Performance Indicators for Sustainable Agriculture

(Discussion Note)

October 1998

Julian Dumanski,

Eugene Terry,

Derek Byerlee,

Christian Pieri

Rural Development Sector

The World Bank

Washington, D.C.

policies of the World Bank.

Performance Indicators for Sustainable Agriculture

(Discussion Note)

Julian Dumanski, Eugene Terry, Derek Byerlee, Christian Pieri

ABSTRACT

Agriculture continues to make major and important contributions to global GNP, but society is beginning to demand that agriculture becomes more than simply putting food on the table. Sustainable agriculture in the future will provide economic and social opportunities for the benefit of present and future generations, while maintaining and enhancing the quality of the environment and the natural resource base that supports production, and provides a basis for all terrestrial life on the planet.

Agricultural systems in transition recognizes that farming systems are and always have been changing. In fact, it is this capacity to respond (rapidly) and to capture market, technology, environmental, and other opportunities, that will ensure sustainable systems in the future. Static agricultural systems are not sustainable systems. Major factors that shape current agricultural change are shifts towards global markets, important advances in science and technology, and the emerging shift of emphasis from food security to reduction of rural poverty. The concept of sustainability as opportunity emphasizes that choices for future production systems are not compromised by decisions made today.

This paper reviews biophysical and economic approaches to assessing sustainable systems, and proposes a checklist, based on scientific principles and criteria, as a first step towards integrating these two approaches.

INTRODUCTION

Agriculture that is truly sustainable will not be business as usual. It will be a type of agriculture that will provide environmental, economic and social opportunities for the benefit of present and future generations, while maintaining and enhancing the quality of the resources that support agricultural production. This will not be the agriculture of to-day or of the recent past, with an emphasis on maximizing yields and economic returns, but rather one with the objectives of optimizing productivity and conserving the natural resource base. The objective of optimization implies trade-offs in the production systems to ensure maintenance of environmental quality and global, environmental, and life support systems. Experience indicates that these tradeoffs will be defined and implemented voluntarily by farmers and other rural land users, or they will be implemented through policies and legislation. Society is beginning to demand that agriculture become more than simply putting food on the table; it is beginning to demand that it also becomes the steward of rural landscapes.

The theme of the joint World Bank/Tri-Societies October 1998 workshop is “Sustainability in Agricultural Systems in Transition”. This theme is in recognition of the continued evolution of global agriculture in response to the major factors which act to shape this evolution, namely, strategic shifts towards a global market place, important recent advances in science and technology, and the recent change in emphasis from food security to reduction of rural poverty. This also recognizes that agriculture and the institutions and policies that support it have always been in a continual state of flux, although at different rates at different points in time. Although some people view continual change with suspicion, it is indeed the capacity of agricultural systems to respond to change, i.e. the capacity to remain flexible, that will ensure sustainable systems. Static agricultural systems, like the dinosaurs, are not sustainable systems. For certain types of production systems, this transition will lead to a search for new opportunities to intensify production, increase productivity and exploit emerging commodity markets. In other cases, negative market forces and adverse natural conditions beyond the control of producers will lead to transition out of agriculture and a search for off-farm employment.

This perpetual state of transition and evolution applies to all production systems from mono-culture production systems designed strictly to capture market opportunities to diversified systems employed by small-scale farmers to provide for household and market needs. For example, the largely mono-cropped wheat production systems in the northern Great Plains in North America are in transition due to a combination of bad weather, declining wheat prices, loss of soil quality, and a deadly fungus disease that has led to average losses in farm income of about $30,000 annually since 1994. The diversified system practiced by farmers in the Cauca Valley of southwestern Colombia, based on coffee, plantains, common beans, fruits, and livestock, is also in transition. These farmers have recently adopted intensive production systems and management practices designed to control erosion on their steeply sloping land, including live barriers of sugarcane, various forage grasses, as well as the use of chicken manure as fertilizer, and the elimination of pesticides (Russell, 1998, personal communication). Another example of production system in transition is in the Chipata District of Eastern Zambia where a group of largely women farmers have adopted a soil fertility improvement program on their maize farms by using local leguminous shrubs. Some of the immediate benefits include not only improvement of soil fertility and yields of hybrid maize of up to 4 tons/ha, but also extra fuel wood (Kwesiga, 1998, personal communication). Similarly, in transition is the system adopted by a large group of rice farmers in Indonesia who had experienced large crop losses, perhaps as much as a million tons annually, to the brown plant hopper. These farmers adopted techniques taught in Integrated Pest Management (IPM) Farmers' Field Schools, which enabled them to switch from a calendar-spraying schedule to an economic-based threshold for spraying. The results of this innovation have led to increases of 13% in crop yields, and a sharp reduction in the use of pesticides (Wallis 1997).

These examples illustrate that farming systems that are capable of responding to outside influences (stresses, such as market changes, transportation policies, climate change, etc), exhibit the best evidence of being sustainable. Also, these systems have one or more defining elements that relate to what are described as the five pillars of sustainable land management in agriculture, namely productivity enhancement, risk reduction, protection of natural resources, prevention of degradation of the environment, economic viability, and social acceptability (Smyth and Dumanski, 1993).

In sustainable agricultural systems, producers make management interventions that lead to sustained productivity increases without degrading the land resource on which production depends. The critical issue, however, is to decide which interventions give the best short-term benefits, but also are sustainable over the long term. An important additional dimension is how to design monitoring systems to track the impacts of these management interventions, and to assess whether these are contributing towards or away from sustainability.

Technological and economic performance indicators of sustainable agriculture will enhance our capabilities to make informed decisions about which management interventions are the most appropriate. This paper reviews performance indicators of physical and biological dimensions of sustainability, relating to productivity enhancement and protection of natural resources.

THE SUSTAINABILITY CONTINUUM

The concept of sustainability has considerable popular appeal, but it is a phrase without meaning unless indicators and monitoring systems are available to track the performance of agricultural production systems towards this ideal. The agricultural landscape is constituted through the individual management decisions of millions of often small scale entrepreneurs. Since similar land management decisions are made for somewhat similar conditions, this results in the repetitive landscape patterns commonly observed in agricultural areas.

The agricultural landscape traverses a very broad and varied range of characteristics and practices. Intensive agricultural production is often found in the "favored" areas, with high yield production under closely monitored management. Contemporaneously, there are areas with an inherently poor resource base susceptible to degradation, fragile soils with low resilience to disturbance, problems of salinization, soil compaction, serious soil erosion, and nutrient mining. Often, these areas also suffer from irregular supply of external inputs, unreliable water supply for irrigation, inappropriate land-use policies, soil and water pollution, and land use conflicts. Poor management decisions may lead to pesticide pollution, serious pest infestations, inadequate soil cover, poor soil structure, excessive loss of soil organic matter, intensive cropping, inadequate fertilization, and excessive soil erosion.

Achieving sustainability is often much easier in the high potential areas than those with multiple physical and biological constraints. In most cases, this is because the resource base is of higher potential and more resilient (more "room" for management errors), and also because agriculture services are better in these areas and they attract more investment and government attention. However, even these areas are not immune to practices which lead to unsustainable systems, such as inappropriate use of agro-chemicals, due to market distorting policies and incentives, inadequate land-use planning, and poor extension services. Although impacting directly on land quality, these conditions may also reflect the economic and social condition of producers, such as inadequate agricultural services and market development, lack of alternate rural employment opportunities, and pervasive rural poverty.

Whether the resource base is of high or low potential, inappropriate land and crop management ultimately results in a progressive degradation of the production base, continued poor performance of the rural economies and social systems, and perpetuation of the "poverty spiral" as described by Greenland, et. al, 1994, Fig. 1). If these conditions persist without management interventions to enhance the quality and production potential of the natural resource base, these system will become "unsustainable" at some point in time – however, areas with poorer soils will fail sooner.

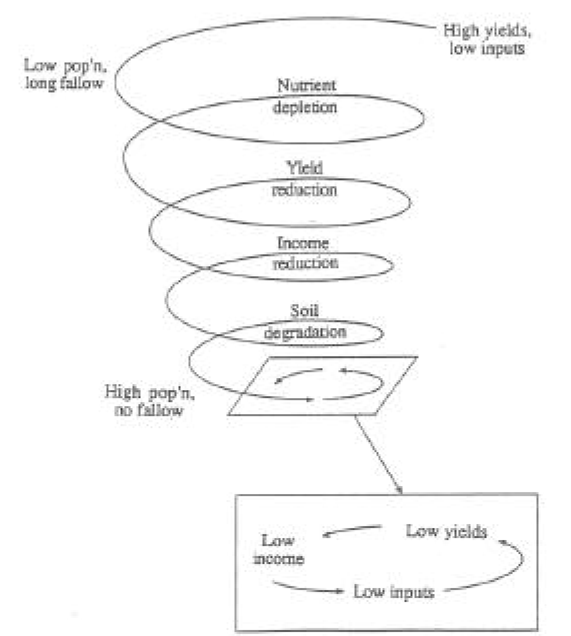


Figure 1 The downward spiral to the poverty trap (McCown and Jones, 1992).

The ultimate objective is to evolve sustainable systems in which appropriate technological and policy interventions have created resilient production systems that are well suited to local socio-economic and physical conditions, and that are supported by affordable and reliable policies and support services. However, these systems cannot be static systems, but must be carefully designed to be flexible and responsive to change, i.e. systems in transition. Sustainability of any systems cannot be assured unless the production technologies and associated management practices continuously evolve to accommodate changes in the agro-climatic, economic, and demographic environment in which agricultural intensification is being undertaken. The appropriate level of analysis of sustainability is at the level of cropping or farming system on a relatively homogeneous agro-ecological resource base, within which similar choices of crop and livestock management decisions can be made.

Although the debate on the definition and measurement of sustainability is in itself a long-standing continuum, there is some consensus that the major dimensions of sustainability, physical, biological, economic, and social must be integrated in some still undefined way to assess progress towards this goal. The physical and biological dimension relates to productivity enhancement and the maintenance or enhancement of the productive resource base. The economic and social dimensions relate to the long-term economic stability and viability of family farming and the rural communities in which they operate.

THE DIMENSIONS OF SUSTAINABILITY

A broadly acceptable definition of sustainable agriculture, from a biophysical perspective, has been proposed by the Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR):

"Sustainable agriculture involves the successful management of resources for agriculture to satisfy changing human needs, while maintaining or enhancing the quality of the environment and conserving natural resources" (Daniella Lucca, personal communication)

This is a practical approach to sustainability since it recognizes the legitimate use of natural and man-made resources for satisfaction of human needs, but it cautions against the exploitation of these resources in a manner which would degrade the quality and potential of the resources on which production depends. It also recognizes that human needs change and therefore the systems of production must also change.

We add to this by arguing that to best achieve these objectives, sustainable agricultural systems must always be in a position to respond and capture the opportunities provided by changing markets, technologies, global environmental conditions, and so on, and that the foundation for this flexibility and resilience is based on maintenance of natural resource and environmental quality. This leads to the concept of sustainability as opportunity[1], which can be identified as ensuring that the choices for future production systems are not reduced by decisions made in the present. Our view of sustainability is not based on overcoming constraints, but rather as a process to capture concomitant economic and environmental opportunities. This concept recognizes that considerable substitution is possible in agricultural systems (the physical, biological, economic and social dimensions of sustainability), but it also recognizes that this substitution is not perfect. For example, investment in new knowledge has allowed many traditional farming systems to become more sustainable in the face of rapid population growth, by shifting from extensification based on expanding land area, to intensified use of existing land area.

Although the conceptual definition of sustainability is clear, it is not easy to identify indicators and measures to operationalize the definition in practice. Natural science specialists have tended to focus on physical and biological indicators such as crop yields, and input indicators such as soil and water quality (e.g. SSSA,1995; Barnett, Payne and Steiner, 1995; Pieri, at al., 1995). However, there are serious limitations if these measures are used in isolation from the other dimensions of sustainability. Under experimental conditions, crop yields are a useful measure of sustainability, especially if long term experimental data with controlled inputs are available. Under farmers' conditions, however, crop yields are a useful measure of sustainability only if they are adjusted for changes in management practices (changing input levels).

[1] Sustainability as Opportunity was first proposed by Serageldin (1995) as a definition for sustainable development: Sustainability is to leave future generations as many, if not more, opportunities as we have had ourselves.

On the input side, trends in land quality, using indicators such as nutrient balance, land cover, and agro-biodiversity (Dumanski and Pieri, 1998), are useful indicators of resource degradation, but they do not provide definitive conclusions with respect to sustainability of a system. For example, it may be quite rational to deplete natural resources over time, since most agricultural production processes allow for a certain amount of input substitution, such as among different sources of crop nutrients, substitution of labor for land, and so forth. Such substitutions may contribute positively to sustainability as long as the impacts of the substitution are reversible, and they contribute to more resilient and flexible systems.

A continuing challenge is how to relate sustainability assessments using data from long term experimental plots to trends in farmers fields, and in turn relate these to system level sustainability. It is difficult to replicate farmers' practices in terms of inputs and cropping systems.

The appropriate time period of analysis presents a problems in assessing sustainability, since many years of data are required to establish a trend with some degree of confidence. The number of years required to estimate a statistically valid trend in a variable rainfall environment, may be as high as 30 years. This problem is compounded by the fact that in practice, many systems have undergone several stages of technological and perhaps even structural changes during this relatively short period. For example, in Asia, irrigated systems have experienced a Green Revolution that has propelled systems from very low external input use to high input use in a period of two decades, compared to several decades that was needed in industrialized countries to undertake this change. Since sustainability is likely to relate to the particular stage of technical change, it may be difficult to detect underlying trends before the system evolves into a new stage of change.

PERFORMANCE INDICATORS OF SUSTAINABILITY USING AN INTEGRATED BIOPHYSICAL PARADIGM

Any measure of physical and biological sustainability must combine measures of productivity enhancement, measures of natural resource protection, and measures of social acceptability. Thus we advocate some combination of the ideas of those who focus on indicators of resource quality and those who emphasize economic productivity measures. Such an integrated approach is being developed as a <u>Framework for Evaluation of Sustainable Land Management (FESLM).</u>

The FESLM was developed through collaboration among international and national institutions as a practical approach to assessing whether farming systems are trending towards or away from sustainability (Smyth and Dumanski, 1993). In this context, sustainable land management (SLM) is defined as:

"Sustainable land management combines technologies, policies and activities aimed at integrating socio-economic principles with environmental concerns so as to simultaneously:

- *maintain or enhance productivity/services;*
- *reduce the level of production risk;*
- *protect the potential of natural resources and prevent degradation of soil and water quality;*
- *be economically viable;*
- *be socially acceptable."*

These factors are referred to as the five pillars[2] of sustainable land management, and they can be applied for sustainable agriculture. Performance indicators for each pillar are used for assessing the contribution of that pillar to the general objectives of sustainable land management. Thus

[2] The pillars are carefully designed so that they can be aggregated into the physical, economic, and social factors of sustainability.

for any given agricultural development activity, sustainability can be predicted if the objectives of all five pillars are achieved simultaneously. However, as is the likely case in the majority of situations, only degrees of sustainability can be predicted if only some of the pillars are satisfied, and this results in partial or conditional sustainability. The recognition of partial sustainability, however, provides valuable direction on the interventions necessary to enhance sustainability.

This framework facilitates the use of performance indicators for each of these five pillars, but there is still the need to develop useful and cost-effective indicators to monitor long term changes in resource quality and input use efficiency, and devising procedures to integrate these into evaluations of sustainability. A core set of land quality indicators is available to describe the state of the biophysical resource (Dumanski and Pieri, 1998), but similar progress has not been made for the economic and social indicators. However, preliminary results from field research with farmers in developed as well as developing countries indicate the usefulness of the approach (see Boxes 1, 2).

Land Quality Indicators – the Biophysical Component of the FESLM

Indicators of land quality (LQI) are a key requirement for sustainable land management, and the World Bank is leading an international coalition to develop these indicators. The LQI program addresses the dual objectives of environmental monitoring and sector performance monitoring for managed ecosystems (agriculture, forestry, conservation, and environmental management). It is being developed for application at national and regional scales, but it is also part of a larger, global effort on improved natural resources management (Pieri, et al., 1995). The LQI program recommends addressing issues of land management by agroecological zones (Resource Management Domains). This approach favors incorporating farmer (local) knowledge into the overall process of improving agricultural and environmental land management.

Although a single indicator of land quality is not realistic, a very large number reflecting all possibilities is also not useful. To help resolve this problem, a panel of internationally acclaimed scientists and administrators recommended a core set of <u>strategic land quality indicators</u> as described below.

Core LQIs[3] being developed for immediate application:

- *Nutrient balance*. Describes nutrient stocks and flows as related to different land management systems used by farmers in specific AEZs and specific countries.
- *Yield gap*. Describes current yields, yield trends, and actual : potential farm-level yields in cereal equivalents.
- *Land use intensity*. Describes the impacts of agricultural intensification on land quality. Intensification may involve increased cropping, more value-added production, and increased amounts and frequency of inputs; i.e. management practices adopted by farmers in the transition to intensification.
- *Land use diversity (agrodiversity)*. Describes the extent of diversification of production systems over the landscape, including livestock and agroforestry systems; reflects the degree of flexibility (and resilience) of regional farming systems and their capacity to absorb shocks and respond to opportunities.

[3] Currently, indicator guidelines are available only for nutrient balance and yield gap; the other indicators are in various stages of development.

Box 1. Indicators Used in Sustainability Assessments in three Systems of Land Management from the Saskatchewan Prairie Region.

Farmers use a variety of strategies to make their systems more sustainable. Case studies of 24 farmers in Saskatchewan representing three levels of farming intensity were undertaken to identify the priority indicators they use to monitor the performance of their systems. Questionnaire responses and in-depth interviews were used. These are summarised below according to the pillars of sustainable land management.

This shows that while some indicators may be common to two or more of the systems, they may be interpreted by farmers in differing contexts, e.g. yield response under high input, yield trends under moderate input, and variety performance under organic systems. Also, the choice of indicators for each pillar indicates that farmers are making choices (substitutions) on management practices within the context of their regional constraints and their management preferences.

FESLM Pillars	Indicators by Farming System		
	High Input	Moderate Input	Organic
Productivity	-soil fertility trends -crop yield response -availability of labour	-yield trends -adoption of new technologies & techniques -crop variety availability & performance	-length of rotation -weed management -crop variety availability & performance
Security	-economic status -yield trends -weather trends	-time required in mastering new techniques -catastrophic weather/ weather trends	-resource potential of land -soil moisture at seeding -weather trends
Protection	-degradation risk -extent of crop cover	-degradation trends -length of rotation -extent of fallow	-degradation trends -crop yield trends
Viability	-cash flow/revenues -presence of livestock -management objectives	-cash flow/revenues -government programs -management objectives	-organic market demands -extent of value added -availability of labour
Acceptability	-personal & family health -viability of farming	-availability of services -off-farm impacts	-public awareness of organic farming -viability of farming -age level of community

Box 2. Examples of Sustainability Assessments from South East Asia

Case studies of 53 farms in Indonesia, Thailand and Vietnam were undertaken to assess the sustainability of different land use systems currently practiced on sloping lands, using the Framework for Evaluating Sustainable Land Management (FESLM). Detailed socioeconomic and biophysical surveys characterized the land management systems, outlined their constraints and potentials, and identified indicators and thresholds of sustainability in line with the five pillars of sustainability of the FESLM.

A suite of SLM indicators, with associated thresholds, were identified. Feedback on the indicators was obtained from the farmers after they were used to evaluate their farming systems. The indicators make a useful first step towards development of a more generic system for evaluating sustainability of agricultural systems.

Priority Indicators[4] of Sustainability Identified From Farmer Surveys

Productivity		
Yield	<village mean by 0-25% <village mean by >25%	Average over 10 years
Plant growth	Vigorous Normal Stunted	
Risk Management and Security		
Drought frequency	>2yrs. Continuous 2 yrs. in 7 <2yrs. in 7	
Income from livestock	>25% of total income 10-25% of total income <10% of total income	Usually require 20-30%
Conservation and Protection		
Total soil eroded	>4.5 cm, rills on >50% 0.7-4.5 cm, rills 25-50% <0.7 cm, rills on <25%	Amount observed over last 10 years
Cropping intensity and extent of protection	2-3 crops with conservation 2-3 crops, no conservation 1 crop with conservation 1 crop, no conservation	
Economic Viability		
Net farm income	Rising Constant	Total family income

[4] Indicators identified by farmer cooperators from survey information; threshold values were also identified where appropriate (last column). Information summarized from IBSRAM research.

	Declining Fluctuating	
Off-farm income	>25% of total income 10-25% of total income <10% of total income	Usually require at least 10%
Availability of farm labor	2 full-time adults 1-2 full-time adults 1 full-time adults	Labor per farm unit
Size of land holding	<1 ha 1-2 ha >2 ha	1.2 - 2 ha per family holding
Social Acceptability		
Land tenure	Full ownership Long term user rights No official land title	
Training in soil conservation	Once in 3 yrs. Once in 5 yrs. None available	Focus on younger farmers

- *Land cover*. Describes the extent, duration, and timing of vegetative cover on the land during major erosive periods of the year. Land cover is a surrogate for erosion, and along with land use intensity and diversity, it offers increased understanding on issues of desertification.

Core LQIs still in the research stage:

- *Soil quality*. Describes the conditions that make the soil a living body, i.e. soil health. The indicators will be based on soil organic matter, particularly the dynamic (microbiological) carbon pool most affected by environmental conditions and land use change.
- *Land degradation* (erosion, salinization, compaction, organic matter loss). These processes have been much researched and have a strong scientific base, but reliable data on extent and impacts are often lacking.
- *Agrobiodiversity*. This concept involves managing the gene pools utilized in crop and animal production, but also soil micro and meso biodiversity important for soil health. On a macro scale, it involves integrated landscape management including maintenance of natural habitat, as well as managing the coexistence of wildlife in agricultural areas.

Core LQIs being developed by other sectors:

- Water quality
- Forest land quality
- Rangeland quality
- Land contamination/pollution.

This list of strategic indicators are the biophysical components of sustainable land management. Although useful in their own right, they must still be complemented with indicators of the other pillars of sustainable land management: economic viability, system resilience, and social equity and acceptability. Considerable additional work is required to develop these pillars to the same level of detail as the land quality (biophysical) indicators.

Procedures to Assess Sustainability using the FESLM

The application of the FESLM approach is based on using participatory approaches in field data collection. This implies making the farmer a true partner in the research team, using structured interviews to capture local farmer knowledge, but supplementing this knowledge with field data collection as necessary. The procedure requires that the farmer is involved in all stages of sustainability evaluation, including identifying the criteria and indicators to be used in the evaluation, and most importantly in the final rating for the sustainability of the system. The data base thus derived for the sustainability evaluation is often a hybrid of quantitative and qualitative information, and requires mixed techniques for analyses.

In all cases the objective is to establish a representative rating of the degree to which the objective of each pillar of sustainable land management is being attained, then expressing the results in a sustainability classification or schematic. The rating for each pillar is obtained using quantitative and qualitative procedures, sometimes gained through consensus, but always involving the farmer in the final judgement. These procedures are recommended since it is usually the farmer who best knows his/her local situation, and is best able to judge whether or not certain management interventions are cost effective.

Preparing the data for analyses

Each indicator for each pillar is analyzed separately in light of its contribution to the objectives of sustainable land management. All members of the research team, including the farmer, agree on the evaluation criteria by which to judge the performance of the indictor, and participate in the rating exercise. Often the procedure used is to scale the indicator(s) (e.g. from 0 to 10), and then apply these in some form of sustainability classification, as described below. A large number of indicators may require that individual indicators be combined in some meaningful way prior to establishing the rating.

Examples of Sustainability Classifications

1. Aggregate Indicator Ratings: the performance of each indicator for each pillar is assessed in view of its limitations to sustainable land management. Numbers are assigned from lowest to highest, then accumulated using additive or multiplicative procedures. Results are expressed in a sustainability classification.

2. Conditional Sustainability: It is common that the sustainability analyses will show that some but not all requirements for the sustainability pillars are met. For example:

- In sloping areas in country "X", a new land management technique may be better able to control soil erosion, while maintaining crop production levels, improving water quality, and so on, but profitability is marginal because of unexpected costs in the start up phase. In these cases, the systems are judged as conditionally sustainable, pending resolution of the residual problem of start up.
- In some situations, the analyses may show that the system is sustainable, but this is dependent on a particular market niche. In this case, the system would also be conditionally sustainable, because maintenance of the special market is likely to be beyond the control of the farmer.
- In other cases, the analyses may indicate that sustainability may currently be adequate, but future sustainability is uncertain. In these instances, a temporal conditionality can be used.

3. Index of Sustainability – Sustainability Polygons: This assessment is constructed by first arranging the indicators around a central focus like the spokes of a wheel. The performance of each indicator is then rated (as described earlier), and this value is positioned on the respective spoke. All

values are then connected to form a sustainability polygon (Fig. 2).

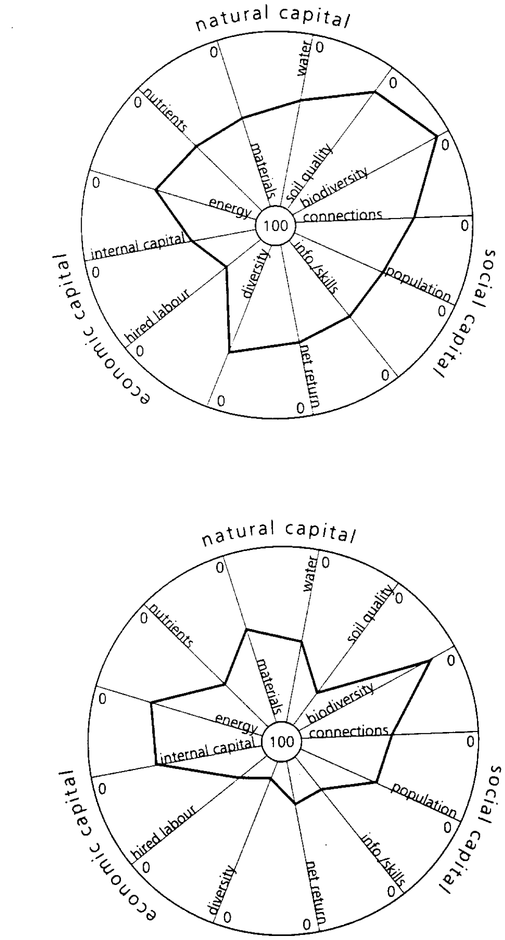


Figure 2

The asymmetry of each polygon indicates the extent to which each farming system lacks sustainability, and also the kinds of management interventions necessary to improve the performance of the system. By comparing the polygons from several systems, lessons from one location can be transferred to another. Also, reconstructing the polygons after several years of intervention indicates whether progress is being made toward or away from sustainability.

PERFORMANCE INDICATORS OF BIO-PHYSICAL SUSTAINABILITY BASED ON PRODUCTIVITY

By definition, sustainable systems must be able to at least maintain existing productivity levels. In developing countries that face rapid population growth, continued rapid increases in productivity are required to meet future food, fiber, and income needs. One measure of productivity, Total Factor Productivity (TFP), has been developed by economists as a single measure of the physical and biological sustainability of an agricultural system. TFP is an index that relates changes in all outputs to changes in all inputs. As proposed by Lynam and Herdt (1989), a non-negative trend in TFP over the period of interest implies sustainability.

TFP has been measured largely at the national and state level, and at such aggregate levels, even if it exhibits positive trends, these measurements are unlikely to identify lower level systems that are unsustainable. Indeed we would argue that sustainability can only be defined at the farming system level (Smyth and Dumanski, 1993).

TFP as conventionally measured by economists, does not take account of environmental externalities which are important in defining bio-physical sustainability. For example, sedimentation of water courses, destruction of wildlife habitat, deterioration and pollution of water courses, are externalities that often originate from agricultural activities, and although not impacting directly on farming systems in the local areas, they generate additional costs for society that society increasingly will no longer tolerate. These externalities can be as important as farmland quality and on-farm economic viability in assessing sustainability.

Accordingly, the TFP measure was modified to include non-market inputs and outputs in order to account for changes in resource quality or other environmental externalities, and this was termed Total Social Factor Productivity (TSFP). It was argued that a sustainable system should exhibit a non-negative trend in TSFP, and that this should be achieved within acceptable limits of agro-ecosystem health (Herdt and Lynam, 1992).

While the concepts of TSFP are used fairly widely among economists, this still poses formidable problems in empirical application, due mostly to problems of measuring and valuing non-market inputs and outputs such as resource degradation and environmental pollution. In practice, there are few quantitative data at the farming system level on resource quality and environmental pollution, and even less information on trends over time. For these reasons, there are few attempts to apply the TSFP concept other than for experimental plots (Ehui and Spencer 1993, Whitaker, 19??), including long term experiments (Steiner, 199?). Some studies at the farming system level have used TFP as a useful indicator of lack of sustainability, especially in the intensive cereal-based systems of Asia (Cassman and Pingali 1995).

While TFP is an appropriate indicator of productivity (which is one of the pillars of biophysical sustainability (FESLM)), the interpretation of trends in TFP requires information on indicators of resource quality. Work is now beginning to integrate indicators of productivity with indicators of resource quality at the level of specific farming systems. Box 3 provides an example from Pakistan that identifies specific systems with definite problems of sustainability.

A CHECK LIST FOR ASSESSING SUSTAINABILITY

Realizing the two prevailing schools on assessing sustainability, the question is can they be somehow better integrated. This is a practical rather than academic question, since decisions on investments are being made all the time, and society cannot wait until the ultimate procedure is defined. For these reasons, we advocate a progressive, step-wise approach to the problem, learning as we go, and building on successes achieved along the way.

The checklist for assessing sustainability options, described below, is a first step towards this objective. The check list can be used for preliminary assessments of management interventions likely to affect sustainability. The approach is based on a series of carefully structured questions based on extensive experience gained from numerous field studies and local farmer interviews in developing and developed countries. The checklist relates to national policies, stakeholder participation in decision making, and the integration of environmental and economic objectives. Guiding principles and criteria that were earlier identified for agricultural development projects (Dumanski, 1997), are used in this paper to develop this checklist.

The basic paradigm in sustainable agricultural systems is that principles and criteria are transferable, but technologies are local. This is a considerable departure from the classical, top-down model of research and technology transfer, and it demands a new role for extension agents. In sustainable agriculture there are no single solutions or magic bullets; in fact the magic bullet approach must be consciously avoided[5].

Sustainability will remain an area of research and debate in the foreseeable future. However, experience gained from developing the FESLM indicates the importance of technological interventions that are carefully tailored to the production and marketing environments of local areas, i.e. blanket recommendations and “magic bullets” are rarely successful, and innovations found to be successful in one area will likely have to be modified somewhat to be successful in another. On the other hand, the basic principles underlying successful technologies are often more universal and therefore transferable to other regions.

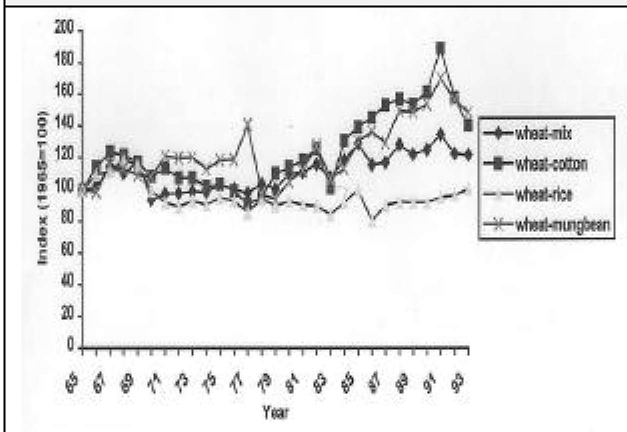
For example, zero-till is a successful technology contributing to sustainable land management, but some local modifications of the technology are almost always required for it to be successful. However, the basic principles of zero-till, i.e., minimal disturbance of the soil surface and maintenance of continual soil cover, are universal and therefore transferable.

[5] For the extension agent, this means he/she must work more actively in a participatory approach with farmers, and develop an enabling atmosphere for local farmer innovation as to what will work and what is not acceptable. However, providing technological backstopping to the store of local farmer knowledge is often a critical component.

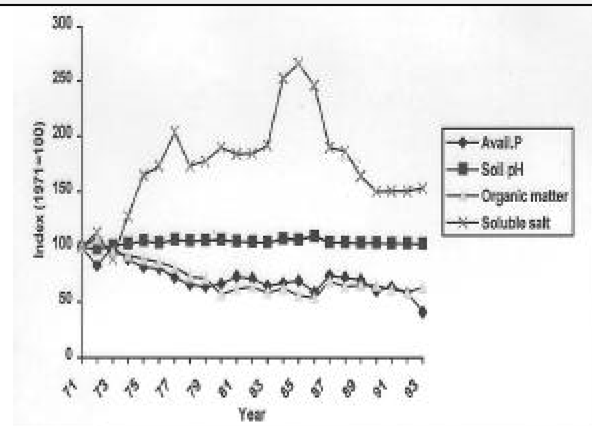
Box 3. Examples of Assessing Sustainability from the Indo-Gangetic Plain

The sustainability of intensively cropped, irrigated cereal systems in Asia is being questioned. These systems experienced rapid productivity growth in the Green Revolution but yield trends have slowed in recent years, and there are worrying signs of serious resource degradation. This example illustrates how TFP and indicators of resource quality can be combined to assess sustainability in the case of Pakistan's Punjab.

Data on 28 crop and livestock products and 16 input categories were assembled for 30 years beginning in 1966 for each district. These data were used to construct measures of TFP for each of four dominant production systems defined on the basis of the major winter and summer crops in each district—wheat-rice, wheat-mixed, wheat-cotton, and wheat-mungbean. The trend in TFP was found to vary significantly by system and stage of technological change. Importantly, the trend in TFP was negative for the wheat-rice system for two of the three periods, suggesting underlying problems of sustainability. Data from soil and water tests carried out in farmers' fields for the same period pointed to steady resource degradation with decreasing levels of organic carbon and soil phosphorus, and increasing salinity and residual sodium carbonate in tubewell water. These results confirmed that resource degradation was present in all four systems, but currently only the wheat-rice system showed convincing evidence of unsustainability.



TPF by Production System



Trends in Soil Quality

A preliminary version of the checklist, and associated principles and criteria, are illustrated below:

1. Do national policies adversely affect the flexibility of local farmers to chose options they consider best for their production systems?

Sustainability can be achieved only through the collective efforts of those immediately responsible for managing resources. This requires a policy environment that empowers local decision makers, including farmers, to reap benefits for good land use decisions and be held responsible for inappropriate land uses. Although the concerns for sustainability are global, the required actions must be local and national.

2. Are responsibilities for sustainable land and crop management being shared by all segments of society?

Although farmers and land managers directly affect how natural resources are managed, sustainable land and crop management is the responsibility of all segments of society. Governments must ensure that their policies and programs do not create negative environmental impacts, society needs to define requirements for land maintenance and develop a "social" discount rate for future land use options, and farmers and land managers must expand their knowledge of sustainable technologies and implement improved procedures of land stewardship.

3. Are environmental and economic objectives fully integrated?

Integration of environmental and economic interests in a comprehensive manner is necessary to achieve the objectives of sustainable land and crop management. This requires that environmental concerns be given equal importance to economic performance in evaluating the impacts of technological innovations, and that reliable indicators of environmental performance and land quality be developed.

Sustainable land and crop management, if properly designed and implemented, will ensure that agriculture becomes a part of the environmental solution, rather than being considered part of the problem. Arguing for the continued maintenance of agriculture without reference to environmental sustainability is increasingly difficult.

4. Are off-site costs and benefits adequately addressed?

Environmental problems do not recognise political or land ownership boundaries, or geopolitical spheres of influence. Land degradation affects yields obtained by the farmer, but the higher impacts are often off-site, e.g., degradation of water quality, loss of habitat, and loss of biodiversity. Further, the collective impacts of land use decisions by the millions of farmers world wide can impact on global biogeochemical cycles and ultimately on global life support systems.

5. Are the technological options congruent (suitable) for the local soil and climate conditions?

Good land management in balance with accepted ecological and economic principles is more likely to ensure sustainability. Sustainable agriculture must work within the bounds of nature not against them. This means matching land uses to the constraints of local environments, planning for production not to exceed biological potentials, and carefully limiting fertiliser, pesticides, and other inputs to ensure that they do not exceed the capacity of the environment to absorb and filter any excess.

Agricultural production technologies must be more carefully tailored to local environmental conditions than has been the case in the past. Farming systems have to be more flexible and more diversified, and developed on a broader genetic base. There has to be higher efficiency of (high-cost) inputs, and more emphasis on value-added marketing. Environmental maintenance, including habitat preservation, will have to receive more attention.

6. Will the technological innovations ensure improved economic return for the farmer? the region?

Agricultural intensification is often necessary to achieve more sustainable systems. This requires shifts to crops with higher yields or value, more inputs per unit of production, or higher standards of management (more knowledge intensive). This generally results in higher output per farmer (and consequently fewer farmers per unit area), but also more job opportunities in the agricultural service sectors.

7. Are there opportunities for off-farm work in the region?

Agribusiness has to be instrumental in the transition to more sustainable systems by providing increasingly more reliable advisory systems, absorbing excess rural labour, and providing increased opportunities for improved national and international trade. The importance of opportunities for off-farm income, to reduce pressures on land, supplement cash flow on the farm, and generate an investment environment for improved land management should not be underestimated.

8. Are political and institutional structures in place to support the evolution towards sustainable land and crop management?

Technological and scientific advances are instrumental in the transition to sustainable agriculture, but political, economic and institutional structures also have to be part of the solution. This will require some major changes in economic methods to ensure more complete accounting for the use and misuse of natural resources, and to put higher value on environmental maintenance. The bias on economic efficiency as the primary criterion for management decisions will have to be tempered by criteria to assess and monitor national resource quality. The importance given to land and the limitations in supply of fresh water as primary factors of production must be re-established, given that for the first time in history we will have run out of good land for agricultural expansion at the same time that demands for increased global production are increasing.

9. Are objectives of donor agencies in harmony with national policy objectives of developing countries?

This is necessary to achieve orderliness in the policy environments of developing countries, and in the lending objectives of donors. There is urgent need to resolve the global challenge to produce more food to feed rapidly rising global populations, while at the same time preserving the global biological production potential and the global environmental maintenance systems.

CONCLUSIONS

Agricultural sustainability is a concept that is continuously evolving, and therefore it is difficult to define and to measure. In that it reflects our understanding of systems that in themselves are in continual transition, sustainability should be approached as a concept to strive for, like social well being, rather than an objective that can be measured with common analytical techniques. In this sense, being able to track the performance of core indicators towards this goal is more useful than setting specific targets to be achieved (although setting targets is often useful to identify levels of satisfaction). This is not unlike tracking the performance of national economies, where in most cases this is done simply to know how we are doing, and in what direction the economies are trending.

Although progress is being made in developing approaches to monitor agricultural sustainability, considerable additional work remains to better identify the strategic, core indicators to be used, and recommended procedures of integration. At this time, recommended core biophysical indicators are available (LQIs), but a comparable set of economic and social indicators still needs to be defined.

A more serious concern, however, is the lack of a coordinated data base at sub-regional, national and global levels, on which to track performance towards sustainable agricultural systems. For example, data already exist (national agricultural census, special survey data, etc.) for tracking activities such as commodity production, marketing trends, economic performance, and so on, because the information infrastructure for these activities was created in the past and it is being maintained. Unfortunately, this has yet to be achieved for tracking sustainability in agriculture. Currently, much related data are available, and considerable anecdotal and other information on sustainability trends can be obtained, but in the final analyses, these sources have proven to be only partially useful.

A checklist, based on known principles and criteria for sustainable agriculture, is proposed as an initial step towards development of a more comprehensive approach. Farmers, policy makers and others make decisions on technological investments and land management all the time, and cannot wait for the final, ultimate solution. The checklist is being developed as a practical and cost effective approach to provide guidance and enable reasonable decisions, based on scientific principles.

REFERENCES

Barnett, V., R.Payne and R.Steiner (Eds.), 1995. Agricultural sustainability in economic, environmental, and statistical terms. John Wiley and Sons, Ltd., London.

Cassman, K.G. and P.L.Pingali, 1995. Extraploating trends from long-term experiments to farmer's fields: The case of irrigated rice systems in Asia. In V.Barnett, R.Payne, and R.Steiner (Eds.), Agricultural sustainability in economic, environmental, and statistical terms. John Wiley and Sons, Ltd., London.

Dumanski, J. 1997. Planning for sustainability in agricultural development projects. GTZ. Agriculture + rural development 1/97: 15-18.

Dumanski, J. and C.Pieri, 1998. Land quality indicators (LQI) program: Research plan. Land Quality Indicators – Satellite Symposium. 16th World Congress of Soil Science, Montpellier, France (unpublished).

Ehui, S.K. and D.S.C.Spencer, 1993. Measuring the sustainability and economic viability of tropical farming systems: A model from Sub-Saharan Africa. Agr. Econ. 9: 279-296.

Greenland, D.J., G.Bowen, H.Eswaran, R.Rhodes, C.Valentin. 1994. Soil, water, and nutrient management research – A new agenda. IBSRAM Position Paper. IBSRAM, Bangkok.

Herdt, R.W. and J.K.Lyman, 1992. Sustainable development and the changing needs of international agricultural research. In D.R.Lee, S.Kearl, and N.Uphoff (Eds.) Assessing the importance of international agricultural research for sustainable development. Cornell University, Ithaca.

Lyman, J.K. and R.W.Herdt, 1989. Sense and sustainability: Sustainability as an objective in international agricultural research. Agr. Econ. 3:381-398.

Pieri, C., J. Dumanski, A.S. Hamblin, and A. Young. 1995. Land quality indicators. World Bank Discussion Paper No. 315. World Bank, Washington, D.C.

Serageldin, I., 1995.Sustainability and the wealth of nations: First steps in an ongoing journey. Third Annual World Bank Conference on Environmentally Sustainable Development. World Bank, Washington, D.C.

Smyth, A.J. and J. Dumanski. 1993. FESLM. an international framework for evaluating sustainable land management. World Soil Resources Report No. 73. FAO, Rome.

SSSA (Soil Science Society of America) 1995. SSSA statement on soil quality. Agronomy news. June. 1995. SSSA, 677 S. Segoe Rd., Madison, WI 53711, USA

Steiner…..

Wallis, J.A.N. 1997. Intensified systems of farming in the tropics and subtropics. World Bank Discussion Paper No. 364. World Bank, Washington, D.C.

Whitacker….

World Bank User

\\StreetTalk\USER DISK@ESSD@WORLDBANK\JPAIEMEN\jason\dumanski_final.doc

10/07/98 2:55 PM