This paper was not peer-reviewed.
Pages 523-528. In: D.E. Stott, R.H. Mohtar and G.C. Steinhardt (eds). 2001. Sustaining the Global Farm. Selected papers from the 10th International Soil Conservation Organization Meeting held May 24-29, 1999 at Purdue University and the USDA-ARS National Soil Erosion Research Laboratory.

Keynote: Monitoring Progress Towards Sustainable Land Management

Julian Dumanski and Christian Pieri

INTRODUCTION

In the years since the 1992 Rio accords, economic growth of $2.4 trillion and population growth of about 400 million have placed continuing pressures on the earth's natural resources and ecosystems. Tropical forest cover, wetlands and other natural habitats have declined by 3.5%, as much as 10 million hectares of land are being lost annually to severe degradation, carbon emissions have increased by 4% while natural carbon sinks in soils and forests have been degraded or lost.

Global populations are now of such magnitude that for the first time in history how we manage the land impacts on global life support systems, such as global nutrient cycling, atmospheric warming, and the global hydrologic cycle. Already, about one-third to one half of the non-glaciated land surface is moderately to intensively managed, and about 70% of the total land surface is under some form of human intervention (Vitousek 1994), and estimates are that by early in the next century, all land will be under some degree of management. As a society, we have never been at this point, and we are unsure how best to proceed.

WHAT IS THE CHALLENGE? WHY AND WHAT DO WE NEED TO MONITOR?

The purpose of monitoring is to evaluate changes in value, functions (performance) or benefits. In the case of land resources, this requires monitoring changes in the quality of land, how these changes impact on the benefits society gains from land, and whether these changes are positive or negative, i.e. are they leading us towards or away from sustainability. For agricultural and related biologically based systems, therefore, it is not adequate to monitor land quality, without concurrently monitoring how changes in land quality affect agricultural and related and ecosystem sustainability. However, we cannot afford to monitor everything, and therefore focused indicators are required, as well as cost effective procedures for monitoring.

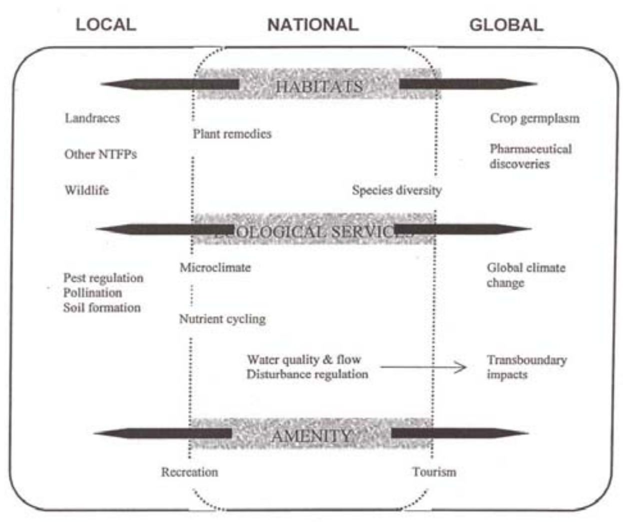
The immediate challenge for agriculture is how to increase food production, while maintaining and enhancing the quality of natural resources on which production depends. Historic gains in agriculture have often been achieved by expanding land area and exploiting the quality of land resources. Consequently, agriculture has been a major contributor to environmental degradation. However, under improved systems of land management, agriculture could be a major contributor to the environmental solution.

Land management decisions by individual farmers have implications for many environmental goods and services[1], such as on *habitats* for fauna and flora, on different kinds of *ecological services,* and on *amenity* or aesthetic values. The impacts may arise directly on land managed for agriculture and livestock, or indirectly as a consequence of fragmentation and degradation of natural (less managed) habitats such as forests and wetlands. For practical purposes, these impacts are often described as having consequences at three main spatial levels (Fig. 1). All three spatial levels are important, and therefore monitoring at all levels is necessary. However, what is monitored and the indicators and procedures used differ with the scales chosen.

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).

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

Figure 1: Environmental Benefits of Sustainable Land Management: Local, National and Global Layers



[1]These are often referred to as biodiversity goods and services. The stock of natural resources from which these goods and services flow is also, referred to as 'natural capital'. An important principle is that land that is managed sustainably constitutes a form of natural capital from which a variety of key services may be derived in the long term.

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.

Performance indicators of sustainable agriculture will enhance our capabilities to make informed decisions about which management interventions are the most appropriate. Proxy indicators from available information are often developed, because of our inability to measure land quality directly. This paper reviews performance indicators of physical and biological dimensions of sustainability, relating to global, national and local level monitoring and assessment.

Indicators for Global Programs for Monitoring Natural Resources Management

The World Bank is in the process of developing core indicators to monitor the evolution and growth of the rural sector in developing countries. The criteria are identified in the four development objectives of the Rural Development Strategy, "Vision to Action" (World Bank, 1997), namely i) poverty reduction; ii) widely shared growth; iii) household, national, and global food security; and iv) sustainable natural resource management. Indicators reflecting growth and development are developed for each category; land quality is approximated in the context of sustainable natural resources management in this program.

Sustainable Natural Resource Management is defined as: Increased sustainability of natural resources requires improved efficiency in the use of resources used for production, maintenance or improvement of land, water, and air quality, and maintenance and conservation of important natural resources. The outputs and recommended indicators are:

Output 1 Increased efficiency in the use of natural resources.
<u>Indicators:</u> freshwater withdrawal / GDP
agricultural value added / ha
Output 2: Ensure conservation of important natural resources.
<u>Indicators:</u>
annual freshwater withdrawals (% total resources)
cropland / potentially (non-marginal) arable land
annual crop production / baseline productivity
deforestation (% annual change 1990-95)
% biologically significant habitat protected.

These indicators are based on data available from national accounts in most cases.

Indicators for National and Sub-National Monitoring of Land Quality

Any measure of physical and biological sustainability must combine measures of productivity enhancement, measures of natural resource protection, and measures of social acceptability. Thus, it is essential to integrate concepts from those who focus on indicators of resource quality and those who emphasize economic productivity measures. Such an integrated approach is being developed as a Framework for Evaluation of Sustainable Land Management (FESLM).

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 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 (Durnanski 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.

<u>Land Quality Indicators</u> -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

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

of a larger, global effort on improved natural resources management (Pieri, et al., 1995). The LQI program recommends addressing issues of land management by agro-ecological 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 set of core land quality indicators 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: base line productivity (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 production systems over the landscape, including livestock and agroforestry systems; reflects the degree of flexibility (and resilience) of regional systems and their capacity to absorb shocks and respond to opportunities.
- *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 understanding on issues of desertification.

Core LQls 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 Iandscape management including maintenance of natural habitat, as well as in the coexistence of wildlife in agricultural areas.

Core LQls being developed by other sectors:

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

These indicators are the most important of 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.

Indicators for Farm Level Monitoring of Land-Quality and Sustainability

Farmers use a variety of strategies to make their systems more sustainable and the importance of their experimentation and innovation is being increasingly recognized. Farmers continuously monitor how their systems are performing, but in particular, they monitor the quality of their land resources. Much useful information can be obtained by working with farmers, and carefully identifying and refining the indicators they consider the most useful.

The following discussion draws from two major studies from contrasting ecosystems and production enterprises, to explore if there are any similarities in the approaches and indicators used by farmers to monitor their performance towards or away from sustainability. A group of 24 farmers from Central Saskatchewan (Semi-arid Temperate) representing three degrees of fanning intensity is East Asia (Humid contrasted with a group of 53 small-scale producers from South Tropical). The latter are primarily field crop and mixed enterprise farmers on sloping and often highly erodible lands. In both cases, only farmers who were judged to be highly innovative and performing above the regional average were selected for the studies. Results are summarized below.

Examples of Sustainability Assessments from the Saskatchewan Prairie Region (Semi and Temperate)

Case studies of 24 farmers in Saskatchewan representing three levels of fanning intensity were undertaken to identify the priority indicators they use to monitor the performance of their systems (Acton, et al., 1999). Questionnaire responses and in-depth interviews were used. The indicators were refined over the course of two years using field days and group discussions in an iterative manner. Results are summarized in Table I according to the pillars of the FESLM.

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.

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

Table 1. Indicators used by farmers in Saskatchewan to monitor sustainability. Considerable additional work is required to develop these pillars to the same level of detail as the land quality (biophysical) indicators.

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

Examples of Sustainability Assessments from South East Asia (Humid Tropical)

Case studies of 53 farms in Indonesia, Thailand, and Vietnam were undertaken to assess the sustainability of different land use systems currently being practiced on sloping lands by farmers in the region (Lefroy, et al., 1999). Detailed socioeconomic and biophysical surveys were used to characterize the land management systems, identify their constraints and potentials, and identify indicators and thresholds of sustainability in line with the five pillars of sustainability of the FESLM. Feedback on the indicators was obtained from the farmers over several iterations using field days and group discussions.

A variety of indicators were identified, along with associated thresholds (danger points) of failure. These include indicators to monitor crop vigor, yields, extent of soil erosion, availability of resources, susceptibility to risk, and security of investment. Although these are small and often considered to be resource poor farmers, they demonstrated a high degree of sophistication and knowledge on optimizing the opportunities available to them in their region. The farmers were found to be continually experimenting and innovating to make their enterprises more sustainable.

Although the two studies come from contrasting ecosystems and totally contrasting production systems, one of the major findings is that there are more similarities than differences in the indicators identified from the two groups of farmers. This may be because in both cases only the most innovative and best performers in the region were studied. These farmers are normally highly knowledgeable in (local) conditions, they commonly follow a highly flexible and responsive management style, and they continually innovate to make their systems more sustainable. Basic, however, is that both groups carefully monitor the quality of their land, and they take action to ensure land quality first before making other investments. Although the indicators used are mostly are qualitative and observational, these can be converted to semi-quantitative and quantitative measures by comparing with available experimental data.

CONCLUSIONS

The need for agricultural growth strategies that can achieve the required growth and food security over the next two to three decades, whilst reversing the historical conflict with natural resources conservation, is now a front line issue for global sustainable development. It is widely recognized that agriculture and environmental management are inseparably linked and that tackling problems of natural resource degradation must be seen as part of a wider set of actions to revitalize the rural sector as a whole. Promoting rural development strategies that have "win-win" outcomes for agricultural livelihoods and the environment is mainstream policy for the World Bank and other major development agencies, and is considered vital to provide a sustainable basis for future productivity growth and poverty alleviation.

The Bank's Rural Vision to Action (World Bank 1997) and related policies establish sustainable land management at the heart of such strategies. It is increasingly recognized that well designed, farmer-centered, sustainable land management interventions have distinct advantages as vehicles for pursuit of joint agriculture-environment objectives. The concepts and criteria of sustainable land management are the application of agro-ecological principles to fanning; an emphasis on human resource development and knowledge based management techniques; a participatory and decentralized approach; the value placed of natural and social capital enhancements in addition to economic efficiency gains, and the role of strong and self reliant rural institutions.

The primary agents of change towards sustainable agricultural systems are the rural communities who depend on the land for their livelihoods, and the primary emphasis is on community-based or ‘fanner-centered’ interventions. Rural families make decisions about production practices

Table 2. Indicators used by farmers in S.E. Asia to monitor sustainability.

PRODUCTIVITY		
Yield	Comparison w/ village mean (>25%)	>25% average over 10 years
Plant growth	Normal, vigorous, stunted	Monitored continuously
RISK MANAGEMENT AND SECURITY		
Drought frequency	Number of years, continuity	GT or LT 2 years continuous
Income from livestock	% of total income	Usually require 20 – 30%
CONSERVATION AND PROTECTION		
Total soil eroded	Frequency and depth of rills	Amount observed over last 10 years
Cropping intensity and extent of crop cover	Frequency of crops/yr, with and without soil conservation	
ECONOMIC VIABILITY		
Net farm income	Trends, fluctuations	Total family income
Off-farm income	Contribution to total income	Usually require at least 10%
Availability of farm labor	Labor per farm unit	1-2 full-time adults
Size of land holding	Ha. per farm unit	1.2 – 2 ha. per family unit
SOIL ACCEPTABILITY		
Land tenure	Ownership and long term user rights	
Training in soil conservation	Focus on younger farmers	At least once in 5 years

and land use in line with their objectives, production possibilities and constraints, but these decisions are part of a wider process to secure and improve the family's food security and livelihood. They are strongly influenced by government policies and market forces, and it is important that these do not interfere with the farmer's options to make the best decisions.

Monitoring land quality requires that we develop better understanding on how changes in land management by farmers and others impact on the services and benefits attained from land, and whether this is leading us towards or away from sustainability. This is a complex procedure, requiring indicators and monitoring activities at global, national and local levels. The indicators and procedures at each scale are not identical, but they link together through the common objectives to measure the impacts of human interventions on the landscape, and our common search to achieve sustainable systems. Although there is increasing need for such indicators, and some progress is being made, the process remains frustratingly slow. The main obstacle is our inability to effectively link the biophysical components of land management with the economic, social and policy components of sustainability. This requires not only the indicators to be used, but also cost-effective monitoring and evaluation systems at local, national, and international levels. Much of the required data and monitoring infrastructure already exist through national census and special surveys, and these are the foundations for future progress. However, the science community must become more proactive, better focused, and more willing to enter into partnerships with the social sciences to achieve and implement the final architecture for the system.

Interest in land quality is higher now than at any time in the past, due to the needs to increase food production, but also the importance of land quality to ecosystem functions and global life support systems. Concurrently, there are increasing opportunities to mobilize monitoring and evaluation activities under the international conventions, particularly the Convention to Combat Desertification, The Convention on Biodiversity, the Framework Convention on Climate Change, the various agreements on International Waters, and the increased interest from the OECD to develop comprehensive agri-environmental indicators. Although these conventions do not always provide extra funding, they are useful instruments under which to better coordinate activities.

Sustainability will not be achieved by overcoming constraints, which has been the approach of the past, but rather as a process to concomitantly capture economic and environmental opportunities. The leads to the concept of "Sustainability as Opportunity"[4], which is a new and evolving concept being promoted by the World Bank.

This can be defined as: "ensuring that the choices for future production systems are not reduced by decisions *made in the present"*. This recognizes that considerable substitution is possible in agricultural and other biologically based systems (the physical, biological, economic and social dimensions of sustainability), but the substitution is not perfect. For example, most agricultural production systems 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

[4]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.

they contribute to more resilient and flexible systems. The 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.

REFERENCES

Acton, D.F. et al., 1999. Report on Farm Studies and Analysis. Canada - Saskatchewan Green Plan Agreement. University of Saskatchewan, Saskatoon, Sk., Canada

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

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).

Lefroy, R.D.B., H-D Bechstedt, M. Rais. 1998. Indicators for sustainable land management based on fanner surveys in Viet Nam, Indonesia, and Thailand. Land Quality Indicators - Satellite Symposium. 16th World Congress of Soil Science, Montpellier, France (unpublished).

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, Wl 53711, USA

Vitousek, P.M. (1994) "Beyond Global Warming: ecology and global change". Ecology 75: 1861-76.

World Bank (1997) "Rural Development: From Vision to Action: A Sector Strategy". Environmentally Sustainable Development Studies and Monographs Series, no 12, World Bank. Washington D.C.