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Land Quality Indicators

Christian Pieri
Julian Dumanski
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FOREWORD

The UNCED conference in 1992, and Agenda 21 which ensued from this conference, identified the importance of widely accepted indicators by which to monitor the status of the environment. Subsequently, the World Bank initiated a publication series "Monitoring Environmental Progress (MEP)" which provides a regular updating of work on the development of such indicators, within the Bank and elsewhere. Recently, work has started to develop Land Quality Indicators (LQIs) to monitor changes which impact on the sustainability of land resources in managed ecosystems. In this context, land refers not just to soil, but to the combined resources of soil, water, vegetation and terrain that provide the basis for land use. The timing for this activity is urgent, since most of the arable land is already in use, and under increasing stress from improper management. At the same time, policy and management decisions on these lands are being made with only a weak and uncoordinated base of information.

The LQI initiative is similar in concept to previous programs, sponsored and coordinated by international agencies, on economic and social performance and state-of-the-environment reporting. Such programs have resulted in the standard economic, social, and environmental indicators used routinely for monitoring national economic performance, and air and water quality. Something similar is being planned for monitoring and reporting on land quality using LQIs.

This Discussion Paper co-published by the World Bank, FAO, UNDP and UNEP explains the LQI program, the accomplishments to date, and the relationships between LQIs and Environmentally Sustainable Development. Much has already been achieved, but an even larger task lies ahead to test and promote the use of such indicators. A broad coalition of international and national agencies, including members of the CGIAR, will be needed to make this initiative a success. On behalf of the four sponsoring Agencies, I invite others to join this initiative, and contribute their knowledge and experience to this collective effort. It is hoped that the Discussion Paper will provide a solid foundation for the next phase of work.

Alex F. McCalla
Director
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ABSTRACT

Maintenance of the productive potential of land resources, and checking of land degradation, is a fundamental element of sustainable land use. For this to be achieved, there is a fundamental need for indicators of land quality, the condition or 'health' of land. Land quality indicators are similar to the economic and social indicators already in use. It is only by means of indicators that changes in land quality can be monitored and policy or management action taken. A global coalition of international and national institutions, led by the World Bank, FAO, UNEP and UNDP, are developing a system of land quality indicators for this purpose, concentrating in the first instance on productive agro-ecosystems.

A conceptual framework for land quality indicators is set out. The pressure-state-response framework, previously developed as a basis for environmental indicators of pollution, provides a means by which land quality can be related to policy and management. Land quality indicators are therefore of three kinds: indicators of pressure upon land resources, of changes in the state of land quality, and of responses by society to these changes. Indicators can be assessed within the context of major land issues; these comprise inappropriate land use systems, land degradation, and inadequacies in the policy environment for land users.

Land quality indicators can be applied at different scales: farm, local, district, national and international. The present effort is focused upon indicators for application at district (project) and national/international scales. Indicators have particular applications first, in development projects, both sectoral and in the area of natural resources management; secondly, with respect to the effects of national policies on land quality; and thirdly, for determination of policy priorities at international level.

Two groups of examples of land quality indicators are given. The first is based on results from two regional workshops, aimed at identifying key land issues and appropriate indicators for some major agro-ecological zones of the tropics and subtropics. The second group sets out pressure, state and response indicators applicable to major problems of land degradation.

Sources of data and information of indicators are reviewed. There is considerable scope for making use of existing data sources, appropriately combined and standardized as indicators. There are also substantial data gaps, notably in the areas of monitoring soil changes and the effects of land management practices. In addition to databases, use can be made of modelling, and of the local knowledge of farmers.

A programme of work is outlined for the development of cost-effective ways of obtaining internationally-agreed sets of land quality indicators. Pilot studies in major agro-ecological zones will form an important element. Because of the urgency of the situation, initial activities will be based on making best use of existing methods and sources of data. This will show where gaps in knowledge exist, and work can then progress towards the collection of new information.

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ACRONYMS

AEZ	Agro-ecological zone
BESD	(World) Bank Economic and Social Database
CGIAR	Consultative Group for International Agricultural Research
CIESIN	Consortium for International Earth Science Information Network
ECOSOC	Economic and Social Committee (of the UN)
EPIC	Erosion Productivity Impact Calculator
FAO	Food and Agriculture Organization of the United Nations
GEMS	Global Environment Monitoring System (of UNEP)
GLASOD	Global Assessment of Soil Degradation
GNP	Gross national product
GRID	Global Resource Information Database (of UNEP)
GTOS	Global Terrestrial Observation Sites
HDI	Human development index
IBSRAM	International Board for Soil Research and Management
ICRAF	International Centre for Research in Agroforestry
ICRISAT	International Crops Research Institute for the Semi Arid Tropics
IGBP	International Geosphere-Biosphere Programme
IIASA	International Institute for Applied Systems Analysis
ISRIC	International Soil Resources and Information Centre
ISSS	International Society of Soil Science
ITC	International Institute for Aerospace Survey and Earth Sciences
LABEX	Laboratory Exchange Programme (of ISRIC)
LQI	Land quality indicator
NDVI	Normalized difference vegetation index
OECD	Organization for Economic Cooperation and Development
PSR	Pressure-state-response framework
SCOPE	Scientific Committee on Problems of the Environment
SOTER	(World) Soils and Terrain Database
TSBF	Tropical Soil Biology and Fertility Programme
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Organization
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFPA	United Nations Fund for Population Activities
WMO	World Meteorological Organization
WOCAT	World Overview of Conservation Approaches and Technologies

CHAPTER 1. THE NEED FOR LAND QUALITY INDICATORS

Concern with land resources

The condition and management of land resources has become an increasing matter of concern in recent years, because of the pressure placed upon soil, water and plant resources by expanding populations and economic development. Whilst there is still scope for expansion of productive land in some areas, the majority of the developing world is faced with the need to increase production from land already in use. This requires maintenance of the productive potential of these resources, as a fundamental element in sustainable land use.

Concern about land resources has been widely expressed. A World Soil Charter, giving guidelines for the sustainable and productive use of soils, has been in existence for some years (FAO, 1982b; UNEP, 1983). Since 1992, the countries which are signatories to the Agenda 21 agreement of the United Nations Conference on Environment and Development (UNCED) have agreed to monitor and report on the status of their land. Effort is being directed at achieving a systematic, integrated approach to the sustainable management of land resources (ECOSOC, 1995; Sombroek and Sims, 1995). Stewardship of environmental resources plays a leading part in current World Bank efforts at achieving sustainable development (World Bank, 1994b).

Land refers not just to soil but to the combined resources of terrain, water, soil and vegetation that provide the basis for land use. **Land quality** refers to the condition or 'health' of land, and specifically to its capacity for sustainable land use and environmental management. Land quality must be assessed with respect to specific types of land use. In this paper, it is considered primarily with regard to managed ecosystems, for agricultural and forestry production.

Pressures upon land quality can lead to various forms of land degradation, such as in soil erosion, soil fertility decline, adverse changes in water resources, salinization of irrigated areas, or decline in the biological condition of forests or rangelands. The cost of rehabilitating degraded areas has been estimated as 10-50 times higher than that of measures to prevent degradation (World Bank, 1992). Similarly in the maintenance of soil fertility, it is more cost-effective to intervene early, before symptoms of extreme degradation appear (Pieri, 1993). Hence it is important to establish indicators for measuring changes in land quality, to provide early warning of adverse trends and identification of problem areas.

The need for indicators

In the area of economic and social data, indicators are already in regular use. Gross national product per capita is an indicator of total wealth, and the Gini coefficient of its distribution. Life expectancy, infant mortality and percentage literacy are employed as indicators of social conditions.

The compilation, *Social indicators of development* (World Bank, 1995d) gives, by country, some 80 indicators of social development, poverty, education, etc..

In contrast, few such indicators have been developed to assess, monitor and evaluate changes in the quality of land resources at national or district levels. Indicators are not merely descriptive. Their purpose is to guide policy changes and management decisions. Indicators are needed, for example, to monitor the effects of agricultural policies on soil fertility, including responses to fertilizer inputs. In regions where forest clearance, forest degradation and shortage of wood products are important land issues, indicators are needed to monitor changes in the condition of these resources over time, and to assess the effects on them of policy changes and management measures.

The World Bank, UNDP, FAO, UNEP and other international and national institutions in many parts of the world are developing the concept and application of **land quality indicators**. The central objective of these efforts is to measure changes in the quality or condition of land, and so promote land management practices that ensure productive and sustainable use of natural resources. Indicators provide a means to monitor the performance of agricultural, forestry and natural resource management projects, at regional, district and community levels,[1] and to measure the impact of national policies on the environment (Adriaanse, 1993; Hammond et al., 1995; O'Connor, 1995).

Without land quality indicators, there is no proper foundation for policy formation and decision making on matters affecting land resources at all scales and levels. At national and international scales, indicators can help to indicate priorities for policy development and budgetary allocation by governments and international organizations. At regional and district scales they can be applied to project planning, monitoring and management.

The pressure-state-response framework

In the past, the results from surveys of natural resources, such as soil survey and forest inventory, have too often been insufficiently put to use in policy and management decisions, whether at national level or on development projects (Dalal-Clayton and Dent, 1993). In order to avoid the same problem, land quality indicators need to be placed within a policy and management context relevant to the needs of human society.

The **pressure-state-response** (PSR) framework has been developed for this purpose (Adriaanse, 1993; Winograd, 1994; Hammond et al., 1995; SCOPE, 1995). Land quality indicators measure pressures upon land resources, the effects of such pressures upon the state of land quality, and the

[1] Reference to "project" level activitives should be interpreted to mean "district" level activities. this reflects that monitoring and reporting on agreed indicators becomes an integral part of government programmes at district level.

response of society to these changes. Examples of indicators of pressure are demand for groundwater in excess of the rate of recharge, wood harvest in excess of the rate of regrowth, or cultivation of sloping land without soil conservation. State indicators describe the resulting changes in land quality. These changes are frequently adverse, such as lowering of the water table, forest degradation or soil erosion, but also include improvements to land conditions as a result of successful management. Response indicators monitor the actions taken by society at all levels, ranging from farmers to national policy makers. They include both desirable responses, such as increase in water use efficiency or adoption of soil conservation practices, or negative responses such as land abandonment. The PSR indicators can also be used to assist decision-makers (at any level) to formulate options for future responses.

A focus on managed ecosystems

Indicators are intended for the purposes of monitoring and evaluating land quality with respect to its potential for production and environmental management. In the initial stages, it is intended to focus upon the application of indicators to rural production systems, including production of crops, livestock and forestry products. The aspects of environmental management considered will be those which are relevant to managed agro-ecosystems, e.g. nutrient cycling. This decision has been taken on practical grounds, in recognition that other institutions are developing indicators with respect to conservation and biodiversity functions of land (Reid et al., 1993). Continuing contacts with such institutions are necessary to ensure compatibility of concepts and methods, and to arrive at agreed trade-offs between the interests of agricultural production and conservation. It is recognized that land also has functions for urban use, including settlement, recreation, industrial use and transportation; these must be taken into account in integrated land resources planning for rural and urban uses.

Hence the main concern is the source, or resource, aspects of the environment, which are of the greatest importance to those developing countries with high dependence on agriculture and forestry. This is in contrast to the sink or pollution issues, concerned with the capacity of land to absorb waste products, which are of greatest concern to developed and newly-industrializing countries. However, certain pollution issues are relevant, such as sedimentation brought about by accelerated soil erosion, or pollution of groundwater through unwise use of fertilizers. In addition, the recent development of indicators to monitor pollution has supplied a conceptual basis for the current development of land quality indicators (Adriaanse, 1993; Hammond et al., 1995; O'Connor, 1995; OECD, 1993).

The danger of land degradation is most apparent in areas of marginal or fragile land, such as the semi-arid climatic zone, steeplands, or soils with severe fertility constraints. However, it is by no means only such areas which require monitoring of land quality. There is evidence, for example, of the build-up of soil problems on highly fertile lands of the Indo-Gangetic plains. Because of the need to depend on intensification, it is from the more fertile land areas, including irrigated land, that the greatest increases in production must come. Hence the work on land quality indicators is intended for application in all types of productive rural land.

Applications of land quality indicators

Land quality indicators are not simply descriptive variables, used to monitor changes. They are intended to guide policy and decision making. These applications are reviewed in Chapter 3, but a few examples are given here to show the requirements for practical purposes.

At farm and community levels, indicators are an important element in local knowledge, employed to guide decisions on land management. Pastoralists, for example, are skilled at judging the condition of rangeland, and farmers use indicator plants to show areas of fertile or degraded soil. There is scope for inclusion of such knowledge within a participatory approach to development.

In the management of development projects, indicators are needed to show responses to measures taken, and to provide early warning of possible adverse effects. They help to provide information on food security risk, have direct applications in projects directed at soil conservation or forest resource management, and are a basis for evaluation of long-term sustainability. This applies not only to natural resource management projects but to sectoral projects, most of which include an element of environmental conservation. Recent World Bank projects frequently contain such objectives as, "improve soil and water conservation, arrest ongoing degradation of natural resources, improve water resources management, increase agricultural production whilst preserving the natural resource base, check loss of forest resources", often quoted within the context of improving food security and reducing rural poverty. Indicators are also now required as part of portfolio management, to improve the performance of the portfolio of projects for each country.

At national level, indicators provide a means to monitor the effects of policy changes upon land resources. They can be included within national environmental action plans (NEAPs). Where it is wished to make valuations of natural resources in economic terms (the 'greening of national accounts') (Schramm and Warford, 1989; Lutz, 1993), land quality indicators provide an essential quantitative basis.

At the international level, comparisons between indicators aggregated to country level provide a means for comparison of agricultural and environmental potential and changes, as a basis for priorities in development effort. These are needed to provide a sound environmental basis similar to that available for economic and social trends (e.g. World Bank, 1995d).

Above all, indicators serve purposes of communication, between scientists, managers and policy makers, and between specialists in different disciplines.

Objectives

The objectives of this Discussion Paper are:

1. To place on record the progress that has been achieved to date, in development of the conceptual framework, examples of land quality indicators, available data sources, and potential applications.

2. To indicate the further research and development requirements needed to achieve an operational system of land quality indicators.

3. To communicate these activities as widely as possible to institutions and individuals, both those with interests in the development of indicators and those with opportunities to apply them, in order to obtain comments and suggestions.

Chapter 2 outlines the concepts underlying land quality indicators, including definitions of the terms employed. Chapter 3 is a review of some potential applications, with reference to the different scales at which indicators can be applied. Chapter 4 is in two parts. Part 4A gives results from regional workshops, in which land issues and indicators were identified for selected agro-ecological zones. Part 4B is an outline of pressure, state and response indicators, grouped according to major issues of land degradation. Chapter 5 discusses the data needs for the development of indicators, including an initial review of available sources. Chapter 6 summarizes the progress so far made and the steps which are proposed for further development.

CHAPTER 2. THE CONCEPTUAL FRAMEWORK

Introduction

A conceptual framework is necessary to provide a rigorous scientific basis for the development of land quality indicators. In particular, it is necessary to be clear about the meanings of terms employed. This chapter sets out such a framework and associated definitions. Formal definitions are given in text boxes, whilst the accompanying text expands these and gives examples of their application.

There are two main sources for the terminology, FAO studies of land resources, and OECD work on environmental indicators. FAO work on land evaluation, land degradation and land use has extended over more than 20 years. Work on environmental indicators is more recent. It has been directed mainly at indicators of pollution (sink) aspects, but is applicable with modifications in the present context.

The framework described here is the outcome of a series of background papers, two regional workshops and one international workshop, at which participants at these were very largely in agreement (World Bank, 1995a, 1995b). Whilst, therefore, the present framework should not be regarded as definitive, it is hoped that to a large degree it will form the basis for future work.

Land and land quality indicators

The established definition of the term land, as employed in procedures of land evaluation and land use planning for more than 20 years, is retained (FAO, 1976, 1993a; ECOSOC, 1995; Sombroek and Sims, 1995). **Land** refers to all elements of the earth's terrestrial surface that affect potential land use and environmental management. Thus land refers not only to soil but also to landforms, climate, hydrology (surface and groundwater), vegetation (forests and rangelands) and fauna. It also includes land improvements, that is, reasonably permanent alterations to land which improve its capacity for land use, such as terraces and drainage works.

Land quality refers to the state or condition of land, including its soil, water and biological properties, relative to human needs. It relates to the condition and capacity of land for purposes of production, conservation and environmental management. Land quality needs to be assessed with respect to specific functions and types of land use.[2]

[2] See note on the definition of land quality, p.14.

Definitions related to land quality indicators

Land An area of the earth's surface, including all elements of the physical and biological environment that influence land use. Land refers not only to soil but also to landforms, climate, hydrology, vegetation and fauna, together with land improvements such as terraces and drainage works (FAO, 1976, 1993; ECOSOC, 1995; Sombroek and Sims, 1995).

Land quality The condition of land relative to the requirements of land use, including agricultural production, forestry, conservation and environmental management.

Land quality indicators (LQIs) Measures that describe land quality and human actions which relate to it. Indicators convey the most significant information in summary form. On the basis of the pressure-state-response framework, indicators can be broadly grouped into:

- **Pressure indicators** Indicators of pressures exerted upon land resources by human activities.
- **State indicators** Indicators of the state of land resources, and specifically of changes in state over time.
- **Response indicators** Indicators of the response by society to pressures on, and changes in the state of, land quality.

State indicators can be subdivided into:

- **Descriptive indicators** Indicators which provide information, in absolute terms, on land quality state of change in state.
- **Performance indicators** Indicators which relate descriptive indicators to predetermined standards or target values.

The present discussion is restricted to land quality with respect to agricultural production, used in its broad sense to include both crop and livestock production, together with range management and forestry. Attention is directed at those aspects of environmental management and conservation which are applicable to managed ecosystems. These include, in particular, maintenance of the natural resource base to provide options for future productive use, a major criterion of sustainability. Other relevant aspects of environmental management include deliberate intervention to improve the recycling of nutrients, filtering of pollutants, transmission and purification of water, source/sink functions for greenhouse gases, and conservation of plant, animal and genetic resources, including biodiversity.

The word indicator is used in its normal sense to mean a number or other descriptor that is representative of a set of conditions, and which conveys information about a change or trend in these conditions. An example is the use of body temperature as an indicator of human health or disease. Visual symptoms can be indicators, such as the yellowing of green leaves of crops as an indicator of disease or deficiency, and such qualitative indicators can be useful for practical management decisions. Indicators can also represent in summarized form the total effect of many variables, as in the use of crop yield as an indicator of soil fertility. Indicators can be derived from qualitative and quantitative measurement, but become standardized and comparable only when transformed into numerical form.

Indicators are not simply data; they are intended to convey the most significant information in summary form, and to act as a means of communication. Thus indicators have the following purposes (Adriaanse, 1993; Hammond et al., 1995):

- selection of the most significant information;
- simplification of complex phenomena;
- quantification of information, so that its significance is more readily apparent;
- communication of information, particularly between data collectors and data users.

Land quality indicators (LQIs) are measures, or values derived from variables, that provide estimates of the condition of land relative to human needs, changes in this condition, and human actions which are linked to this condition. They are the equivalent with respect to land resources of indicators of economic and social conditions, such as gross national product or human life expectancy.

Changes in land quality need to be placed within the context of policy and management. A basis for this was earlier developed in Canada and modified by the OECD for purposes of monitoring environmental pollution (Adriaanse, 1993). The **pressure-state-response (PSR) framework** (Figure 1) represents the linkage between pressures exerted on land quality by human activities; the resulting state of land quality, including changes in state over time; and the response by society to these pressures and changes.

Whilst highlighting these links, the pressure-state-response framework may appear to suggest linear relationships between human activities and environment. This should not be allowed to obscure from view the more complex interactions which take place in agricultural ecosystems between the economy and the environment. When applied to agriculture, its inherent bias towards pressures does not sufficiently recognize the potential for agriculture also to have beneficial effects on land resources (OECD, 1994). The advantage of the framework is that it places land quality squarely within the context of practical policies and decisions.

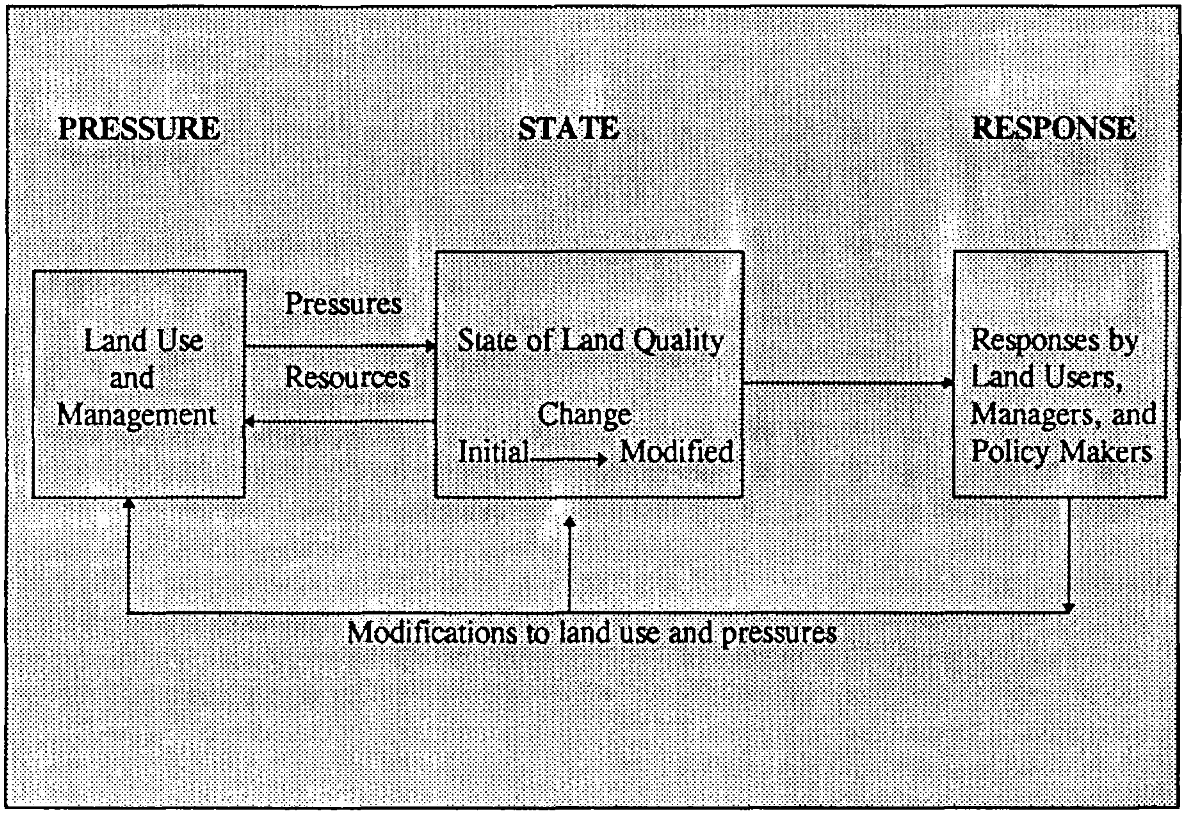


Figure 2.1. The pressure-state-response framework. Modified from Adriaanse (1993).

Land quality indicators may be categorized according to the pressure-state-response framework, and may therefore be grouped into:

1. **Pressure indicators** Indicators of pressure upon land resources, resulting from human activities.
2. **State indicators** Indicators of the state of land resources, including changes in state over time.
3. **Response indicators** Indicators of the response by society to pressures on land quality, and changes in its state.

Pressure indicators do not cover all aspects of land use. They describe those aspects which, if action is not taken, will have adverse affects on land quality. Shortage of land for food production, brought about by increase in population on a limited base of land resources, is a widespread basic cause. Examples of more specific indicators of pressure are destructive forest clearance for agriculture, the extension of cultivation onto steeply-sloping land, or dry-season fodder shortages on rangeland.

State indicators may take the form of a description of present state, e.g. forest area or average soil reaction. Very often they are expressed as change of state over time, such as forest clearance or soil acidification. Such changes can be expressed in terms of type of change, degree of change, its spatial extent, and rate of change (Oldeman et al., 1990). State indicators can also be indirect, as in the widespread use of crop yield as an indicator of soil fertility.

Response indicators show the actions taken by society, which includes managers, decision makers and policy makers at all levels: farmers and other land users, communities, district agricultural services, project managers, politicians, and international agencies. For example, in response to soil erosion, farmers may or may not adopt soil conservation measures, either spontaneously or with assistance at project level. The manager of a project for increased use of fertilizers, on learning (from a state indicator) that soil acidification is occurring, can respond by changes in types of fertilizer made available, or by encouragement of accompanying measures for biological soil improvement.

Response is not necessarily desirable; the final response to irreversible land degradation is abandonment of land or economically-enforced migration. Even deliberate policy responses may have undesirable effects. Thus in the case of overgrazing of semi-arid pastoral lands, government schemes for adding more watering points can lead to severe overgrazing and trampling, contrary to their intention.

The distinction between indicators of pressure, state and response is not always clear-cut. For example, where there is incipient salinization of soils, farmers reduce cultivation of salt-sensitive crops and increase those which are salt-tolerant. This is a response, but where crop statistics are good but soil monitoring absent, it could also be used as an indicator of change in soil properties.

Because the relationship between people and land is dynamic there are forward and backward interactions between pressure and response indicators. Both of these serve to place the central group of indicators, those of the state of land quality and impacts upon it, within the appropriate environmental and socioeconomic context. This helps in the interpretation and prediction of trends, and provides guidance on early action to avoid undesirable consequences. Thus, the pressure-state-response framework provides a continuous feedback mechanism that is conducive to the monitoring of change.

A warning is necessary on the interpretation of land quality indicators for decision making. To rely on only one indicator, or a small number, can be quite misleading. Decisions should be made by considering jointly the three sets of indicators, of pressure, state and response. For example, to look only at population density and soil degradation, without looking at the response of land users and the socioeconomic context may lead to erroneous decisions.

Land issues

Land issues are the major problems and the most important policy-related questions that must be addressed with respect to land quality. Their relative importance differs according to both environmental and socioeconomic conditions. Key land issues can be identified for agro-ecological zones. For example, water erosion is a key issue for steeplands in the humid and subhumid tropics, rangeland degradation for the semi-arid zone. Land issues also differ between broad socioeconomic zones, in the way that the problems associated with nomadic pastoralism are largely an issue for sub-saharan Africa.

The identification of the key land issues for specific areas serves to direct attention to those land-related questions that are critical, and are the most relevant to policy decisions. It is on the basis of land issues that the pressure-state-response framework can be applied, leading to the selection of relevant indicators..

Land issues may be grouped into three clusters. This is a loose grouping, not a classification, and some issues fall into more than one group:

- Inappropriate land use systems.
- Land degradation.
- Inadequacies in the policy environment for land users.

Inappropriate land use systems

The identification of inappropriate land use systems involves a comparison between the requirements of various kinds of land use and the physical characteristics of land units. **Land use** refers to the management of land to meet human needs (FAO, 1993a). It may be described at any level of detail, ranging from the general, such as cultivation of annual crops or forestry, to specific local cropping systems. It is distinct from **land cover**, the cover of the land surface by plants (natural vegetation or cultivated) or human artifacts, although there are partial correspondences between land use and cover.

In the past there have been many different land use classifications. Advances have recently been made towards achieving internationally-recognized standards. These include the distinction between the purposes for which land is used (for example crop production, livestock production, forestry, conservation, or settlement) and the land use systems, or types and sequences of activities carried out on the land, for example shifting cultivation, permanent cultivation of annual crops, or production forestry from natural forests. A recent approximation to land use classification at higher levels is available (see Annex A).

A **land unit** refers to any area of land which possesses specified characteristics and which can be mapped (FAO, 1983, 1993a). They can be at any level of scale, ranging from agro-ecological zones to individual units of terrain, e.g. escarpments or valley floors. The basis for mapping may be land as a whole (as in land systems survey) or specific resources, such as soil series, or forest or rangeland communities.

The comparison of land with land use, or more specifically the matching of the requirements of land use systems with the characteristics of the land units on which they are practised, is basic to the assessment of effects upon land quality. Inappropriate land use systems refer to methods of land use which, under current socioeconomic conditions, are poorly suited to the land units on which they are practised; that is, yields are low or economic returns marginal. In the terminology of land evaluation, the land use is poorly matched to the land (FAO, 1976, 1983a, 1984a, 1985, 1991). An example is the case where land shortage leads to migration towards drier zones; farmers often continue to plant the non-drought tolerant crops which were well suited to their former lands. Steeply-sloping land units might be suitably used for growing of tree crops but are poorly matched with cultivation of annual crops without soil conservation. Inappropriate land use systems can lead to pressures on land quality and to degradation.

Land degradation

Land degradation refers to lowering in the capacity of land for agricultural production or its potential for environmental management - that is, to lowering of land quality. The types or processes of degradation are well recognized (Box 2.2). Some refer to one type of resource: soils, water, forest resources or rangelands; but because of the interactive nature of ecosystems there are always associated changes in other resources. In rangeland degradation, for example, the reduction of plant cover is associated with degradation of soil organic matter and soil physical properties.

The effects of degradation are not confined to the land on which it occurs but may include **off-site effects.** One of the most widespread is the effect of soil erosion in upstream water catchment areas in causing more erratic river flow regimes, higher sediment content in rivers, and reservoir sedimentation.

The term **desertification** was formerly used in very poorly-defined ways, such as 'spreading of the desert margin' or sometimes to cover all forms of land degradation. Following international agreement, it is now defined as land degradation in arid, semi-arid zone and dry subhumid zones resulting from various factors including climatic variations and human activities (UNEP, 1992; UN CCD, 1994). On rangelands, desertification consists primarily of adverse changes in the plant cover, with associated degradation of soil properties.

The converse of degradation is **land improvement**, changes in land quality which improve its potential for land use or environmental management. This term was originally applied to human improvements such as irrigation, drainage or terracing (FAO, 1976). It can be extended to include the results of gradual change, such as the improvement in soil properties following reclamation forestry, or the effects of liming and fertilizer application on the acid soils of the Brazilian *cerrado*.

Definitions related to land issues

Land issues The major problems and most important policy-related questions that affect, or have the potential to affect, land quality.

Land use The management of land to meet human needs. Land use is described by the purposes for which the land is used, and the types and sequences of activities carried out upon the land (FAO, 1993; UNEP/FAO, 1993).

Land degradation The temporary or permanent lowering of the productive capacity of land, or of its potential for environmental management.

Major types of land degradation are (FAO, 1979, 1994; Oldeman et al., 1990):

- **water erosion**: soil erosion by water;
- **wind erosion**: soil erosion by wind;
- **soil fertility decline**: adverse changes in soil physical, chemical and biological properties;
- **loss of soil bio-activity** (e.g. rhizobia, earthworms);
- **salinization**: increase of salts in the soil;
- **waterlogging**: soil inundation through rise of the groundwater table;
- **soil pollution**: effects of accumulation of toxic wastes;
- **lowering of the water table**: through abstraction in excess of recharge;
- **deforestation**: reduction in forest area;
- **forest degradation**: adverse changes in forest composition, structure or biodiversity;
- **rangeland degradation**: adverse changes in composition and density of natural or semi-natural pastures.

Desertification Land degradation in the arid, semi-arid and dry subhumid zones resulting from various factors, including climatic variations and human activities (UNEP, 1992; UN CCD, 1994).

Land improvement An alteration in the qualities of land which improves its potential for land use (FAO, 1976).

Inadequacies in the policy environment for land users

The third group of land issues concerns the policy environment. This refers mainly to effects of policies at a national level and their impacts upon land users at farm level. Examples are:

- pricing policies (taxes or subsidies); for example, a high fertilizer subsidy encouraging inefficient use;
- inadequacies in agricultural services (extension, supply of inputs, credit, marketing);
- the existence of environmental legislation and whether, and by what means, it is enforced;
- inappropriate investment in rural infrastructure; for example, faulty design of an access road network in forested or hilly areas.
- type of land tenure legislation.

Policies can also be set at district level, for example the water pricing policy on an irrigation scheme.

An approach through policies provides a means to assess priorities in the selection of land quality indicators. From the point of view of project management, it is most useful to monitor those indicators which have the potential to respond to policy 'levers' (O'Connor, personal communication). To identify the full consequences of policies for land users will require participatory studies.

Standards, goals, targets and thresholds

Standards are values of a variable which are considered desirable to achieve, or undesirable or illegal to exceed. Their use is common in pollution aspects of environmental management, as in standards for air quality, quality of drinking water, levels of toxic emissions, air quality, etc.. In the area of production, land quality standards can act either as targets or as limits which should not be transgressed, for example, water quality standards for irrigation or for livestock watering.

A standard which presents difficulties is that of 'soil loss tolerance'. This was defined as the maximum level of soil erosion that will permit a high level of crop productivity to be sustained economically and indefinitely (Wischmeier and Smith, 1978, p.2). Standards were set for soils of the United States on the explicit basis of informed opinion, with lower tolerances for thin or non-resistant soils. In developing countries a rate of 10 t/ha^{-1} is commonly taken as a target, although the natural rate of soil formation may be as much as ten times slower (Stocking, 1978; Pimentel et al., 1995). Furthermore, any standard set by mass of soil lost fails to take account of the greater value of topsoil, which contains most of the nutrients and biological activity and is of critical importance in poor countries where opportunities for fertilizer inputs are limited. How this standard is set is therefore highly important, both to ensure long-term options for soil resource use and as a guide to practical conservation programmes, so further work is needed.

Following OECD practice, a distinction may be made between goals and targets (Adriaanse, 1993). **Goals** are ideal or desirable values, identified by scientists and policy makers, but which may never be reached. **Targets** are values, in the present context values of land quality indicators, which are believed to be reachable in the short or medium term. Goals may be set as part of national policy, whilst targets are most relevant to specific development projects or district level government programmes. For example, a country might set the policy goal of reducing the net rate of forest clearance to zero. A soil conservation project could have the goal that 50% of farmers on sloping land practise acceptable conservation practices within the project life of five years.

A performance indicator describes the ratio between actual achievement and a target. Thus in the last example, if the project had in fact attained 40% conservation, it would have achieved a performance of 80% success. No purpose is served in obtaining ever more refined land quality indicators unless there are standards or goals by which to judge performance.

Thresholds, in this context **environmental thresholds**, are values of a variable beyond which rapid, often exponential, negative changes occur. An example is when the condition of soil physical properties (structure, infiltration rate) degrades to levels at which progressive sheet erosion gives place to rapidly accelerating rill or gully erosion. Forest vegetation may be able to withstand a certain level of cutting or burning, but where these processes reach a certain threshold of intensity, a change to wooded savanna takes place. Farming systems often tolerate two years of exceptional drought but collapse with the onset of a third year. This concept has been further applied with respect to soil resilience (Greenland and Szabolcs, 1994).

So long as indicators of land quality remain less than the levels of thresholds, the environment can recover if pressures are removed. Beyond threshold levels, changes are irreversible or very slowly reversible (Barrow, 1991; Myers, 1992).

Notes on definitions

In workshop discussions (World Bank, 1995b), two questions concerning concepts and definitions were raised. These were discussed but not resolved, and may require further consideration in the subsequent programme of work.

1. The definition of land quality Concern was expressed at the use of the term 'land quality' in the sense here employed. In the well-established methodology of land evaluation, as developed by FAO, the definition of a land quality is *a complex attribute of land which affects its suitability for specific uses in a distinct way (FAO, 1976, 1993a).* In this sense, there is not one but a range of land qualities. This concept was formulated as a means of reducing the very large number of individual land characteristics (e.g. mean annual rainfall, soil available water capacity). Examples of land qualities in this sense are availability of water, availability of nutrients, resistance to soil erosion, nutritive value of grazing land, quality of natural timber resources, or terrain factors affecting mechanization. Under this definition there is not one land quality but a range of land qualities. This matter is not simply semantic, nor related only to priority of usage. There is a difference in concept which could have significant consequences.

2. The pressure-state-response framework It was suggested that this concept might be more completely described as a 'pressure-state-impact-response' framework. However, impact occurs at more than one point in the chain of cause and effect: impact of pressures upon the state of land quality, and impact of changes in the land quality upon land users. In view of its established use for environmental indicators of pollution, the original term is retained here.

CHAPTER 3. SCALES FOR THE DEVELOPMENT AND APPLICATION OF INDICATORS

Scales for land resources policy and management

Policy making, decisions and practical actions related to land use planning and management take place at a range of scales, or levels. Land quality indicators must be capable of application at all these scales (Izac and Swift, 1994). Three factors need to be taken into account in the development of such indicators: the nature of the actions to be taken, the patterns of the natural environment, and the data available, each in relation to levels of scale.

Scales for decisions and actions on policy and management are shown in Box 3.1. The **farm scale** is that of individual farms or other landholdings, in developing countries often 0.1-10 ha. This is the level at which decisions are taken on what to plant, how many animals to hold, and how to manage the farm. It is these decisions which have the main direct impact on land quality: its improvement, maintenance or degradation. Policy at farm level can be based on farming systems (or farm-household systems), dominated by the same suite of crops and livestock, which extend in repeating patterns across areas with a similar range of climate, terrain and soils.

The **local scale** is that of the village or other community, normally the lowest level of administrative unit and covering areas of the order of 10-100 km^2. This is another 'grass roots' level, one at which decisions on land resources are taken and implemented. These cover the management of community resources, such as village woodlands, common grazing lands, or community access to water resources. This is also the level for community associations of farmers and other land users, and for the implementation of agricultural extension services.

The **district scale** can refer to districts or other administrative units, typically covering areas of 100-10 000 km^2. It is the level at which agricultural services are administered, although not usually important for policy decisions. This is also the usual scale for development projects, and may be referred to in this context as the **project scale**. This is the level initially for project planning, and subsequently for decisions on project management. Projects need to institute a monitoring and reporting procedure for the land resources, and use this as a management tool for the duration of the project.

The **national scale** is the most important level for policy decisions affecting land use and management, directly and indirectly. Direct consequences arise from policies towards land-related matters such as forest protection and soil conservation, and the effects of these policies are felt at lower levels. Development projects, communities and land users are dependent on the policy environment set at national level, particularly pricing, fiscal and regulatory policies, together with budgetary allocations such as the investment in infrastructure which is so critical to rural development. This is also the level at which project portfolios are planned, and where systems of national environmental accounting or other means for monitoring of natural resources are carried out.

Scales or levels for application of land quality indicators in policy and decision making

Farm	Farmers, land managers, farm decision-making units
Local	Village council, communities
District (Project)	Government administrative units, most development projects
National	National governments
International	UN, World Bank and other international agencies; international NGOs and others.

The **international scale** is the level at which comparisons between environmental performance are carried out, and policy priorities for research, technical assistance and funding on land resource development and conservation are decided by international organizations. It is also necessarily used for environmental questions which transgress national boundaries, either within a limited zone, as in water resource planning of major river catchments, or where there is world-wide concern, such as the relations between land use and coral reef protection, or effects of emission of greenhouse gases on climatic change.

Diversity and scale in the natural environment

The natural environment has extreme diversity and complexity of patterns. This sets problems for land quality indicators and natural resource management, since the areas of relative homogeneity are rarely coincident with administrative units.

Agro-ecological zones (also called agro-climatic zones) are areas of subcontinental and nationa/sub-national extent which have broadly similar climatic characteristics, linked with a specific range of soil, water and vegetation resources and thus of land use potential. The major agro-ecological zones of the tropics and subtropics are the humid tropics (rain forest zone), the subhumid tropics (seasonally-dry tropics, savanna zone), the semi-arid zone (steppe zone, sahel), and the arid zone (desert zone). A detailed classification is given in the FAO agro-ecological zones study (FAO, 1978-81).

In addition, there are certain areas which present highly distinctive problems of land resource management, for example:

- steeplands: areas dominated by moderate and steep slopes, such as the major mountain chains and dissected scarplands;
- alluvial plains, such as the Indo-Gangetic Plain;
- vertisols: black cracking clay soils.

Agro-ecological zones and other areas with distinctive resource management potential and problems can be used as a basis for identification of key land issues. For this purpose, they need to be combined with broad units of the socioeconomic environment. for example between subcontinental areas of contrasting population density and differing socioeconomic conditions. Examples are given below.

At more detailed scales there are classification systems for units of the physical environment as a whole (e.g. land systems and land facets, landscape units, soil-and-terrain units) and for the classification and mapping of individual factors of the environment - climate, soils and vegetation. Units of the natural landscape form an essential basis for project-level land use planning (FAO, 1993a). They are also the basis on which data from remote sensing are collected, and are a necessary base for stratified sampling of land quality.

There are many known procedures for the zonation of natural, biophysical, resources. These classify and group natural landscapes into units which are useful for land use planning and land management decisions. Major land issues can be related to these areas where appropriate, and policies and programmes can be developed which reflect the characteristics of the land units.

This biophysical zonation, however, must be integrated with an additional layer of information concerning how the land is used and managed. This is because land quality is influenced by the combined effects of the natural environment and of human intervention through management. In addition, in developing countries where traditional farming methods are still dominant, such as sub-saharan Africa, land management patterns may be influenced by historical and socio-political factors, such as rules of tenure and rights to use. This combined approach to biophysical and socioeconomic zonation is represented in the *terroir* system of zonation (Mercoiret, 1989) or 'village x catchment' approach (Izac and Swift, 1993) (Figure 3.1). A similar system was proposed by Gallopin (1994) for Latin America, whereby the agro-ecosystems are stratified by major landscape units, production systems and scale.

By means of such approaches, serious problem areas ('hot spots') can be identified. Monitoring and ameliorative action programmes can be concentrated on such areas, with considerable gains in cost-effectiveness.

Examples of key land issues for agro-ecological zones. Based on results from regional workshops (World Bank, 1995a).

AGRO-ECOLOGICAL ZONE	SOME KEY LAND ISSUES
Latin America:	
Suhhumid tropics (acid savannas)	Low agricultural productivity Diversity of land use Agricultural impacts on biodiversity Impacts of land tenure on land quality
Steeplands	Extent, severity and effects of soil erosion
Africa:	
Subhumid zone	Intensity and diversity of land use Extent, severity and effects of soil erosion Soil fertility maintenance or degradation, soil nutrient balance Low agricultural productivity Food security and risk Water quality, sedimentation
Semi-arid and arid zones	Intensity and diversity of land use Woodland and vegetation degradation and fuelwood availability Nutrient balance Pressures of livestock on rangelands, vegetation degradation Soil water availability, runoff, storage and utilization Land users awareness, commitment, and institutional capacity

Data on land management normally come from census bureaux, and are aggregated by administrative boundaries rather than natural landscapes. These data have to be transformed, using geographic information systems, geostatistics and other techniques of information management, to relate them to natural landscape units on a combined georeferenced basis. This transformation and combination can produce a stratification which is similar to the *terroir* system, i.e. based jointly on biophysical and socioeconomic zonation. This may open up possibilities of using indirect or surrogate indicators of land quality, such as changes in methods of land management. Such indicators may be more cost-effective to develop and implement than direct monitoring of land quality in the field. Special techniquess, involving GIS and other information technologies, are becoming available to resolve this problem.

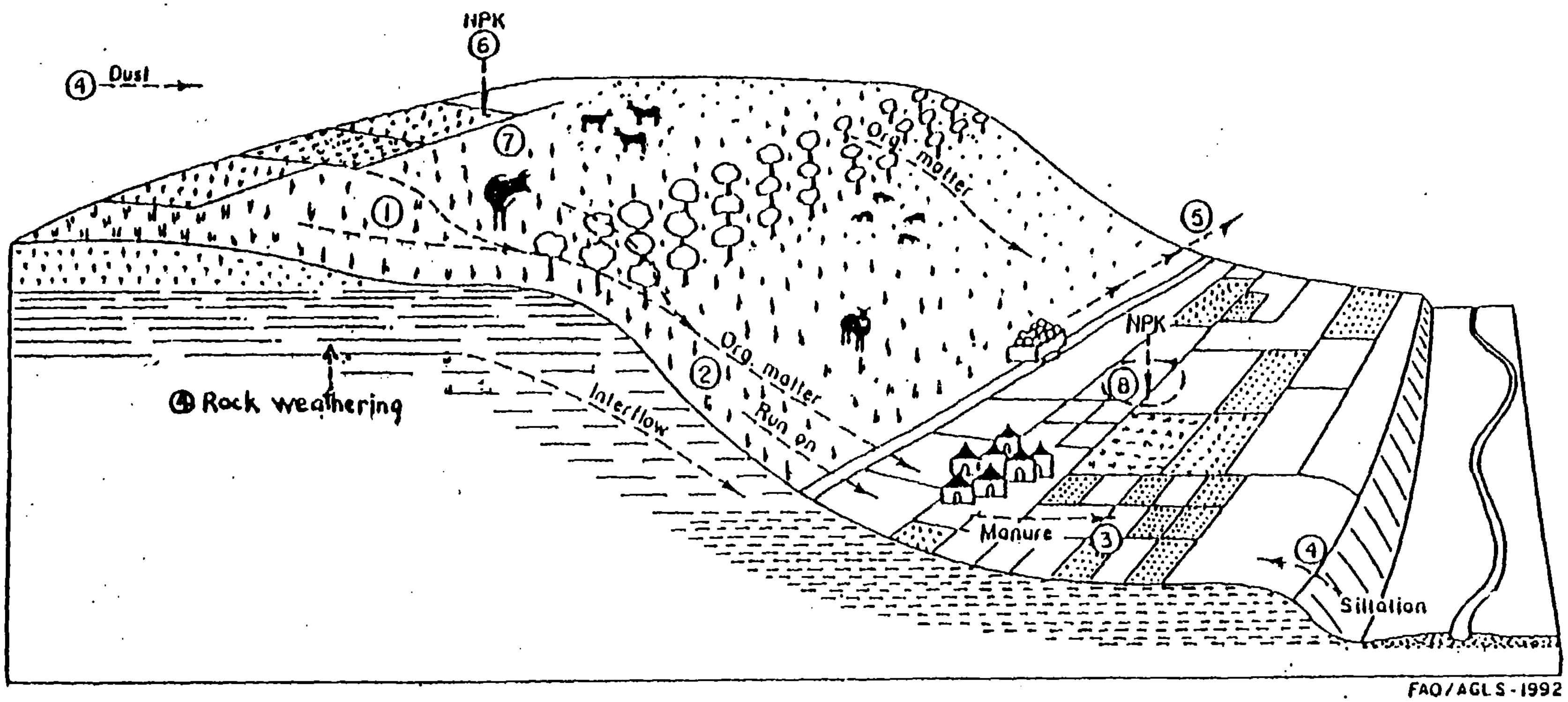
Land quality indicators appropriate to scale of assessment

A central question which requires further work is the degree to which the same land quality indicators can be used at different scales of assessment. There are clearly economies of effort wherever this can be done. The question depends on the types of data available at the different scales, and which indicators are appropriate for the kinds of decision, on policy, management or action, to be taken.

At the farm level, farmers are skilled at looking for symptoms of land and plant conditions that are indicative of productive capacity or can be used to diagnose constraints to production. These include leaf symptoms of plant nutrient deficiency, and local means of detecting soil chemical imbalance or low fertility. When asked to produce indicators of land quality, farmers will often refer to visual indicators, such as indicator plants, weed species or plants which recolonize natural fallows. Pastoral peoples similarly have an intimate knowledge of rangeland conditions which few scientists are likely to match. Such indicators can be of the highest value for local, year-to-year, management decisions. If scientifically interpreted and (at least regionally) standardized, they can also be monitored regularly across large areas to determine changes of land condition, and there is potential for including them into systems of indicators. For example more than 30 years ago, Zimbabwe compiled lists of plant indicators of water and soil conditions.

At the local scale, communities, like individual farmers, must make local responses to local indicators. There is potential for non-governmental organizations or projects to give them assistance in relating local problems to broader trends.

Agronomic experiments are carried out at the detailed scale. Under these conditions, soil properties can be monitored through repeated, sampling and analysis, which directly record changes in soil organic matter, nutrients and toxicities. There is no reason why this same technique, known as soil monitoring, should not be applied at district or national scales, through a set of reference or benchmark sites, although this has been infrequently attempted (p.46).



(1) Local nutrient mining
(2) Nutrient harvesting
(3) Local nutrient enrichment
(4) Natural nutrient import
(5) Anthropic nutrient export
(6) Anthropic nutrient import
(7) Possible nutrient fatigue
(8) Integrated nutrient husbandry

Figure 3.1. Example of a land system, illustrating the association between units of the natural landscape, land use, and plant nutrient dynamics.

At project level, there is a strong demand for indicators of changes in land quality, based on the following concerns:

- raising the yields of farmers closer to those achieved experimentally;
- providing early warning of adverse effects which may reduce production and long-term sustainability (e.g. soil acidification);
- detecting unforeseen effects on land of introduced technologies;
- guiding alternative land-use strategies in regions of potential vulnerability;
- providing a diagnostic kit for land managers and advisers at district to national scales.

From larger to smaller scales (i.e. from local to district and national scales) there is a progressive loss of visible indicators based on local knowledge and an increasing reliance on statistical data. However, analysis of trends and comparative status is often just what is missing at the local level, making it hard for local communities to have reliable estimates of change over time. Interpretation of statistical information gathered by government requires comparison with local field surveys for its full interpretation.

In many cases, project managers will need to institute a monitoring and reporting procedure for use as a management tool for the duration of the project, with the hope that it will become part of the future management procedures beyond the life of the project. In the case of natural resource management, existing information sources are often poor, and the work done on projects will be of much value to national institutions.

At the national scale, governments are increasingly aware of the need to conserve their natural resources for sustainable production, but until now have lacked reliable indicators. They require land quality indicators to formulate policies, monitor the effects of existing policies, and as a guide to allocation of resources. Where environmentally-adjusted systems of national accounts are called for, reliable information on changes in the condition of natural resources is clearly a prerequisite.

Aggregated indicators that are appropriate at national scales may appear too general at project or local levels. However, it is possible to link these with local sub-indicators, to bring evidence to bear on whether land condition is changing over time, the rate of change and the areas at risk. This can be done most clearly where land conditions approach threshold values for degradation, e.g. where there is incipient soil salinization.

Off-site effects introduce a further complexity of scale. A well-known example is the clearance and cultivation of sloping upper watershed areas, resulting in less stable downstream river flow regimes, sedimentation and siltation of reservoirs. Over-use of water on upper parts of an irrigation system can reduce water availability for downstream users, and poor weed control by some farmers causes air-borne seed dispersal to affect others. Some indicators, such as river sediment loads, are directed at monitoring off-site effects.

Aggregation and standardization of indicators

Some natural resource information is not easily aggregated beyond the natural scales imposed by topographic boundaries. Watersheds form the natural unit for hydrological information, whilst within a given climatic zone, soil types are often linked with the underlying geological patterns. Superimposed on these complex patterns are the regional trends in land potential brought about by spatial differences in rainfall, exemplified in the climatic and vegetation belts of West Africa.

None of these natural land units are coincident with administrative units, which are the usual basis for socioeconomic information. However, geographical techniques exist for optimal allocation of data between overlapping spatial units. In the past, decisions have commonly been taken on the basis of administrative units. Where questions of land management are concerned, however, this can be an inefficient process. Managers will need to learn to make use of soil and other natural resource maps, which in the past have frequently been surveyed but not put to use (Dalal-Clayton and Dent, 1993). Conversely, soil scientists should make more effort to produce user-friendly maps that can be interpreted by non-specialists.

The extent to which the same land quality indicators can be used at different scales requires further investigation. It may prove possible to use different attributes of the same key indicators.

Any form of quantitative comparison requires standardization. This applies both to monitoring trends over time and to comparisons between areas. In the case of time trends, it is clearly essential to standardize the methods of observation. This applies to methods of soil analysis, which should be documented. For example, ISRIC operates a laboratory exchange programme (LABEX) for comparison and quality control of soil analyses.

For spatial comparisons, the methods used within the areal unit to be compared must be compatible, and eventually standardized. This means that a spatial hierarchy exists:

- for comparisons conducted at international level, the same indicators used at national level;
- for comparisons conducted at national level, the same indicators used within the areas compared (regions, districts, etc.);
- for comparison of performance between projects or government programs, the indicators must be standardized, or at least compatible, at project level; this can be either between all projects and/or programmes, or all of the same kind, e.g. within a sector.

CHAPTER 4. EXAMPLES OF LAND QUALITY INDICATORS

Introduction

This chapter gives examples of land quality indicators, belonging to the three identified groups:

- indicators of pressure: pressures upon land quality;
- indicators of state: changes in land quality, and impacts of these changes;
- indicators of response: the response by society to pressures or to changes in state.

The indicators are considered with respect to land issues. Both on-site and off-site impacts are included.

The chapter is in two parts. The first part gives results from two regional workshops, at which wide-ranging discussions took place over the potential of land quality indicators, and problems with their identification. The second part is an attempt to systematize sets of indicators, arranged with respect to major issues of land degradation.

RESULTS FROM REGIONAL WORKSHOPS

Introduction

In 1994, two international workshops were organized to assess the feasibility of developing harmonized indicators for monitoring land quality, beginning with some significant agro-ecological zones of the tropics and subtropics. The first[3] examined indicators relevant to farming conditions on the steeplands and acid savannas of Latin America. The second[4] was directed at indicators for subhumid, semi-arid and arid zones of sub-saharan Africa.

Discussions at these workshops were wide-ranging, covering the conceptual framework for land quality indicators, sources of data and information, analytical procedures, scales of application, and the research agenda necessary to bridge the gap between available knowledge and what will be required at operational level. Results from these regional workshops were summarized in a background paper (World Bank, 1995a) for the subsequent workshop held in Washington DC, June 20-21, 1995. Many of the observations and conclusions have been incorporated in the present text.

[3] Sponsored by the World Bank and the Centro Internacional de Agricultura Tropical (CIAT) and held at Cali, Colombia, 6-11 June, 1994.
[4] Sponsored by the World Bank and the International Centre for Research in Agroforestry (ICRAF) and held in Nairobi, 13-16 December, 1994.

The following section gives the outcome of efforts to identify land issues and land quality issues for the five specific agro-ecological zones.

Agro-ecological zones considered

The agro-ecological zones considered at the regional workshops were as follows:

Latin America:

Steeplands These are areas dominated by moderate to steep slopes, many within the Andean mountain chain. There is heavy population pressure and most land holdings are small (2-4 ha), with low economic returns. The zone is significantly affected by deforestation, overgrazing and soil erosion.

Acid savannas (locally *llanos, cerrados*). Areas of heavy seasonal rainfall with a marked dry season, often with soils of low inherent fertility. Land holdings are typically large, with substantial cash farm incomes. Some of the land management practices, such as monocultures, have caused widespread land degradation through nutrient depletion and erosion.

Sub-saharan Africa:

Sub-humid zone These areas resemble the acid savannas of Latin America in having a markedly seasonal rainfall (210-270 growing days), but in contrast have high population densities and small land holdings, averaging less the one hectare in some parts. Agriculture is carried out within a context of rapidly-increasing populations. Soil fertility decline and erosion are common.

Semi-arid zone This zone also has highly seasonal rainfall but with a short growing season (90-210 growing days) and highly variable rainfall. The zone includes cropping, livestock production and mixed crop-livestock systems, but the workshop focused upon issues and indicators for crop-based dry farming systems.

Arid zone The arid zone has a growing season of less than 90 days, too short for most cropping activities, and the workshop focused upon pastoral systems. Migratory pastoralism is the predominant rural activity, and there are problems of rangeland degradation.

Land issues and land quality indicators identified

There was a high degree of consensus on the key issues for land quality indicators in the agro-ecosystems. The workshops recognized the need for two scale of operation, one to serve requirements of projects and farmers, the other to serve the needs of national policy makers.

Tables 4.1 and 4.2 show the results from these workshops in terms of issues and land quality indicators. They are reproduced here in the form in which they were output from the workshops, with only minor editing. The tables are by no means fully consistent internally, nor are they entirely compatible with the framework presented elsewhere in this paper. These were results from 'brainstorming' sessions, in which ideas from participants with wide-ranging backgrounds were discussed and recorded. As an example, for the sub-humid zone of Africa (Table 4.2A), 'extent of risk buffering' was cited as an issue, and 'percentage stunting of children' forcefully argued as an indicator of this. Proposals such as this form a source, of greater variety than the more standardized format of the remainder of this chapter, which can be drawn upon as a source of ideas for the future development of indicators.

In addition to these regional workshops, the following are among sources for examples of land quality indicators:

Source	*Types of ecosystem and indicators*
Adriaanse (1993)	Pollution, the Netherlands
Dumanski ((1993)	Agro-ecosystems, global
Hamblin (1992)	Agro-ecosystems, Australia
Hamblin (1994)	Agro-ecosystems, Asia-Pacific
Hammond et al. (1995)	Pollution and resource depletion
Izac and Swift (1994)	Agro-ecosystems, farm scale, Africa
O'Connor (1995)	Pollution, biodiversity, natural capital
OECD (1993)	Pollution and land resources
Reid et al. (1993)	Biodiversity
SCOPE (1995)	Aggregated source and sink indicators
Winograd (1994)	Agro-ecosystems, Latin America

Table 4.1A. Issues and proposed land quality indicators for agro-environments in Latin America

STEEPLANDS	
ISSUES	**LAND QUALITY INDICATIORS**
• human resources impact	• population density, age-sex ratios • access to land and water • access to markets and services
• land quality	• soil fertility index • soil erosion index • vegetative land cover • distance to domestic and irrigation water • rural water quality • downstream (off-site) water quality
• agricultural impacts on biodiversity	• natural habitats: change in extent and fragmentation • species variation and loss
• land use and practices	• agro-diversity by farm • major land use • percentage adoption of conservation farming practices • number of farmer groups and associations

Table 4.1B. Issues and proposed land quality indicators for agro-environments in Latin America

ACID SAVANNAS	
ISSUES	**LAND QUALITY INDICATORS**
• intensity and diversity of land use	• percent different land use x terrain types • stability of net farm profits
• land quality	• water-table level changes • water contamination • sediment load • percent soil cover/bare soil • crop nutrient uptake vs. fertilizer use • lime consumption/km^2
• agricultural productivity	• actual/potential productivity (climate x terrain) • trends in crop yields • net farm profits
• agricultural impacts on biodiversity	• proportion gallery forests, wetlands, natural savannas
• farm practices	• percent arable land with conservation practices
• land tenure	• percent farmed area with recognized title

Table 4.2A. Issues and proposed land quality indicators for agro-environments in sub-Saharan Africa

SUB-HUMID ZONE	
ISSUES	**LAND QUALITY INDICATORS**
• intensity and diversity of land use	• intensity index: (permanent cropped area/total cultivable area) • diversity index: S (number of species x area of land use type)/total area
• extent of erosion	• predicted/actual erosion rate
• water quality	• sediment load in surface flows per crop cycle
• soil fertility	• carbon balance in soil (percent returned/produced) • nutrient balance
• societal value of farms	• market price of farm lands • rural/non rural values
• erosion controls	• length of run-off controls • conservation farming practices • percent farmers with access to financial incentives for conservation practices
• extent of risk buffering	• percent stunting of children • actual yields/target farm yields
• equity in society	• Gini coefficients (and trend in evenness in income distribution)

Table 4.2B. Issues and proposed land quality indicators for agro-environments in sub-Saharan Africa

SEMI-ARID ZONE (dry farming only)	
ISSUES	**LAND QUALITY INDICATORS**
• resource availability	• deforestation rate • consumption of firewood and charcoal sales (urban) • price of fuelwood and charcoal in urban areas
• intensity and diversity of land use	• change in arable land per capita
• land quality	• visible soil erosion (area, degree, percent of land) • nutrient balance, acidification • change in water supply
• land practices of farmers	• rate of adoption of on-farm organic matter recycling (including agroforestry), improved stock
• land users' awareness and institutional capacity	• number of farmer associations • farm gate/market prices for inputs • ratio of farmers to extension agents (public and private) • percent land users with security of tenure for more than one farming generation

Table 4.2C. Issues and proposed land quality indicators for agro-environments in sub-Saharan African

ARID ZONE (pastoral systems only)	
ISSUES	**LAND QUALITY INDICATORS**
• population: pressure relative to rangelands	• ratio of land/people and livestock/people
• vegetation condition/cover	• ratio perennial/annual vegetation • density of living perennial vegetation • ratio vegetation biomass/feed demand
• vegetation quality	• ratio palatable/unpalatable vegetation • ratio young/mature perennial vegetation (grasses, shrubs, trees)
• soil water storage capacity and runoff	• ratio crusted soil surface area/total area
• response of land users to land quality	• rate of out-migration • range and quantity of products for sale (wood, grass) • human diet: ratio cereal/livestock products
• societal commitment	• budget for livestock and social services • number and cohesion of pastoral associations (formal and informal) • number of conflicts over resources

INDICATORS FOR ISSUES OF LAND DEGRADATION

This section sets out lists of indicators of pressure, state and response on a systematic basis. They are given with respect to one set of land issues that of land degradation. The examples place emphasis on different types of land resources: soil, water and vegetation (forest and rangeland). However, in all cases there are interactions between these; the complexity of managed ecosystems is such that no single land resource can be considered in isolation.

Priority is given to indicators for which data are available or could be measured, including indicators which have already been used. In some cases the indicators suggested are not given in precise quantitative form; most have a potential for quantification, although not always for standardization and inter-regional comparison. In many cases, neither standards nor threshold values have yet been developed.

At this stage, the lists of indicators should not be regarded as definitive nor comprehensive. Their purpose is to illustrate their nature, including practicability for application, by means of examples. The indicators discussed refer mainly to the two priority scales of application, district and national, but some consideration is given to indicators at local and farm scales.

Four of the issues considered are of widespread occurrence: soil erosion, soil fertility decline, forest clearance and forest degradation. Three others are of zonal importance. Rangeland degradation is found particularly (although by no means exclusively) in the semi-arid agro-ecological zone, whilst lowering of the groundwater table, salinization and waterlogging occur most severely in irrigated areas of the arid zone.

Land issue 1. Soil erosion: water erosion on arable land

Examples: Ethiopia, Haiti, Lesotho, Mexico

Soil erosion: water erosion on arable land

Indicator of pressure:
- *Extent of cultivation of sloping land without adequate conservation measures*

Indicators of state and impact:
- *Rates of erosion (t ha^{-1} per year), obtained by field measurement or modelling*
- *Loss of topsoil, soil organic matter and nutrients; truncated soil profiles*
- *Extent and severity of visible signs of erosion, e.g. thin or rocky soils, soil slips, gullies, areas of abandoned land*

Indicators of response:
- *Extent of adoption of soil conservation practices, by area or farm*
- *Number of farmer associations active in conservation*
- *Abandonment of land formerly cultivated*

Soil erosion is the land issue that has been longest recognized, awareness dating from the early history and becoming a prominent issue in the 1930s. Water erosion is a leading problem of steepland areas in all agro-climatic zones, and wind erosion is an issue in the semi-arid zone. Both types can occur under either cultivation or grazing. The case considered here is that of water erosion under arable use.

In many countries it is observed that in former times, farms were largely on gently-sloping land, but that cultivation has since been extended onto hillslopes. Where this has been in association with terracing or other conservation measures it may be sustainable, but arable use of steep slopes with little or no conservation is widespread.

The basic indicator of pressure is the land use type, 'arable farming without conservation' found in association with sloping land. Data could be obtained from remote sensing or sample surveys.

A widely-employed, although not fully satisfactory, indicator of change in state is the current rate of erosion, as tonnes per hectare. This is extensively measured on experimental plots but only infrequently on farms, although the latter is possible (Lewis, 1987). Monitoring of river sediment loads is an alternative. Because of the difficulties of field measurement, remote sensing or modelling are widely employed. For example, a national survey for the United States was based modelling are widely employed. For example, a national survey for the United States was based largely on the EPIC model (USDA, 1989). Loss of topsoil with its higher content of soil organic matter and nutrients is more significant than bulk soil loss as such, except for off-site effects. In severe cases of sheet erosion, truncation of soil profiles has been observed. There are a wide range of visible indicators of erosion, the frequency of which might be converted into semi-quantitative form (FAO, 1979). Soil erosion has to be assessed in relation to critical and threshold limits (p.13).

As an indicator of the response of society, the most direct and positive is the adoption of soil conservation practices by farmers. This may be linked to the existence of farmer associations. A negative response is the abandonment of formerly cultivated land (also an indicator of past impact).

Land issue 2. Soil fertility decline

Examples: India, Pakistan, Malawi, Bangladesh, subhumid (savanna) zone of West Africa

Soil fertility decline

Indicators of pressure:
- *Rural (or agricultural) population density, in relation to agro-climatic zone and soil type*
- *Cultivation/fallow ratio*
- *Ratio of cultivated to cultivable land*
- *Ratio between monoculture and multiple cropping or crop rotation*

Indicators of state and impact:
- *Ratio between actual and estimated potential crop yields*
- *Balance between soil nutrient inputs and outputs, obtained by measurement and modelling*
- *Changes in soil properties over time*
- *Occurrence of specific soil deficiencies, e.g. of micronutrients*
- *Occurrence of indicator plants for soil degradation or soil health*

Indicators of response:
- *Extent of cultivation of marginal (fragile) land*
- *Extent of use of biological methods of soil improvement*
- *Use of crop rotation or multiple cropping*
- *Use of fertilizers*
- *Number of farmer groups or associations*
- *Number of conflicts over land resources*
- *Abandonment of farmland*

Possibly the most widespread land issue in developing countries is soil fertility decline with loss of production. The fundamental cause is a combination of increase in population, limited resources of potentially arable land, low capital resources for agricultural inputs, and sometimes inappropriate soil management. The problem is found in the humid, subhumid and semi-arid agro-ecological zones.

Rural population density as such is not an indicator, but it can be used as a data source for construction of an indicator where it is combined with the estimated productive potential of agro-climatic zones and soil types. The cultivation/fallow ratio is applicable to low-input systems, and is in common use with respect to the transition between shifting and permanent cultivation. It is measured as the R factor, where R = years under cultivation/total years in the cultivation-fallow cycle, expressed as a percentage (Ruthenburg, 1980).

A direct indicator of pressure is the ratio of cultivated to potentially cultivable land. A ratio close to 1.0 indicates actual or potential land pressure, since the former solution to production shortfall, that of taking extra land into cultivation, is no longer available. To obtain this ratio requires a biophysical assessment of how much land is cultivable, together with monitoring of how much is actually cultivated. At national level, this indicator is available from the FAO/UNFPA population-supporting capacity survey (FAO, 1982a, 1984b). This gives estimates of areas of cultivable land and their food-producing capacity, taking into account soil conservation, irrigation and other factors. These estimates can be set against country populations at present or future dates. This study was conducted once only, but data are available potentially to update it. A methodology exists for its application at district scale, and has been applied to Kenya (FAO, 1993b).

Monoculture without fallowing, crop rotation or multiple cropping frequently places stress upon land resources, through selective nutrient depletion and buildup of pests and diseases. Well-managed swamp rice cultivation can be an exception. Monoculture of maize or other food-producing crop serves both as a surrogate indicator of land shortage and a direct indicator of likely stresses upon soil resources. More generally, it may be possible locally to identify other land management options which farmers adopt as a consequence of population pressure.

Changes in soil properties can be observed indirectly through crop yield, or directly by measurement of soil changes. The ratio of actual to potential crop yield is a valuable indicator of the health of the soil. Estimates of potential crop yields can be made for given climatic and soil conditions, linked with agricultural input levels. Yield estimates based on biophysical potential tend to be unrealistically high, but can be set against local knowledge of yields obtainable from land in good condition. Where actual yields are substantially lower, this may be an indicator of soil degradation. Research will be needed to develop standards. Crop yield modelling may have a role to play.

Change in crop yields over time, assessed in relation to changes in inputs, is a highly significant indicator. A long-term decline in yields under low-input farming, or a divergence between increase in fertilizer use and in crop yields, strongly suggests degradation of soil properties (Hamblin, 1994; Pagiola, 1995).

The soil nutrient balance can be estimated by comparing inputs (natural processes and fertilizer) with outputs (natural processes, accelerated processes, and harvest removal). Data from field observation and estimates can be processed by nutrient balance modelling. At national level, such estimates have been made for Africa, and the same approach can be applied at farm and district scales (Figure 4.1) (Stoorvogel and Smaling, 1990; van der Pol, 1990).

Adverse changes in soil properties over time are the most direct indicators of soil degradation. The significant properties are soil organic matter, physical properties, soil reaction, nutrient content, biological activity, and toxicities. An increase in micronutrient deficiencies has been held to indicate over-reliance on basic fertilizers leading to unbalanced nutrient availability (FAO, 1994; Pagiola, 1995). Because of spatial microvariability, significant changes are not likely to be detected over periods of less than 3-5 years. Threshold or critical values, related to specific soils, are needed.

Observation of changes in soils requires soil monitoring, by means of stratified sampling and analysis, repeated over time. Other than under agronomic experimental conditions it has been infrequently attempted, but could be undertaken at national level, as a task for national soil survey organizations, or for critical zones ('hot spots') identified on projects (p.46). Cases of such monitoring at village and farm scales have been reported, e.g. for India and Brazil (S. Ayala, C. Pieri, personal communications).

The use of indicator plants for degraded soils is an example of making use of indigenous knowledge. Many farmers know of local plants which are signs of fertile soils and others associated with degraded soils, including some specific types of degradation.

Indicators of response to soil fertility decline show the action taken (or its absence) by land users, institutions or government. Response indicators are very often location-specific, although in some cases it may be possible to develop standards. Normally it will be changes in indicators over time which are monitored, at national or district levels.

Land shortage commonly results in extension of cultivation onto climatically marginal drylands, infertile soils or steep slopes. These changes can be observed as a qualitative indicator, and trends over time can be shown by monitoring land use in relation to surveyed land units.

Changes in soil management practices can be monitored by statistically-controlled surveys. Examples are changes in the ratio between monoculture and rotational or multiple cropping; the extent of use of methods for soil fertility maintenance or improvement (agroforestry, composting,

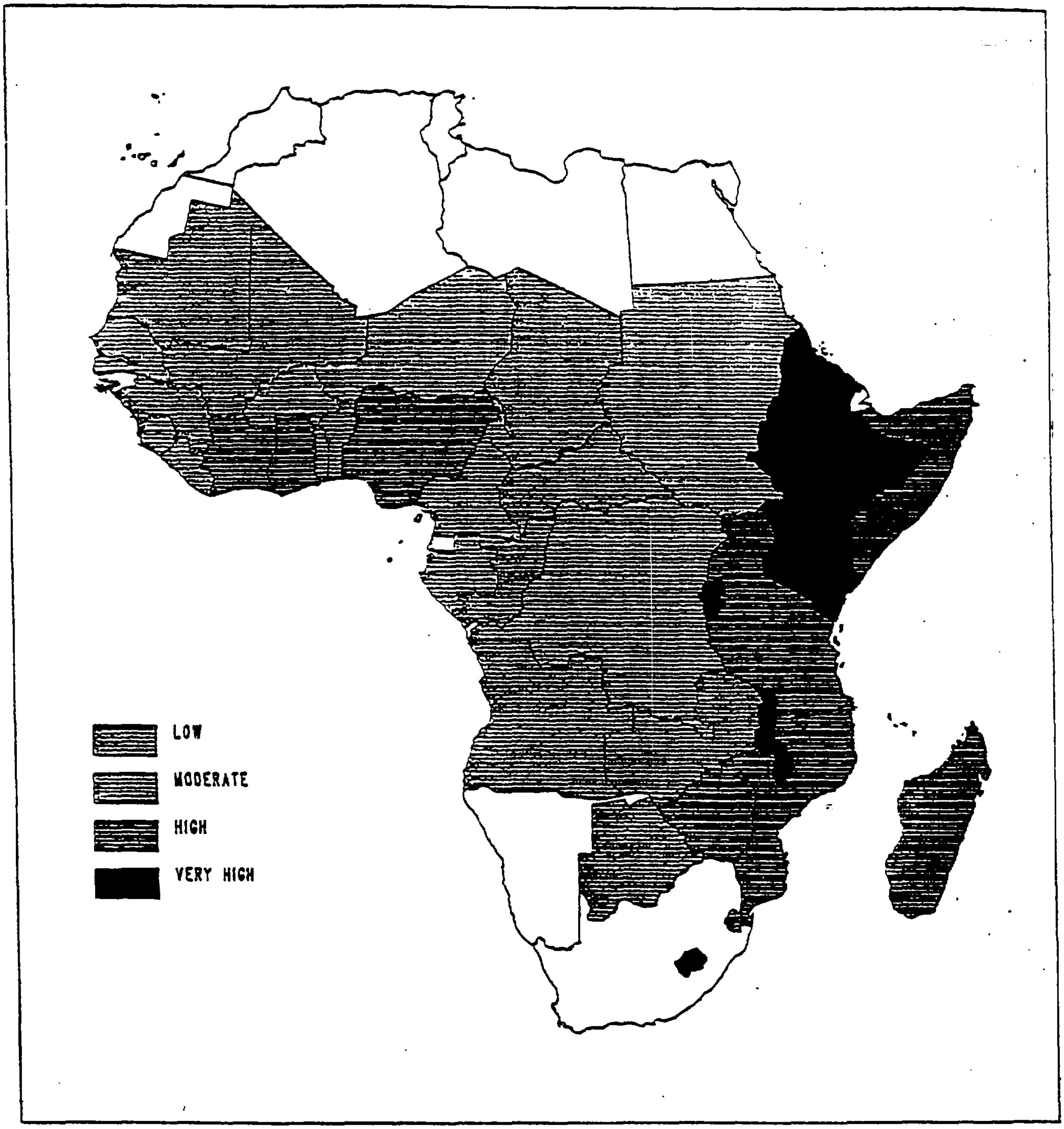


Figure 4.1 Estimated soil nutrient deficiency for countries of sub-saharan Africa (Stoorvogel and Smaling, 1990)

etc.); and the types and amounts of fertilizers applied. In many areas the existence and activity of farmer associations is linked with the adoption of improved soil management practices.

Land issue 3. Forest clearance for agriculture

Examples: Brazil, Kenya, Indonesia

Forest clearance for agriculture

Indicators of pressure:

- *observed clearance of forest areas for cultivation*
- *ratio of cultivated to cultivable land*

Indicator of state and impact:

- *Percentage decrease in area of forest cover*

Indicators of response:

- *government legislation to protect forest, and effectiveness of its implementation;*
- *public awareness campaigns for forest protection, and their effectiveness;*
- *increased afforestation (communal, private or governmental)*
- *reduction in rate of forest cover loss*

Forest clearance is a land issue that has received recognition because of the importance of forest as a productive resource, a conservation resource (including ecosystems, biodiversity, and plant and animal genetic resources), and a sink for atmospheric carbon dioxide. In the two last respects, loss of forest is regarded as a concern for the world community as a whole as well as for the countries concerned. Indicators for these respective functions of forest are very different, and only those for production forestry are considered here. A review of biodiversity indicators is given by Reid et al. (1993).

Observation of current forest clearance, such as illegal settlement in forest reserves, is the most direct indicator of pressure. Particular pressure arises where shifting cultivation persists, with its high requirements of land for the cultivation-fallow cycle. Since the major source of pressure comes from demand for land for agricultural purposes, the same indicator is applicable as that for Land Issue 2 above, the ratio of cultivated to cultivable land.

Only one indicator of state is needed, since change in forest area can be directly observed. There are doubts as to the reliability of statistics (e.g. Myers, 1980; Grainger, 1993), but opportunity for cross-checking between census data and remote sensing exists (FAO, 1993c). This is the first land quality indicator of state to be included alongside economic and social indicators in the *World Bank Atlas* (World Bank, 1995c).

Response to forest clearance can be taken by government or at local community level. Legislation to protect forest areas has a role to play, but this is often difficult to enforce, and measures to increase public awareness may be more effective. Increased afforestation is a significant response, especially if undertaken spontaneously by local communities. The ultimate indicator of effective response is the same as that of change in state, viz. a reduction in previous rates of forest loss.

Land issue 4. Forest degradation

Examples: Nepal, northern Thailand, Vietnam

Forest degradation

Indicators of pressure:

- *ratio between harvest of wood (for all purposes) and estimated regrowth*
- *shortages of fuelwood, charcoal or domestic timber, as indicated by high prices*
- *illegal cutting within forests*

Indicators of state and impact:

- *presence of degraded forests (communal or government), as determined by forest inventory or qualitative observation*

Indicators of response:

- *improved community participation in forest protection and management*
- *increased adoption of agroforestry*

The issue of forest degradation, or adverse changes in species and age composition of existing forests and woodlands, is often be a matter of concern at the local level, in the degradation of village or communal woodlands. It can also occur in forest plantations, by illegal cutting.

The basic cause of pressure is an excess of demand for wood products (domestic timber, fuelwood and charcoal) over their supply. National or local surveys can be made of the consumption of wood products, and compared with estimates of the rate of regrowth. Where projected into the future (as has been done, for example, for Kenya), this indicator can serve as an early warning of the need for action. Observed shortages of wood products, as indicated by high prices, are a more easily obtained indicator.

Change in state of forest quality is less easily measured than change in area, requiring forest inventory for quantitative assessment. Response includes both the better management of management of forests, usually based on community participation, and the reduction of pressure through on-farm production of wood by means of agroforestry.

Land issue 5. Degradation of rangelands, particularly in semi-arid areas (desertification)

Examples: Botswana, West African semi-arid (sahel) countries

Degradation of rangelands

Indicators of pressure:

- *Fodder shortages, particularly in the dry season*
- *Ratio of vegetation biomass to feed demand;*
- *Ratios between land, livestock and population, assessed with respect to agro-climatic zone*

Indicators of state and impact:

- *Reduction in plant cover on rangelands*
- *Slow recovery of plant cover after drought years*
- *Adverse changes in plant species composition of pastures, e.g. ratio of annual to perennial grasses, frequency of unpalatable species, presence of indicator plants for degraded pastures*
- *Appearance of areas of trampled, crusted or gullied land*

Indicators of response:

- *adoption of measures for improved range management (control over livestock numbers, rotational grazing, etc.)*
- *number and effectiveness of community institutions for purposes of range management*
- *conflict between pastoral peoples and neighbours*

Following earlier use in loosely-defined ways, desertification is now defined as land degradation in semi-arid areas (p.12). It refers to severe and slowly-reversible, or irreversible, degradation of the plant cover in dry lands, with associated degradation of soils.

Estimation of the ratio between livestock feed demands and vegetation biomass or net primary production (sometimes expressed as livestock carrying capacity) presents particular difficulties due to seasonal migration, but a methodology exists (FAO, 1991). This can be compared with surveys of actual livestock numbers, to develop an index of pressure upon rangeland resources. For rapid and approximate purposes, guideline values on livestock densities which can be supported in different agro-climatic belts exist.

However, this is an example where the need to recognize both pressure and response sides of the issue is crucial. For a given zone, substantially higher livestock densities can be sustained where systems of improved range management are in use (e.g. Ridgway, 1995).

Estimates of the condition of rangeland require ecological surveys. Land cover as estimated by remote sensing (the normalized difference vegetation index, NDVI) provides a standardized approximation, already employed in monitoring systems for early-warning purposes for food security and locust control purposes. These systems are functional at operational level and can be accessed through FAO and WMO regional offices.

Land issue 6. Lowering of the groundwater table caused by over-pumping for irrigation

Examples: Indo-gangetic plains of Pakistan and India

Lowering of the groundwater table

Indicator of pressure:
- *farm water requirements estimated to be in excess of groundwater recharge*

Indicators of state and impact:
- *falling water tables, as monitored at specific sites*
- *reports of tubewells drying up*
- *reports of crop failure/shortfall through insufficient irrigation water*

Indicators of response:
- *reports of deepening of tubewells*
- *adoption of management practices that increase water use efficiency*

Falling water tables in areas dependent on groundwater irrigation are a clear case of natural resource depletion leading to non-sustainable land use. The three groups of indicators are largely self-explanatory. For pressure, the net farm water use (applied water minus drawdown) is compared with the estimated rate of groundwater recharge. Changes can be recorded directly, by monitoring the level of the water table. The first response indicator, that of land users deepening tubewells, shows merely a postponement of the problem; whereas the second, improved water use efficiency, is a move towards a sustainable situation.

Land issue 7. Salinization: rising groundwater tables associated with increase of salts in soils, saline groundwater, or waterlogging

Examples: China, former USSR, Indo-gangetic plains of Pakistan and India

Salinization

Indicators of pressure:

- *application of irrigation water (through dam and canal systems) without adequate measures for drainage*
- *inappropriate water pricing*

Indicators of state and impact:

- *rising water tables, as monitored at specific sites*
- *increasing salinity levels of groundwater*
- *increasing salt content of soil*
- *appearance of patches of saline soil*
- *appearance of areas of waterlogging*
- *reports of crop failure or shortfall through soil salinization or waterlogging*

Indicators of response:

- *implementation of improved measures for irrigation water management*
- *initiation of soil reclamation schemes*
- *increased cultivation of salt-tolerant crops*
- *abandonment of fields or farms due to salinization or waterlogging*
- *trends in expenditure on maintenance of distribution canals, etc.*

Pressure on the land resource is widely experienced where canal irrigation is practised without adequate drainage and water management, It involves interaction between water and soil resources. Consequences for soils include salinization and alkalization. It has been estimated that worldwide, water management on 60 percent of irrigated areas requires upgrading if the land is to remain in good condition (World Bank, 1994, p.29).

Pressures are brought about directly where irrigation water is applied without adequate measures for drainage. This can be brought about by inappropriate water pricing. One of the response indicators, an increase in cultivation of salt-tolerant crops, can also be regarded as an indirect indicator of pressure.

Among the state indicators, rising water tables provide an early warning of the problem. The appearance of salinized patches, areas of total crop failure surrounded by rings of crop damage, indicate a late stage. These indicators are already employed in the management of some irrigation schemes. However, many canal schemes are inefficient users of water, with over two thirds of water lost to evaporation and seepage.

In the case of large-scale canal irrigation, ameliorative response must be taken at project level. This land degradation issue provides a clear illustration of the general case, that the cost of prevention is far higher than that of reclamation. In the absence of action for the scheme as a whole, the only responses open to farmers are to cultivate salt-tolerant crops or abandon the land.

Conclusions

The land quality indicators listed above are examples only, and are not intended to be comprehensive The lists of indicators include some which are only suited to use at national level, others at district and local levels. By no means all are fully quantitative, particularly those appropriate for the local level. For any given scale of use, selections will need to be made from the lists of indicators given. The selection of indicators should meet three basic criteria:

- measurability;
- analytical soundness;
- policy relevance and utility for users.

The pressure-state-response framework is not a rigid classification; some indicators directly describe one of these three aspects, but indirectly show another. The main conclusion is that for any given land issue, land quality indicators can be identified on which appropriately show the nature and degree of pressure, changes in state, and response, and for which data are either available or can be obtained practicably.

A considerable amount of testing and validation will be required before proven sets of indicators become available, which will permit comparisons in space and time. Aspects requiring further work include (see Chapter 6):

- testing of proposed indicators, appropriate for use at district and at national scales;

- identification of data sources for these (Chapter 5);
- specification of standards and threshold limits (p.13).

CHAPTER 5. SOURCES OF DATA AND INFORMATION

The information pyramid

Indicators are not simply data. They convey the most significant aspects of complex phenomena in a manner which is easily understandable, including by non-specialists. Data and information can be regarded as an information pyramid (Figure 1). At the base, and having the largest volume, are the primary data. In the field of soil science, for example, this would contain records of soil texture, organic matter, nitrogen content, etc.; in forestry, it would be the primary results of forest inventory. Next comes a level of analyzed data, formed by combining elements of primary data, including statistics and maps.

Indicators come higher in the pyramid and are fewer in number. They can be obtained either by synthesis or selection. In the case of synthesis, a range of information obtained from primary or analyzed data is combined to form the indicator. An example is the ratio of currently irrigated to potentially irrigable land, obtained by comparing records of land use (primary data) with estimates of irrigable land (analyzed data). The alternative is to select, from primary or analyzed data, one measure which is representative of a group of features. An example is forest area, which is at the same time a surveyed variable and a direct indicator of deforestation.

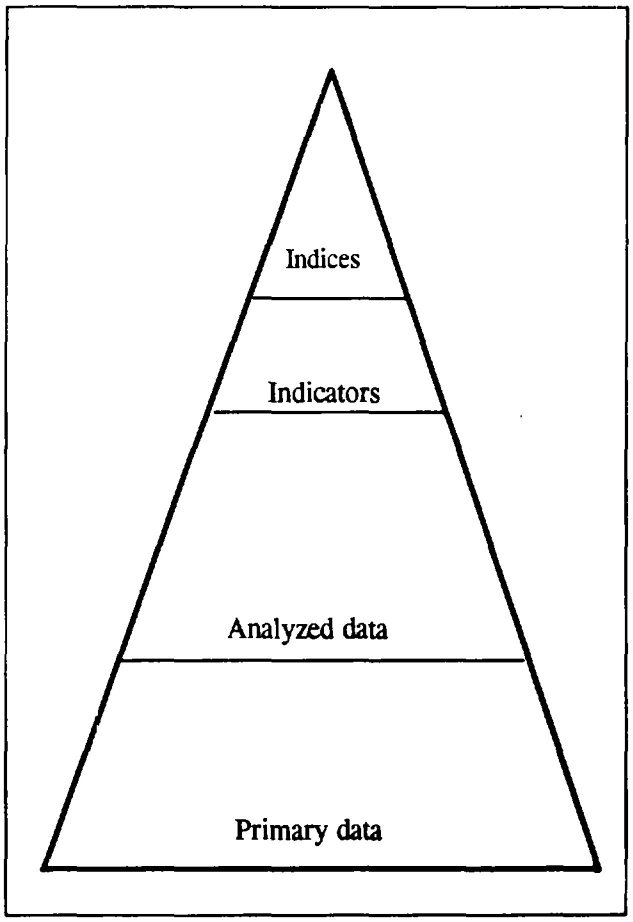


Figure 5.1 The information pyramid (Hammond et al., 1995; SCOPE, 1995).

Data sources for land quality indicators

The following brief review of some major data sources is of necessity concerned mainly with sources at national and international levels. Data at country and district levels are highly variable as to their existence, nature, quantity and reliability. Once the data requirements for indicators are determined, countries will need to do their own reviews of availability and gaps. A recent review of core data needs is given in Estes et al. (1995).

The pressure-state-response framework will be taken as a basis for review, although some sources cover more than one aspect. There is some degree of overlap, different databases being dependent upon the same primary sources.

Sources for pressure indicators

At national level, pressure indicators can be developed in many cases by using available statistical data, mainly census-based. It is not enough simply to take socioeconomic data, such as population, production, etc., in isolation. The essence of pressure indicators is to show the relations between the requirements of society (for food, wood products, etc.) and the land resources available to produce those requirements. Hence what is required is to link socioeconomic data with information on land resources. Examples are to relate food production with the volume of water used to produce it, or the nutritional value of food to measures of health of the rural population.

Some international sources for the development of pressure land quality indicators are:

World Bank Economic and Social Database (BESD) About two million time series in 40 data files, obtained from World Bank and UN agency sources. The most relevant data files are FAOPROD and FAOFERT, which include agricultural production, inputs and land use.

World Resources Institute Database Over 500 variables for about 200 countries. Contains many data from the same sources as BESD but the data are processed further, often combining human requirements with land resources and summarized as ratios, some of which can be directly used as indicators.

At national and district levels, information at various scales and of differing quality is available from national census sources, including agricultural censuses.

Sources for state indicators

All information about the state of land quality is dependent upon the extent and quality of basic surveys. A large amount of work has been directed at natural resource survey and land evaluation, respectively the mapping of land resources and the assessment of their potential. Methods for these purposes have been well standardized, although the proportion of the developing world covered by surveys at other than small (broad) scales remains very limited.

Far less work has been done on monitoring changes in land quality over time. An exception is the continuing effort being put into securing improved knowledge of deforestation (FAO, 1993c;

Grainger, 1993). Quantitative information on soil erosion and its effects remains patchy, whilst estimates of desertification are highly subjective (Bie, 1990; Thomas and Middleton, 1994). To date, there have been few attempts to monitor soil changes over time, other than on agronomic experimental sites (p.46).

Some international sources for the development of indicators of state, and change in state, of land quality indicators are:

World Resources Institute Database (see above)

FAO/ISRIC Databases FAO maintains a collection of climatic, soil and agro-ecological databases, some held jointly with the International Soils Reference and Information Centre (ISRIC). Among these are;

- The FAO/ISRIC Soil Database, consisting of a digitized version of the Soil Map of the World (scale 1:5M) (FAO/UNESCO, 1970-80), together with representative soil profiles.
- The Agro-ecological Zones (AEZ) Data Bank, a global database on climate, soils, landforms and some land use. This is linked to a generalized crop growth model which estimates 'anticipated yields', which could provide a basis for comparison with actual yields.

UNEP/ISSS/ISRIC/FAO Databases Methodology develop new for these databases was done by ISRIC, with technical advice from FAO and ISSS, and funding from UNEP.

- The Global Assessment of Soil Degradation (GLASOD) database, a digitized version of the GLASOD world maps of human-induced soil degradation (scale 1:1M) (Oldeman et al., 1990). The map and data are based on estimates of the types, extent and severity of soil degradation made by scientists from each country. It is thus subjective, but is the only world source presently available.
- The World Soils and Terrain Database (SOTER), is a database structure that which provides information on landforms, soils, vegetation, land use and climate, linked to a geographic information system (ISRIC, 1993). It is currently available only for certain countries.

World Soil Resources Database This is maintained by the Natural Resource Conservation Service of the US Department of Agriculture. It contains global, national and regional digitized soil maps, and files on soil pedons (profiles), soil carbon and soil climate. Whilst considerably more detailed for the USA, there is also substantial world information, and it is the largest store of soil profile data available.

Databases maintained by international agricultural research centres (CGIAR centres) The data holdings of some centres are extensive, often with a regional emphasis. These include CIAT (including climatic information for 19 000 tropical stations), ICRAF (mainly for Africa) and ICRISAT.

Other sources for indicators of state are information derived from long-term experiments, modelling and local knowledge, discussed below.

Sources for response indicators

Because of the widely differing nature of policies, institutions and services, many response indicators will need to be developed on a national basis. In some cases, changes over time in pressure or state indicators will also be responses to policy or actions, for example, reductions in the rate of deforestation or soil salinization. Improved access to fertilizers, or a change in the balance of types of fertilizer applied, may be response indicators which can be obtained from agricultural census statistics. The WOCAT Project (University of Bern, Switzerland) is compiling a database of conservation practices used in different regions of the world.

Taking soil conservation as an example, response indicators could be developed covering such aspects as:

- increase in the extent of land with adequate conservation measures, as a percentage of land at risk;
- adequacy of conservation services available to farmers;
- percentage of farmers belonging to associations active in conservation;
- existence and effectiveness of government programmes for improved land husbandry.

The use of modelling

The scarcity of information for state land quality indicators, and the slow rate of change of some soil properties, requires the application of indirect procedures, among which are physical process models. In soil science, many such models have been developed for research purposes (Young, 1994), and some have been verified in different environments, including the tropics. Among the models potentially applicable for development of indicators are the following:

- Erosion Productivity Impact Calculator (EPIC). This is a complex model, requiring much data input, which was developed on the basis of US conditions but is being adapted to tropical environments. It provides estimates of the rate of erosion (t ha^{-1})

and predicted effects on crop yield. It has been integrated with economic models to analyze the environmental impact of proposed agricultural programmes (Foster, 1988).

- CENTURY. The CENTURY model (not an acronym) provides estimates of future changes in soil organic matter (as carbon) and nitrogen under specified environmental conditions and agricultural practices (Parton et al., 1989).
- Nutrient balance model. This estimates the nutrient balance for specified land use systems, based on data for nutrient inputs and outputs. It can be applied as scales ranging from farm to national (Stoorvogel and Smaling, 1990; see also p.32).

EPIC and CENTURY require a large number of input variables, although default data are available for some environments. Simpler models, applicable to tropical conditions, are available through the Tropical Soil Biology and Fertility programme (TSBF), and in the SCUAF (Soil Changes Under Agriculture, Forestry and Agroforestry) model developed by ICRAF (Young and Muraya, 1990).

There are dangers in the uncritical application of models, particularly that they may give the impression that actual field data exists. Comparison with indicators derived from direct measurements (e.g. of crop yields) is always desirable.

Long-term agronomic experiments

Long-term agronomic experiments are a source of direct information on trends in soil properties and crop yield in response to known inputs and management. One of the best known is the 'broadbalk field' at Rothamsted, UK, which has been cropped to wheat for more than 150 years (Powlson and Johnston, 1994). Such experiments are few in number owing to problems of finance and institutional continuity, but there has been renewed interest in them, for their potential to provide real-time rates of processes that are too slow to measure within the life of single-projects or standard agronomic experiments. For example, 24 experiments in semi-arid West Africa revealed differing trends according to environment and inputs, some showing a decline in soil fertility, others sustainable production (Pieri, 1995).

The Rockefeller Foundation has completed a global inventory of long-term agronomic experiments as a source of research information (Steiner and Herdt, 1993). These could be a valuable supporting source of information on land quality indicators, particularly in revealing probable trends, for which surveys could be made to determine their extent on farmland.

The GTOS program (Global Terrestial Observing System) is preparing a database of existing terrestial monitoring sites. This program is sponsored by FAO/UNEP/UNESCO/WMO/ICSU.

Making use of local knowledge

In many parts of the world there is a large store of local knowledge which, in the sense employed here, would be called knowledge of land quality indicators. Often this consists of plant indicator species, indicative of fertile, infertile, shallow or saline soils, or of impeded drainage. A well-known example is the colonization of highly-degraded land by the grass, *Imperata cylindrica*. Pastoral peoples are skilled at judging rangeland quality, and make livestock management decisions on the basis of this knowledge.

There is scope for making use of such knowledge in systems of indicators. On the one hand, it could be put on record for wider use, for example as lists of indicator plants. Studies could be made of how local knowledge is linked to trends based on indicators at higher levels of scale.

Combining data of different types

Problems arise in relating census-type data with data from remote sensing. Established statistical data is collected administratively or by means of questionnaires. Its spatial basis is administrative units or census areas, often aggregated to larger areas on the basis of administrative boundaries. By contrast, remotely sensed data, based on inference from landforms and land cover, supported by sample ground observations, lead directly to production of maps based on boundaries of natural landscape units, and are thus not directly available for administrative units. Remote sensing can lead to considerable economies of effort and expense in data collection. The use of remote sensing in conjunction with geographical information systems, in which thematic (including environmental) information can be digitized and overlaid onto topographic, administrative and cadastral maps, has advanced rapidly to operational levels among international and some national agencies.

Data from these two kinds of source can be made compatible where:

- both types of survey collect data on the basis of common classification systems;
- census data are collected, and made available, for georeferenced areas;
- in remote sensing surveys, the boundaries of administrative units or census areas are transferred to maps, and data abstracted for these (UNEP/FAO, 1994, p.38).

Whilst possible in principle, the practical problems of achieving such integration in developing countries are considerable. They include problems of delineating administrative boundaries in countries with a poor topographic and cadastral mapping base, and problems of confidentiality and security in the release of data. Integration of this kind has been achieved, for example in Canada (Korporal, 1993). There is particular value for cases where data can be checked from one source to another. This applies to many types of land use and cover, including forest cover, arable land and types of crop.

Dispersed data sources and guides to their use (metadata)

It is not intended that there should be any one central data bank for land quality indicators. Data will be held on a dispersed basis, among existing institutions, linked electronically and shared through established protocols.

To coordinate these sources, there is a need for compilation of metadata banks, where **metadata** refers to information about data held by specific institutions: its nature, sources, scale, reliability, how to obtain it, cost, security, and georeferencing system. Development of such a metadata base will assist in highlighting gaps in required information. Some major institutions involved in metadata are the US Geological Survey, the Consortium for International Earth Science Information Network (CIESIN), and the GEMS/GRID facility (Estes et al., 1995).

Filling gaps in data

In the present review, emphasis is placed on the potential for making better use of existing sources of data. Modelling may help to fill some gaps. There is a further possibility of using surrogate (substitute) indicators, as in the use of crop yield to indicate soil fertility. These proposals are made with a view to economy of effort, and to allow indicators to be obtained and put to use immediately.

However, this should not be allowed to obscure the fact that there are large gaps in data on land quality, and many problems over its reliability. For two kinds of land use and cover of the highest importance, arable land and forest cover, considerable doubts have been expressed over the reliability of official statistics (UNEP/FAO, 1994; Rodenburg, 1993). There is a need for better field measurement of soil erosion and its effects upon production. Estimates of desertification are still more uncertain (Bie, 1990; Thomas and Middleton, 1994). The extent to which current land use and management practices are causing land degradation is poorly quantified, and there is an over-reliance on modelling and visual criteria. There is scope for the enlargement of national agricultural censuses to provide better data on land management practices (Dumanski et al., 1994, p.46).

The measurement of changes in soil properties, or **soil monitoring**, is still at an early stage. It has been successfully achieved on agronomic experiments, but only rarely under practical field conditions. By means of benchmark sites or a statistically-controlled programme of stratified sampling, it would be possible to design a system of soil monitoring for inclusion in the monitoring and evaluation activities of projects. At national level, soil monitoring could become one of the basic activities of national soil survey organizations (Young, 1991; Acton et al., 1995). This is possibly the most serious data gap needed for land quality indicators.

If decisions on land policy and management are to be put on a sound factual basis, it is of the highest importance to improve data availability for less developed countries. The UNCED conference noted that, "the gap in the availability, quality...and standardization of data between the developed and the developing world has been increasing, seriously impairing the capacities of countries to make informed decisions concerning environment and development" (UNCED, 1992).

Although it has been noted here that useful data for indicators can be obtained by making use of existing sources of information, it should be appreciated that to obtain reliable, quantitative information on changes in land quality will require time, effort and expenditure. This is no different from the situation which applies to economic and social data, the collection and analysis of which requires much effort and skill. "The significance of the information supplied by [land quality] indicators depends on the level of professional analysis which is undertaken" (Hamblin, 1994).

For developing countries, further work is best done by national environmental organizations, some of which are at present weakly staffed and poorly financed. There is a need for international assistance to such institutions.

A land quality index?

In a number of economic and social areas, the top of the information pyramid (p.40) has been reached in the form of indices. These are values which represent a summation of conditions over broad fields. Gross national product (GNP) per capita is widely used as an index of the wealth of nations, and child malnutrition as an index of food availability (World Bank, 1995c). A human development index (HDI) has been developed to represent human well-being, consisting of a combination of GNP with measures of health (using life expectancy as an indicator), and education (UNDP, 1994).

Could a similar index be developed for land quality? This would need to combine sub-indices for changes in soils, water resources, forests and rangelands. One component, change in forest cover, is already available (World Bank, 1995c). There can be no such land quality index until much further work has been done on the indicators on which it must be based. In principle it is possible, however, and it represents a target for the future.

CHAPTER 6. THE NEXT STEPS

Objectives of further work

As the outcome of work conducted in 1994-95, including consultancies and three international workshops, substantial progress has been achieved. A set of definitions and a conceptual framework for land quality indicators have been established, and a first appraisal of data needs and sources conducted. Sets of major land issues have been identified for a range of environmental conditions in the tropics and subtropics, and examples of land quality indicators relating to these have been formulated. The applications of land quality indicators at different scales - farm and local, district or project, national and international - have been recognized.

The next objectives are to obtain specifications for sets of land quality indicators which can be used to guide policy and decision making at the required scales, and to develop standard procedures for measuring these. Substantial further work will be needed, particularly in developing countries, for this to be achieved. As noted above, the focus of the work to be conducted under the current World Bank/FAO/UNDP/UNEP programme will be on managed agro-ecosystems, that is, on land used primarily for agricultural and forestry production purposes. Priority will be given to two scales or levels, district (project) and national, with the data at national level permitting international comparisons. Contact will be maintained with other institutions working in the area of natural ecosystems, conservation and biodiversity.

The basic requirement is to develop cost-effective ways of obtaining internationally agreed sets of land quality indicators. The broader objective is to build a strong global coalition among international, regional and national organizations to work towards the establishment of decision-support tools that integrate biophysical and socioeconomic information requirements for undertaking sustainable land management.

Requirements for the development of land quality indicators

Specific requirements necessary for achieving the above objectives include the following:

Data sources Further sources of data need to be identified, at national scales and at district scales for selected countries. The focus should be on selecting data most relevant to land quality indicators, using existing and concurrent data inventories as a guide (Estes et al., 1995). A purpose-built metadata guide should be compiled, which tells users what data are available and how they can be accessed. The role of remote sensing applications, and how these can be linked with conventional statistical sources, needs further study. Ways in which local knowledge ('grass roots' information) can be formalized, and linked with conventional data sources, need to be investigated.

Ways of making better use of data from existing national institutions, such as census bureaux and soil surveys, should be examined.

Data gaps Parallel to the work on data sources will be the task of identifying what important data gaps exist and how they might be filled. An example is the present extreme scarcity of georeferenced information on changes in soil properties over time, at scales significant for decision makers. Improvements in land use data will be needed, based upon current work on land use and cover classification (UNEP/FAO, 1994). Another large gap concerns information on current land management practices, such as management of organic residues, or methods of soil conservation actually employed. These data gaps should be related to the need for upgrading of existing data banks.

Standards and thresholds To be of practical use in policy and management, quantitative standards and threshold limits for indicators will be needed. In soil erosion, for example, there is a need for estimates of the rate of soil loss at which production is sustainable, and the threshold rate at which there is a danger of acceleration leading towards severe and irreversible damage, in each case linked to specific soil types. Comparable work is needed with respect to other natural resources and physical processes.

Priority land quality indicators The preceding aspects contribute towards the main objective, to develop sets of indicators for measuring change in land quality in the major agro-ecological zones of developing countries. As noted above, this will be targeted at agricultural and forestry production systems, and at the district (project) and national scales. The indicators should cover all major natural resources for rural land use, including soils, water and vegetation.

Scales of application Methods will be needed to convert indicators developed at local scales (large scales, e.g. 1:10 000 to 1:25 000) to regional and national scales (small scales, e.g. 1:250 000 to 1: 1 000 000), and more generally, to achieve compatibility between indicators at different scales.

Applications of indicators It is neither necessary nor desirable to wait until completion of the development work before applying land quality indicators in practical situations. As soon as specific indicators have been clearly defined, they can be tested through application to policy and management decisions, and the effects noted. In this respect, the monitoring of response, and of its feedback effects upon pressure and land quality, is of special importance.

Pilot studies and observation sites

An important contribution towards the above work will be made by means of a set of pilot studies in different agro-ecological zones of developing countries. These should include countries with relatively good data coverage and with poorer sources of information, the former to give guidance on the ideal methods, the latter to test what can be done in less favourable circumstances. Without such studies, further work on land quality indicators will be of very limited value.

The pilot studies can be built into existing situations. At the district level, this can be done through ongoing World Bank projects in the area of natural resource management, projects of other agencies, or by linking with university research studies. At national level, countries should be sought which express a willingness to cooperate in the development and application of indicators. Both at district and national levels, much of the pilot project work should be carried out by national staff. This will require methodological guidance and some financial support.

Another possible approach is to establish a network of observation sites, located in critical environmental areas ('hot spots'), and possibly linked with the recently-developed Global Terrestrial Observation Sites (GTOS) initiative of FAO/UNEP/UNESCO/WMO/ICSU. These would consist of areas of normal farmland, either as coherent block or by means of controlled sampling within larger farm systems. The focus would be to monitor changes in land quality, but in accordance with the pressure-state-response framework, indicators or pressure and response would also be recorded. In this way, changes in land quality, and their causes, could be observed in more detail than is possible at even the district scale. The observation areas could be linked with still more intensively-studied sites, of one hectare or less, on which research is conducted into the basic processes underlying changes in land quality. Current research conducted by the Tropical Biology and Fertility programme (TSBF) demonstrates this approach (Woomer and Swift, 1995).

Requirements for the programme of work

There is no question that land quality indicators are needed, both at district and national scales. The extent and severity of land degradation alone calls for better methods of quantifying and monitoring changes in land quality, so that practical measures can be taken which will lead to better methods of land management to ensure sustainable production.

Because of the urgency of the situation, initial activities will be based on making best use of existing methods and sources of data. This will show where important gaps in knowledge exist, and work can then progress towards the collection of new information.

To carry out a programme of work for the development of land quality indicators, the following organizational elements will be needed:

- **Scientific continuity** Coordination and further development of the research activities, including the capacity to take new scientific initiatives where required.
- **Interdisciplinary resources** Joint work between specialists in land resources, sector specialists, and socioeconomists.

- **A global coalition of institutional collaboration** Many of the tasks will be carried out by a range of institutions, both in developed and developing countries. A clear framework is needed to coordinate these activities.
- **Cooperation with users of indicators** An ongoing interchange between the specialists responsible for the development of indicators and the policy and management staff who can apply them to practical situations.

These requirements will call for professional staff of high calibre, an appropriate collaborative institutional structure, scientific and administrative continuity, and funding.

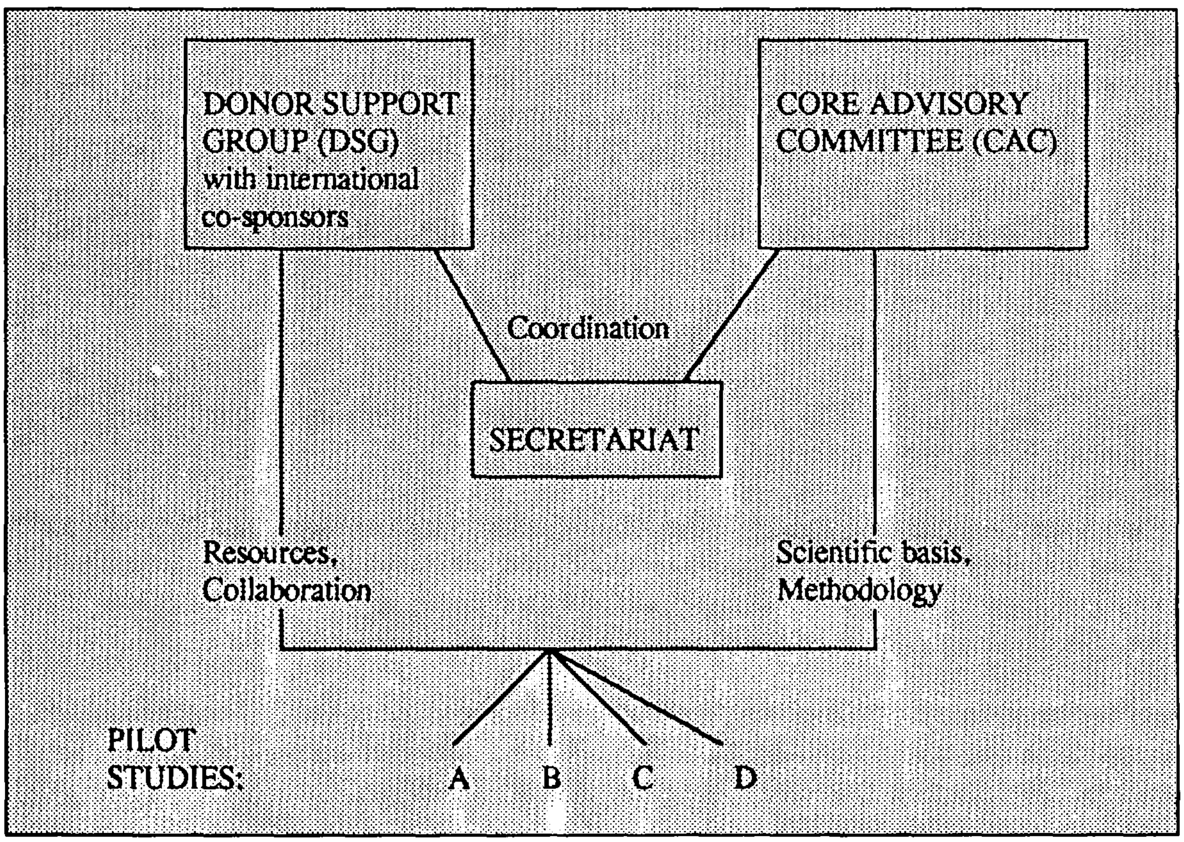


Figure 6.1. A proposed institutional framework for the development of land quality indicators (World Bank, 1995b)

Institutional Framework

The Workshop held in Washington DC, June 1995, proposed an institutional framework to undertake further development of land quality indicators. This would consist of a Secretariat, a Donor Support Group, and a Core Advisory Committee (Figure 6.1). Leading roles would be taken by the World Bank, FAO, UNDP and UNEP, based upon joint letters of agreement. The provisional functions of the framework are as follows:

Donor Support Group (DSG) To provide financial resources and support for participating institutions. Membership would be self-selecting, by donors expressing willingness to join in supporting the activities.

Core Advisory Committee (CAC) To provide scientific guidance on the development of land quality indicators. Membership would include both technical experts and potential users of results, particularly from developing countries. Members would participate as individuals.

Secretariat To coordinate activities, including those of the donor support group, the core advisory committee, and pilot studies. Specifically, the Secretariat's role would be:

- to build a broad coalition among donors, institutions engaged in developing land quality indicators, and potential users of indicators;
- to provide guidance, via the Core Advisory Committee, on specific work to develop land quality indicators through cooperation between agencies;
- to provide scientific coordination and continuity;
- to secure funding for these tasks.

Annex A. An approach towards an international classification of land use. Modified from UNEP/UNDP/FAO (1994) and Sombroek and Sims (1995)

Level I DEGREE OF MODIFICATION OF ECOSYSTEM	Level II PURPOSE OF LAND USE	Level III LAND USE SYSTEM
USES BASED ON NATURAL ECOSYSTEMS	Not used	Not used
	Conservation	Total, e.g. Nature reserves Partial
	Collection	Of plant and/or animal products
USES BASED ON MANAGED ECOSYSTEMS	Forestry production	From natural forests From planted forests
	Livestock production	Nomadic grazing Extensive grazing Intensive livestock production Protected livestock production
	Crop production	Shifting cultivation Production of annual crops Production of perennial crops Wetland cropping (rice, etc.) Protected crop production
	Fisheries production	Fishing Aquaculture
SETTLEMENT AND RELATED USES	Recreation	Types of recreational activities
	Mineral extraction	Mining Quarrying
	Settlement	Residential Commercial Industrial Infrastructure
	Uses restricted by security	Military use, etc.

REFERENCES

Acton, D.F. (ed.) 1994. A program to assess and monitor soil quality in Canada. Centre for Land and Biological Resources Research. Research Branch. Agriculture and Agri-Food Canada. Ottawa, Canada.

Acton, D.F. (ed.). 1994 .A program to assess and monitor soil quality in Canada. Centre for Land and Biological Resources Research. Research Branch. Agriculture and Agri-Food Canada. Ottawa, Canada. pp. 201.

Adriaanse, A. 1993. Environmental policy performance indicators. A study on the development of indicators for environmental policy in The Netherlands. Uitgeverij, The Hague.

Barrow, C. J. 1991. Land degradation: development and breakdown of terrestrial environments. Cambridge University Press, Cambridge, UK.

Bie, S. W. 1990. Dryland degradation measurement techniques. Environment Working Paper 26. The World Bank, Washington, D.C.

Dalal-Clayton, B. and Dent, D. 1993. Surveys, plans and people. A review of land resource information and its use in developing countries. Institute for Environment and Development, London.

Dumanski, J. D., L. J. Gregorich, V. Kirkwood, M.A. Cann, J.L.B. Culley, and D.R. Coote. 1994. The status of land management practises on agricultural land in Canada. Centre for Land and Biological Resources Research. Research Branch. Agriculture and Agri-Food Canada. Ottawa, Canada.

Dumanski, J., Eswaran, H., Pushparajah, E., Smyth, A. and Elliott, C. R. (eds.) 1991. Evaluation for sustainable land management in the developing world. Volumes I-III. IBSRAM Proceedings 12. IBSRAM, Bangkok.

ECOSOC (Commission on Sustainability) 1995. Review of sectoral clusters, second phase: land, desertification, forests and biodiversity. UN, New York.

Estes, J., Lawless, J. and Mooneyhan, D. W. (eds.) 1995. International symposium on core data needs for environmental assessment and sustainable development strategies, Bangkok, November 15-18, 1994. Volumes I and II. UNDP/UNEP, Nairobi.

FAO 1976. A framework for land evaluation. FAO Soils Bulletin 32. FAO, Rome.

FAO 1978-81. Report on the agroecological zones project. Volumes I-IV. World Soil Resources Report 48/1-4. FAO, Rome.

FAO 1979. A provisional methodology for soil degradation assessment. FAO, Rome.

FAO 1982a. Potential population supporting capacities of lands of the developing world. FAO/UNFPA/IIASA, Rome.

FAO 1982b. World soil charter. FAO, Rome.

FAO 1983. Guidelines: land evaluation for rainfed agriculture. FAO Soils Bulletin 52. FAO, Rome.

FAO 1984a. Land evaluation for forestry. FAO Forestry Paper 48. FAO, Rome.

FAO 1984b. Land, food and people. FAO, Rome.

FAO 1985. Guidelines: land evaluation for irrigated agriculture. FAO Soils Bulletin 55. FAO, Rome.

FAO 1991. Guidelines: land evaluation for extensive grazing. FAO Soils Bulletin 58. FAO, Rome.

FAO 1993a. Guidelines for land-use planning. FAO Development Series 1. FAO, Rome.

FAO 1993b. Agro-ecological assessments for national planning: the example of Kenya. FAO Soils Bulletin 67. FAO, Rome.

FAO 1993c. Forest resources assessment 1990: tropical countries. FAO Forestry Paper 112. FAO, Rome.

FAO 1994. Land degradation in South Asia: its severity, causes and effects upon the people. World Soil Resources Report 78. FAO, Rome.

FAO/UNESCO 1970-80. Soil map of the world 1:5 000. Volumes 1-10. UNESCO, Paris.

Foster, G. R. 1988. Modeling soil erosion and sediment yield. In: Soil erosion research methods (ed. R. Lal, Soil and Water Conservation Society, Ankeny, USA), pp. 97-117.

Gallopin, G. C. 1994. Agroecosystem health: A guiding concept for agricultural research? In: N.O. Neilsen (ed.). Agroecosystem Health. University of Guelph, Guelph, Ontario, Canada.

Grainger, A. 1993. Rates of deforestation in the humid tropics: estimates and measurements. Geographical Journal 159, pp. 33-44.

Greenland, D. J. and Szabolcs, I. 1994. Soil resilience and sustainable land use. CAB International, Wallingford, UK.

Hamblin, A. (ed.) 1992. Environmental indicators for sustainable agriculture. Report on a national workshop, November 28-29, 1991. Bureau of Rural Resources, Canberra.

Hamblin, A. 1994. Indicators for sustainable agriculture in the Asia-Pacific region. In: Technology assessment and transfer for sustainable agriculture and rural development in the Asia-Pacific region - a research management perspective (ed.R. Kwaschik, R. B. Singh and R. S. Padoda, FAO, Rome), pp. 47-86.

Hammond, A., Adriaanse, A., Rodenburg, E., Bryant, d. and Woodward, R. 1995. Environmental indicators: a systematic approach to measuring and reporting on environmental policy performance in the context of sustainable development. World Resources Institute, Washington, D.C.

ISRIC 1993. Global and national soils and terrain digital databases (SOTER). Procedures manual. ISRIC, Wageningen, The Netherlands.

ISSS 1982. The world soil charter. Plan of action to implement a world soils policy. Bulletin of the International Society of Soil Science 62, pp. 30-37.

Izac, A.-M. and Swift, M. J. 1994. On agricultural sustainability and its measurement in small-scale farming in Sub-Saharan Africa. Ecological Economics 11, pp. 105-125.

Korporal, K. D. 1993. Remote sensing: the Statistics Canada experience. In: The impact of remote sensing on the European statistical information system (European Communities, Luxembourg), pp. 55-61.

Lewis, L. A. 1987. Predicting soil loss in Rwanda. In: Quantified land evaluation procedures. ITC Publication 6, ed. K. J. Beek, P. A. Burrough and D. E. McCormack, ITC, Enschede, The Netherlands), p. 137-139.

Lutz, E. 1993. Toward improved accounting for the environment. an UNSTAT-World Bank symposium. World Bank, Washington, D.C.

Mercoiret, M.-R. (ed.) 1989. Les interventions en milieu rural: principes et approche méthodologique. Ministère de la Cooperation et du Developpment. La Documentation Française, Paris.

Myers, N. 1980. Conversion of tropical moist forests. National Academy of Sciences, Washington, D.C.

Myers, N. 1992. Population/environment linkages: discontinuities ahead. *Ambio* (1992), pp.116-118.

O'Connor, J. 1995. Monitoring environmental progress. A report on work in progress. Draft March 1995. World Bank, Washington, D.C.

OECD 1993. OECD core set of indicators for environmental performance reviews. Environment Monograph 83. OECD, Paris.

OECD 1994. The use of environmental indicators for agricultural policy analysis. COM/AGR/CA/ENV/EPOC(94)48/REV1. OECD, Paris.

Oldeman, L. R., Hakkeling, R. T. A. and Sombroek, W. G. 1990. World map of human-induced soil degradation. ISRIC, Wageningen, The Netherlands, and UNEP, Nairobi.

Pagiola, S. 1995. Environmental and natural resource degradation in intensive agriculture in Bangladesh. Environment Department Paper 15, The World Bank, Washington, D.C.

Parton, W. J., Sanford, R. L., Sanchez, P. A. and Stewart, J. W. B. 1989. Modelling soil organic matter dynamics in tropical soils. In: Dynamics of soil organic matter in tropical ecosystems (ed. Coleman, D. C., Oades, J. M. and Uehara, G., University of Hawaii, Manoa, USA), pp. 153-171.

Pieri, C. 1993. Soil fertility management for intensive agriculture in the tropics. In: Agriculture and environmental challenges (ed. J. P. Srivastava and H. Alderman, World Bank, Washington, D.C.), pp. 81-100.

Pieri, C. 1995. Long-term soil management experiments in semiarid francophone Africa. In: Soil management. Experimental basis for sustainability and environmental quality (ed. R. Lal and B. A. Stewart, CRC, London), pp. 225-266.

Pimentel, D. and 10 others 1995. Environmental and economic costs of soil erosion and conservation benefits. *Science 267*, pp. 1117-1123.

Pol, Floris (van der) 1991. L'épuisement des terres, une source de revenus pour les paysans au Mali-Sud. In C. Pieri (ed.) *Savanes d'Afrique, terres fertiles*, pp. 403-418

Powlson, D. S. and Johnston, A. E. 1994. Long term field experiments: their importance in understanding sustainable land use. In: Soil resilience and sustainable land use (ed. D. J. Greenland and I. Szabolcs, CAB International, Wallingford, UK), pp. 367-394.

Reid, W. V., Neely, J. A., Tunstall, D. B., Bryant, D. A. and Winograd, M. 1993. Biodiversity indicators for policy-makers. World Resources Institute, Washington, D.C.

Ridgway, R. 1995. Development of desertification indicators for field level implementation. Working Paper prepared by the Office to Combat Desertification and Drought (UNDP/UNSO) and Natural Resources Institute (NRI), Chatham Maritime, UK.

Rodenburg, E. 1993. Eyeless in Gaia. World Resources Institute, Washington, D.C.

Ruthenburg, H. 1980. Farming systems in the tropics. Clarendon, Oxford, UK.

Schramm, G. and Warford, J.J. (eds.) 1989. Environmental management and economic development. Hopkins, Baltimore, for World Bank.

SCOPE 1995. Environmental indicators: a systematic approach to measuring and reporting on the environment in the context of sustainable development. Bureau de Plan, Brussels.

Sombroek, W. G. and Sims, D. (1995). Planning for sustainable use of land resources: towards a new approach. FAO, Rome.

Steiner, R. A. and Herdt, R. W. (eds.) 1993. A global directory of long-term agronomic experiments. Volume 1. Non-European experiments. Rockefeller Foundation, New York, USA.

Stocking, M. 1978. A dilemma for soil conservation. *Area 10*, pp. 306-308.

Stoorvogel, J. J. and Smaling, E. M. A. 1990. Assessment of soil nutrient depletion in Sub-Saharan Africa: 1983-2000. Volume I: Main Report (second edition). Report 28, Winand Staring Centre for Integrated Land, Soil and Water Research, Wageningen, The Netherlands.

Thomas, D. S. G. and Middleton, N. J. 1994. Desertification: exploding the myth. Wiley, Chichester, UK.

UN CCD. 1994. Part 1, Article 1a). UNEP, Nairobi.

UNCED 1992. Agenda 21. 1. Adoption of agreements on environment and development. 2. Means of implementation. UNCED, Rio de Janeiro.

UNDP 1994. Human development report 1994. Oxford University Press, Oxford, UK.

UNEP 1983. Environmental guidelines for the formulation of national soil policies. UNEP, Nairobi.

UNEP 1992. Desertification, land degradation [definitions]. Desertification Control Bulletin 21. UNEP, Nairobi.

UNEP/FAO 1994. Towards international classification systems for land use and land cover. Annex V in: Report of the UNEP/FAO expert meeting on harmonizing land cover and land use classifications. GEMS Report Series 25. UNEP/FAO, Nairobi.

UNEP/UNDP/FAO 1994. Land degradation in South Asia: its severity, causes and effects upon the people. World Soil Resources Report 78. FAO, Rome.

USDA 1989. The second RCA appraisal. Soil, water and related resources on nonfederal land in the United States. Analysis of condition and trends. US Department of Agriculture, Washington, D.C.

Winograd, M. 1994. Environmental indicators for Latin America and the Caribbean: towards land-use sustainability. GASE Ecological Systems Analysis Group, World Resources Institute, Washington, D.C.

Wischmeier, W. H. and Smith, D. D. 1978. Predicting rainfall erosion losses - a guide to conservation planning. US Department of Agriculture Handbook 537, Washington, D.C.

Woomer, P. L. and Swift, M. J. 1995. The biology and fertility of tropical soils. Report of the Tropical Soil Biology and Fertility Program (TSBF) 1994. TSBF/UNESCO-ROSTA, Nairobi.

World Bank 1992. Development and the environment: world development indicators. World Development Report 1992. World Bank, Washington, D.C.

World Bank 1994. World development report 1994. World Bank, Washington, D.C.

World Bank 1994b. Making development sustainable: the World Bank group and the environment, fiscal 1994. World Bank, Washington, D.C.

World Bank 1995a. Workshop on land quality indicators, June 20-21, 1995, Washington, D.C. Background Papers I-V. World Bank, Washington, D.C.

World Bank 1995b. Land quality indicators: report on a workshop, June 20-21, 1995, Washington DC. World Bank, Washington, D.C.

World Bank 1995c. World Bank Atlas 1995. World Bank, Washington, D.C.

World Bank 1995d. Social indicators of development 1995. Johns Hopkins for World Bank, Baltimore.

Young, A. 1991. Soil monitoring: a new task for soil survey organizations. Soil use and management 7, pp. 126-130.

Young, A. 1994. Modelling changes in soil properties. In: D. J. Greenland and I. Szabolcs (ed.) Soil resilience and sustainable land use. CAB International, Wallingford, U.K., pp. 423-447.

Young, A. and Muraya, P. 1990. SCUAF: soil changes under agroforestry. Computer program with user's handbook. ICRAF, Nairobi.

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