosystems.

The Human Factor in Sustainability

The logic of necessary and sufficient conditions provides insights into the nature of agroecosystems. However, attempts to distinguish necessary and sufficient conditions are perhaps the source of some differences of opinion regarding the importance of the sociocultural or human dimension of sustainability. Haskett states that "the foundation of sustainability in agriculture is a set of biologically/physically possible processes involved in the production of food." He also states: "Sustainability is further bounded by a subset of the biologically/physically possible, which might be referred to as the socially/culturally possible." However, "it is important to recognize that these two components, the physical/biological and the social/cultural are not equal in terms of determining sustainability." "Biological possibility is necessary for social possibility but not the other way around." "Not everything that is biologically/physically possible is socially/culturally possible."

One might logically extend this line of reasoning in that economic possibilities are a subset of social/cultural possibilities. Environmental soundness might be considered a necessary condition for economic viability, and economic viability a necessary condition for social justice. Using the same logic as Haskett, one might contend that economic viability and social justice are not equal in terms of determining sustainability. Economic viability is necessary for social justice but not the other way around. Not everything that is economically viable is socially just.

However, the logic necessity and sufficiency fails to explicitly recognize the unique dynamics of managed ecosystems. Haskett states that we must be able to distinguish between "causality and mere correlation" in study of interactions between biophysical and socioeconomic possibilities. However, in dynamic systems the concept of causality becomes tenuous. Do natural ecosystem constrain or restrict human actions or do humans actions constrain or restrict natural ecosystems? Of course, both are true. Humans respond to their environment in ways that change their environment. Thus, causality becomes a circular process from environment, to action, to environment, to action, to environment..... The question of whether environmental degradation is a consequence of social injustice or social injustice a consequence of environmental degradation becomes moot in a dynamic model of agroecosystems. The feed-back loops between biophysical and socioeconomic elements of agroecosystems go in both directions.

In the study of dynamic systems, defining trends and patterns is more important than determining causation. For example, systems can become entrenched in self-perpetuating trends toward growth or degradation, or cyclically reoccurring decline and regeneration (Senge). The fundamental nature of the action elements in systems may not be subject to change, as in the case of laws and principles of ecology and human behavior. Such patterns can be broken or changed only by intervening in the action-reaction "process." For example, if a society becomes locked in a action-reaction cycle of environmental degradation, the action-reaction "process" must be broken. It is no more useful to say than an unjust society is the cause of environmental degradation than to say that past environmental degradation is the cause of social injustice. The fundamental question is: how can the continuing action-reaction cycle of environmental degradation and social injustice be broken?

From a systems perspective, humans are the only actors in agroecosystems capable of self-conscious, intentional actions. Thus, the key to reversing environmental degradation is to change the action-reaction or stimulus-response patterns of humans. The fundamental nature of the

human species is not more changeable than are the fundamental laws of nature. However, the ability to learn, to discover new options, and to choose new responses are fundamental aspects of human nature. If the ultimate objective is intervention, the study of ecosystem health and sustainability must include the study of intentional human actions.

Knowledge related to the biophysical dimensions of ecosystems is useful only if people "choose" to use this knowledge to guide their actions. Biophysical constraints cannot "force" humans to the take actions necessary to sustain the natural environment. On the contrary, the humans species appears to be capable of continuing acts of environmental degradation to the point where ecosystems lose their ability to support human life. Past societies have demonstrated this destructive capacity at local, regional, and national levels. Current human society appears to be capable of such destructive behavior on a global scale. Thus, voluntary, self-conscious intervention is necessary to ameliorate destructive patterns of human behavior and to sustain the health of agroecosystems.

Economic Viability and Social Justice

In many situations the natural inclination of the individual may be toward actions that contribute also to the collective good of society. The "invisible hand" of classical economic theory is a prime example. Individuals, by pursuing their own self interest in a competitive open-market economy, unwittingly allocate economic resource among competing uses so as maximize economic efficiency for society as a whole.

In many cases, however, inherent conflicts exist between individual and collective or social benefits and costs. In such cases societies purposefully devise social and economic incentives, both positive and negative, for individuals to act in ways that benefit the larger society. Norms, values, and rules are social forces which help shape human behavior and are primary products of any human society. Social incentives for conformity range from moral suasion to criminal law enforcement. Public policy also is a means of providing non-market economic incentives, where necessary, for individual actions to conform to the desires of society. Public policies rely on a variety of subsidies, penalties, rules, and regulations which reward those whose actions contribute to the societal good and penalize those who cause societal harm.

Economic Viability

Economic viability is an objective that may be pursued by a variety of means, including but not limited to open markets and public policies. Economic viability is a characteristic of production systems that persistently create output of greater economic value than the economic value placed on inputs or resources devoted to the process. Human societies, by various means, place economic values on both the outputs produced and inputs used in production. Systems that use inputs and resources that humans value less to produce goods and services that humans value more are economically viable. Systems that use inputs and resources of greater human value to produce goods and services of lesser human value will not be economically viable.

Long run economic viability is not synonymous with short run profitability. Short run profits may be generated by exploiting natural or human resources that are undervalued, or not valued at

all, by market economies. However, such systems eventually will degrade or destroy their resource base and lose their ability to produce. Such systems are neither economic viable nor sustainable over time.

In the absence of violence, force, or the threat of force; economically viability ensures resource uses consistent with the economic values of society. Systems that produce greater economic value from any given set of resources, will be able to control resource use by competing use rights away from less productive alternative systems. However, in situations where resources are controlled by force, or the threat of force, the concept of economic viability is distorted. In such cases, resources may be used to benefit those in positions of power rather than to benefit the larger society.

Social Justice

Even in societies ruled by the will of the people, some systems that are otherwise economically viable may not be socially just. Economic power may be less concentrated than physical power but still is not equally distributed among all people. Economic power arises from an ability to produce something of economic value to society, something that others are willing and able to pay for or otherwise reward through exchange. In an ideal world, each person's ability to contribute to society would match their needs to receive from society. Patterns of resource use would accurately reflect both human needs and human abilities. In reality, however, great inequities may exist among people with respect to their ability to create economic value. Thus, inequities will exist among people in their economic power to control or influence resource use. Consequently, there are great disparities between the needs of individuals and their abilities to contribute economically. Such disparities exist both within and among families, communities, states, and nations. The resolution disparities between abilities and needs is an enigma which no human society has yet been able to resolve.

How should we balance the rights of those with "surplus" abilities against those with "unmet" needs so as to achieve greater social equity? One's concept of social justice inevitably reflects one's values regarding a just resolution of disparate abilities and needs. The issue of sustainability raises yet another issue of social equity. Sustainability implies equity in rights to resources among people over time and among generations. Sustainability requires that we use resources in such a way as to meet the needs of the current generation without impairing the ability of future generations to do the same.

Socioeconomic Necessities for Sustainability

It in understandable that physical scientists might question the wisdom of including social justice as a prerequisite for sustainability. Human capacity for intentional actions, individually and collectively, impose layers of complexity that are qualitatively different from those of naturally occurring "societies" that ecological methods can study. However, the self-conscious, intentional acts of "humans" and the differences in detail and dynamic complexities of "managed" ecosystems simply cannot be ignored in dealing with the issues of agroecosystem health or agricultural sustainability.

Crews, et al, contend that ecological soundness is both necessary and sufficient to ensure agricultural sustainability. They argue against giving equal weight to ecological, sociological, and economic dimension of sustainable agriculture. They state: "that the profitability of sustainable agricultural systems is constrained by the social structure of agriculture but that sustainability itself is constrained solely by the ecological conditions of agriculture" (page 146). They contend that if one accepts their ecological guidelines of sustainable agriculture, the resulting ecological constraints ultimately will interact with the social structure to determine what is profitable. They argue that "Profitability, on the other hand, will never determine what is ecological sustainable" (page 147).

However, one cannot derive an ecologically based set of sustainable alternatives and expect social and economic systems to adjust automatically to make them economically viable and socially just. Any definition of sustainability based on ecology alone begs the question of sustainability for whom, or at least how many? More directly, how many people are to be sustained at what level? For example, agricultural systems that were sustainable, when land currently in the United States was populated by a million or so Native Americans, clearly are not capable of sustaining today's population of some 260-plus million people.

Barring some dramatic occurrence in global society, agriculture worldwide will need to sustain about twice as many people fifty years from now as are sustained today. No set of ecologic possibilities will sustain the maximum population that humankind might choose to procreate. The history of human civilization provides little evidence to support an hypothesis that global population will automatically adjust to some optimally sustainable level. To the contrary, overpopulation seems more likely to result in the destruction and degradation of natural resources to a point only a fraction of the population can be sustained that might have been sustained if overpopulation had been avoided. No set of ecological constraints will prevent starving people from consuming the seeds that might have produced a bountiful harvest, if the harvest comes only after the people are dead.

Even when physical survival is ensured, people still tend to act in their own economic self interest. In fact, they cannot persist in actions inconsistent with economic survival, regardless of any personal desire to do so. Enterprises which lack economic viability will lose control of resource use to their economically viable competitors. However, there appears to be no natural limit to human greed or desire for control. Historically, individuals and nations with abundant resources or other economic means of production have amassed great fortunes while individuals and nations lacking the ability to compete economically hovered on the brink of starvation. This disparity in economic power is reflected in a disparity of control over total resource use and consumption of non-renewable resources.

Human societies that lack economic equity and social justice are inherently unstable, and thus, are not sustainable over time. Such systems will be characterized by reoccurring social conflicts which may do irreparable damage to both economic and ecologic systems. Deserts, drought, floods, and famine are more frequently the result of failed social and economic systems than of naturally occurring ecosystem phenomena. Today's "nature" is a human reconstructed nature, and tomorrow's nature will be reconstructed again by individual and collective human actions of today. A society that will not ensure social equity among those of the current generation cannot

be expected to ensure equity between the current generation and those of generations of the future.

Even thoughtful observers may become pessimistic about the possibility of global sustainability when they ponder the challenges to humanity in meeting the demands of an exploding global human population while utilizing a finite natural resource base of rapidly declining proven productivity. There would appear to be just cause for concern. But, many fail to explicitly consider the potentially positive aspects of humankind as an integral element of the global ecosystem.

Human population is not external to the global ecosystem and human need is not an exogenous demand that the system must meet. Human needs arise from and are interconnected within the same systems that must meet human needs. Human populations have expanded in response to the expanded capable of systems to support larger populations. Population expansion seems to be a biological instinct that humans share with many other species. However, the human species is capable, at least conceptually, of intentionally limiting its numbers, needs, and demands to match a sustainable level of global production. Unlike other species, humans are capable of the voluntary, intentional intervention required to reverse the conflicting trends of population explosion and resource degradation.

In general, the sustainability of managed ecosystems depends of self-conscious, purposeful human actions which reflect our abilities to learn from our mistakes, to delay gratification, and to persuade each other to work collectively for the common good. But, all these actions are consistent with the nature of our being human. Social and economic systems will not naturally evolve toward sustainability. But, knowledge-based, purposeful human actions may well be capable of ensuring sustainability. Such actions must reflect an equitable balance among environmental soundness, economic viability, and social justice. All are necessary and no one is sufficient to ensure the health of agroecosystems.

Socioeconomic Indicators of Ecosystem Health

Both socioeconomic and biophysical indicators are required to monitor health of agroecosystems. The emphasis on socioeconomic indicators here is not intended to diminish the importance of biophysical indicators which are equally important in sustaining the health of agroecosystems.

The socioeconomic indicators proposed below are based on the following set of postulates regarding the health of managed ecosystems.

- Inherent conflicts exist between maximum short run economic rewards of individuals and the long run ecologic well-being of society as a whole. Preservation, conservation, and protection of the natural, ecological resources needed to support future generations require that the current generation make collective economic sacrifices. Investments needed to support future productivity must be made at the expense of current consumption.

- Collective human actions can ensure the long run sustainability of managed ecosystems whereas individual actions cannot. The actions of each person, individually, has too little impact on regional, national, and global ecosystems to ensure overall ecosystem health or sustainability. Thus, individuals must persuade others to work collectively to sustain or enhance the health of agroecosystems.
- Sustainable collective actions must be based on voluntary decisions rather than decree, force, or coercion. Social systems that rely on physical threats or coercion to enforce dictatorial rules are socially unjust, inherently unstable, and thus, are not sustainable over time. Social stability and sustainability require that individuals possess an ability to significantly influence, if not control, their own destines.
- Voluntary, collective actions taken to ensure ecosystem health and sustainability will require human understanding of critical linkages within and among managed ecosystems, including the "detail complexities" arising from complex interrelationships among many different ecosystem elements and "dynamic complexities" arising from the temporal separation and circular nature of complex causes and effects.
- A set of basic human rights eventually must be developed and guaranteed for all to ensure that people will have the ability to take the necessary voluntary, collective actions needed to ensure global sustainability. Among those basic human rights are individual rights to life, thought, speech, and action, and collective rights to interact socially and to act collectively. Without such rights, humans will not be able to take the actions necessary for long run sustainability.
- A set of basic human responsibilities eventually must be developed to ensure that collective human actions are consistent the long run survival and health of the global ecosystem. Human responsibilities necessary for long run sustainability include ensuring economic opportunity and social equity among people who differ with respect to gender, ethnicity, economic class, social status, nationality, geography, and ensuring equity in balancing the needs of those in the current generation with needs of those of generations to come. If human society fails to accept these responsibilities, we will not be willing to take the collective actions necessary for long run sustainability.

On the basis of these postulates, a basic set of generic socioeconomic indicators of ecosystem health may be developed for managed ecosystems. Starting with the individual and moving to the global, socioeconomic indicators of ecosystem health might include the following:

- Individual Freedoms-- Including rights to life, thought, speech, and action.
- Human Health -- Including adequacy, availability, and safety of food and water, clothing and shelter, and remedial health care.
- Personal Security -- Including incidence of physical abuse, criminal activity, and violent crimes such as assault and murder.
- Self-Esteem -- Including whether individuals are valued, nurtured, and encouraged of achieve their full potential.
- Social Acceptance -- Characterized by the absence of discrimination, affirmative actions to correct inequities, and valuing of diversity.
- Economic Opportunity -- Characterized by universal education, freedom of entry into occupations, ease of entry into economic enterprises.

- Social Equity -- Characterize by effective families, strong communities, political freedom, valuing of diversity, and nurturing institutions.
- Resource Stewardship -- Supported by societal ethics, essential public policies, and effective public and private institutions.
- Environmental Protection -- Supported by societal ethics, essential public policies, and effective public and private institutions.

In many cases the generic criteria for managed ecosystems are sufficient to address concerns related specifically to the health of agroecosystems. However, some cases more specific criteria may prove useful. Some socioeconomic indicators of agroecosystem health derived from the generic list above include:

- Quantity, quality, and cost of food or fiber produced
- Risks of degrading water quality
- Risks to human health and worker safety
- Number of people productively employed
- Utilization of human abilities
- Rewards for human productivity
- Social dignity of the work
- Equity of opportunities with respect to gender, ethnicity, social status, etc.
- Opportunities for individual ownership -- scale negative or neutral
- Potential for strengthening families
- Potential for strengthening local communities
- Support of resource stewardship ethics or actions
- Support of environment stewardship ethics or actions

The above lists of criteria have not been validated by research nor are they intended to be inclusive. The lists simply illustrate that socioeconomic indicators are associated with farming methods, farming systems, rural communities, and higher levels of systems aggregation, and can be linked directly with the basic concepts of ecosystem heath and sustainability.

Some may question the wisdom of assessing agricultural sustainability for an individual field, farm, community, or nation when sustainability ultimately must be achieved for the total of society at the global level. One might logically conclude that production from a particular field is sustainable if the field is part of a sustainable whole-farm system, a farm is sustainable if it is part of a sustainable farming community, and a community is sustainable if it is part of a sustainable global society. If risks to sustainability arising at one level of aggregation can be countered at some higher level, the larger system will be sustainable. But, the parts of natural ecosystems are not separable. Thus, complete nullification of ecosystems system risks may not be possible.

The human body is a system. The basic function of some body organs, such as the liver and kidneys, is to handle wastes generated by other body functions. Other parts of the body, such as the heart and lungs, may adjust their activity to accommodate stresses placed on other parts of the body. Generation of waste is a normal function of living, and some level of stress is necessary for a healthy body. However, the body as a whole has definite limits to its ability to

assimilate wastes and absorb stress. When its critical limits are exceeded an organ or subsystem of the body begins to die. When a critical organ or part of the body dies, the whole body dies. The system ceases to function.

When agricultural production on a particular field is not autonomously sustainable, it places stress on the farming system as a whole. When a farm is not sustainable, it places stress on the community of which it is a part. A nation that is not sustainable places stress on global society. Some lack of autonomous sustainable should be considered necessary and normal in a healthy, interdependent society. However, the stresses the one element of society imposes on society as a whole should be monitored and measured in the same sense that stresses on the body need to be monitored and measured. In addition, it is no less important to measure the social and economic stresses an agriculture system places on society than to measure the physical and biological stresses that agriculture places on the natural ecosystem. Excessive social or economic stress are no less a threat than excessive biological or physical stress to the long run sustainability of an agroecosystem.

In summary, measures of ecosystem health developed for natural, unmanaged ecosystems are necessary but not sufficient for measuring the health of managed agroecosystems. Elements of agroecosystems of obvious human value will be protected and nurtured while elements considered detrimental, or of no value, to humans may be systematically destroyed. Ecosystem elements with both positive and negative human attributes will be managed so as to achieve the greatest social and economic good at the least social and economic cost. Such is the nature of being human. Sustainable agroecosystems must meet the current human needs of the current generation without degrading the ability of future generations to provide for their human needs as well. Thus, the ability to meet current social and economic needs is critical to the ecological health of managed ecosystems.

Voluntary, intentional human interventions will be required to ensure the ecologic sustainability of managed ecosystems. The human actions necessary to ensure agroecosystem health and sustainability will not be taken unless our managed ecosystems are socially just and economically viable, as well ecologically sound. Thus social, economic, and ecologic indicators, all three, are required to monitor the health of agroecosystems.

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