Methodologies for Decision Making in Natural Resource Management.

Identifying and Classifying Local Indicators of Soil Quality

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1. General Introduction, 2. Technical Indicators of Soil Quality, 3. Identifying and prioritizing Local Indicators of Soil Quality, 4.Integrating Technical and Local Indicators of Soil Quality, 5. Integrated Soil Management Strategies, 6. Soil Fair: Integration in Practice

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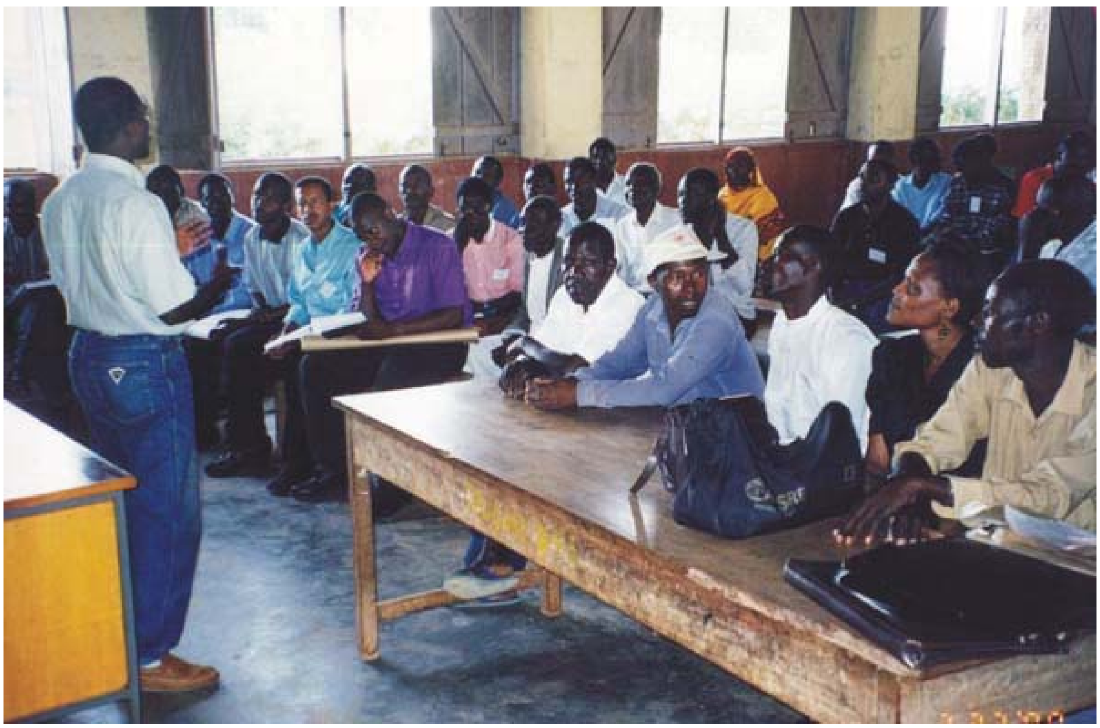
SECTION 1

General Introduction



Section 1. General Introduction

1. The Guide on Local Indicators of Soil Quality

1.1 Reason for this guide

This training guide aims at empowering local communities to better manage their soil resource through better decision making. The methodological approach presented here constitutes one tool to capture local demands and perceptions about soil constraints as an essential guide to relevant research and development activities. A considerable component of this approach involves the improvement of the communication between the technical officers and farmers and vice versa by jointly constructing a effective communication channel.

Sustainable land use in sub-Saharan Africa is a major concern because the natural condition of the continent creates a challenging environment within which to identify strategies to maintain and increase agricultural productivity (Defoer and Budelman, 2000). Many soils of sub-Saharan Africa suffer from inherently low fertility because the continent is dominated by geologically old, usually deeply weathered landscapes (Bationo et al., 1998). As agricultural production intensifies in better soils to satisfy the needs of an increasing population, the pressure on natural resources, such as soil, water and air also increases. Soil degradation is occurring at an alarming pace with 65% of African agricultural land, 31% of permanent pasture land, and 19% of forest and woodland already degraded and an estimated 332 million hectares of African drylands subjected to degradation (Bationo et al., 1998). In East and Southern Africa, for instance, nutrient depletion has been identified as the principal constraint on food supply (Nandwa and Bekunda, 1998). By using a nutrient balance approach Stoorvogel and Smaling (1990) showed that average annual nutrient losses were about 22 kg of N, 2.5 Kg of P and 15 Kg of K for each hectare of arable land for the last 30 years in 37 African countries (about 200 million hectares), excluding South Africa. Therefore, despite declining per capita food production for over three decades, there are clear indications that the basis of future yield increases in African agriculture will be dependent on improved nutrient supply to crops and forages as much of food production over the past three decades has been based on the mining of inherent soil fertility (Lynam et al., 1998).

The example of soil degradation through nutrient depletion illustrates the often late identification of a soil degradation process that has been operating for many years.

Therefore, soil users and those responsible for formulating policies, require indicators for early diagnosis of degradation processes. In this way, preventive rather than remedial approaches to soil degradation should become the norm rather than the exception. It is in this context that local indicators derived from an intuitive integration of changes in soil quality as a result of management and climate over time becomes of special importance (Barrios et al. 1994).

1.2 The Living Soil and Environmental Quality Standards

The soil is considered a living and dynamic resource whose condition is vital both for both agricultural production and ecosystem function. Due to the regulating role the soil plays as part of the nutrient biogeochemical cycles, as a modulator of water availability and quality, as well as its role in the filtering and decomposition of contaminating agents, it is a key natural resource for our future survival. It is imperative that we manage this basically non-renewable resource with better skills and foresight, to avoid additional degradation, and the loss of the agricultural production potential.

Society already has indicators and critical levels available for air and water quality; less attention, however, has been paid to the soil as an essential natural resource. Therefore, the need for indicators of soil quality (ISQ) has been recognized by the farming, extension, NGO and scientific communities, and by those responsible for formulating policies.

1.3 Soil Quality as a Diagnostic and Monitoring Tool

Soil quality has been defined in many ways. Here we use Doran and Parkin's definition (1994), according to which:

"soil quality is its capacity to be functional, within the limits imposed by the ecosystem and land use, to preserve the biological productivity and environmental quality, and promote the plant, animal and human health"

"Soil health", often used interchangeably with "soil quality", is defined here as: "the continuous capacity to operate as a vital biosystem, within the ecosystem and land use limits, to maintain the biological productivity, thus promoting quality in the atmospheric and hydric surroundings, and preserve plant, animal and human health" (Doran and Safley, 1997).

In order to establish a difference between these two concepts, it is suggested to use the expression "soil quality" when soil use is specified (Pankurst et al., 1997). The term "soil health" differs from "soil quality" because it includes a time dimension and the recognition of the soil as a vital biosystem.

Given that the soil keeps a unique balance among its physical, chemical and biological factors, ISQ should also be made up of combinations of these factors, specially in those situations where some parameters integrate the three factors and their functions. An example would be the water infiltration rate of a soil which is influenced by the soil physical structure (specially the texture), soil chemistry (relationships among soil surfaces, especially clays), and soil porosity (that can be affected by soil biological activity, e.g. earthworms). Biological indicators or bio-indicators are, by nature, integrative, as they reflect simultaneous changes in soil physical, chemical and biological characteristics. This characteristic allows them to capture slight changes in soil quality and, therefore, have a great potential for early diagnoses.

According to Doran and Safley (1997) and Beare et al. (1997), in order for ISQ's to be useful for a wide variety of users, including farmers, extension agents, researchers and policies makers, they should:

- Be relatively easy and practical, so that farmers, extension agents, specialists and researchers can use them under field conditions.

- Be relatively accurate and easy to interpret.

- Be relatively economic.

- Be sensitive enough to reflect the impact of soil management practices and climate on long term changes, but not so sensitive, that can be affected by short-term metereological patterns.

- Integrate soil physical, chemical and biological properties and processes, and serve as basic inputs for the estimation of soil properties or functions that are more difficult to be directly measured.

- Have a good correlation with ecosystem processes, with plant and animal productivity, and with soil health.

- Be, ideally, components of the existing soil data bases.

Selecting a suitable set of ISQ, and developing its use as a monitoring system (Soil Quality Monitoring System, SQMS), can be captured in the following figure (modified from Beare et al., 1997):

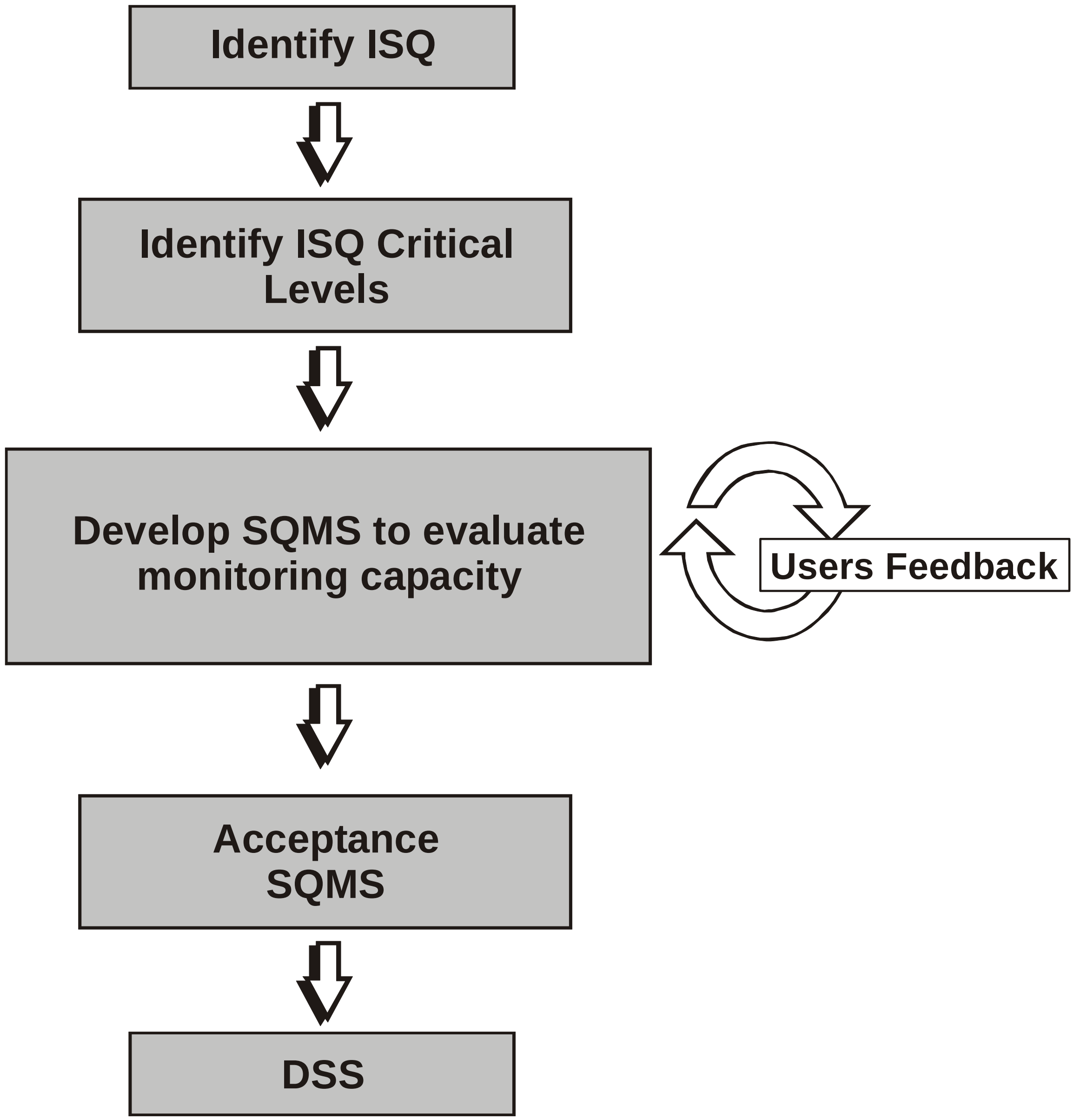


Fig.1 Process leading to the development of a Soil Quality Monitoring System

Suitable ISQ are identified from the local and technical knowledge base and critical levels defined.   This phase is followed by the definition of guidelines to establish a Soil Quality Monitoring System (SQMS), along with interpretation information, as well as reaching an agreement about the suitable ISQ for the relevant conditions. User feedback is very important at this stage as it will provide the grounds for acceptance of the SQMS for soil quality diagnosis and monitoring. Once the SQMS is fully accepted by users it becomes part of the Decision Support System for Natural Resource Management

This "guide" is mainly focused on the first phase of this process; i.e.: identifying soil quality indicators that can be used by farmers, extension officers, NGO's, technicians, researchers and educators.

The ISQ will help in identifying the main soil biophysical limitations of the agricultural system under study. The most sensitive and robust ISQs selected for the soil constraints identified can then be incorporated into a Soil Quality Monitoring System (SQMS), and should include basic parameters such as bulk density, pH, effective rooting depth, water content, soil temperature, total C and electrical conductivity (Doran and Parkin, 1994).

Since our objective is to develop a SQMS for the land users, local indicators of soil quality must be included in the monitoring system. The combination of native and scientific parameters varies according to the monitoring objectives; e.g.: if they are farmers, extension agents or policies makers. It is likely that integrative ISQ might be more useful to land users, than a measurement of, for example, soil available P, since many indicators used by the farmers are also of the integrative type; for instance, soil color, soil structure, crop yield, presence of specific weed species. Attention should be paid to the inclusion of indicators that can be used while progressively increasing the scale at which results are applied (e.g. from plot to field and farm level, up to watershed, region and nation level). Some examples of such indicators might be crop yield and yield trends, land cover, land use intensity and nutrient balances (Pieri et al., 1995). More recently, Defoer and Budelman (2000) have proposed the use of resource and nutrient flows at farm scale to assess land use sustainability and local variation usually missed in studies at higher levels of aggregation (i.e. region, country).

1.4 Scaling up: from plot scale to landscape scale

The need to avoid site specificity and make local results and findings valid for wider regions requires interactive research activities carried out simultaneously at different spatial scales (Fig.2). Plot scale studies should detect soil quality changes generated by new cropping systems and the impact of the adoption of such cropping systems, in turn, should be detectable at the landscape scale (Barrios, 1998).

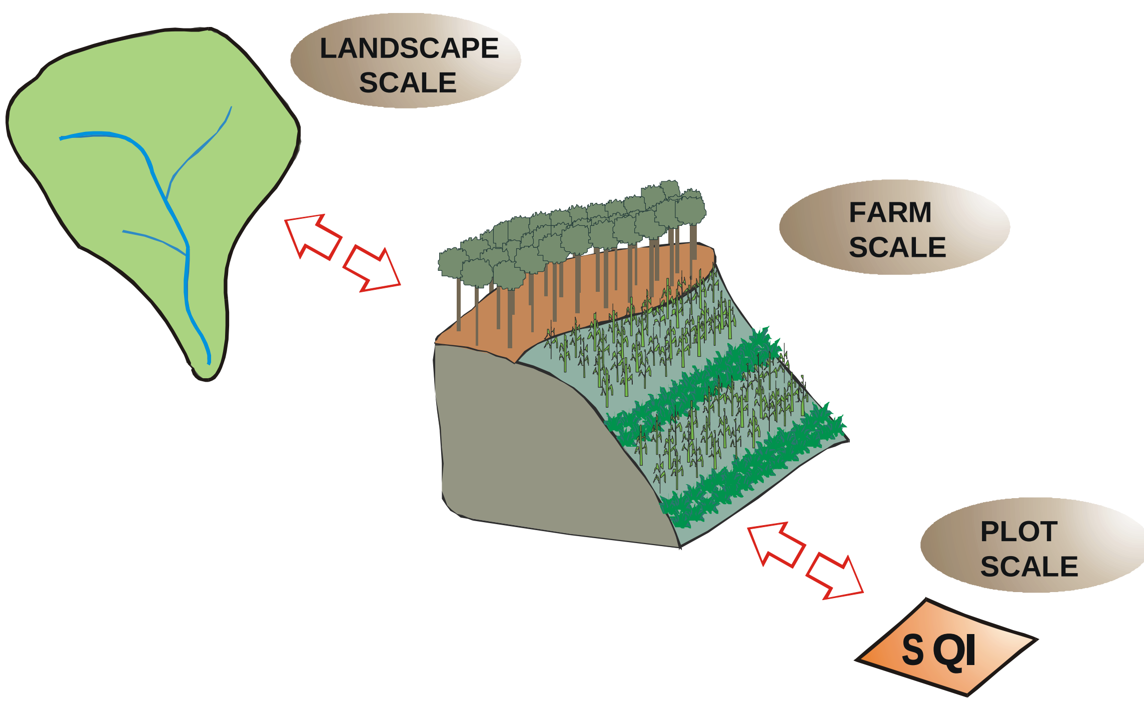


Fig.2 Relationships among processes simultaneously ocurring at different spatial scales (Barrios, 1998)

Watersheds are useful as landscape study units because they have clearly defined physical boundaries and the impact of land use changes can be measured in the water. Water quality (i.e. contents of pesticides, nitrates, etc.) becomes an integrative measure of soil use and management by cropping systems within the watershed. The integrative nature of this measure permits the establishment of a baseline associated with the current land use in the watershed. Therefore, it becomes possible to assess the impact of adoption of new cropping systems in the watershed by changes in selected water parameters in comparison with baseline levels (Fig.3).

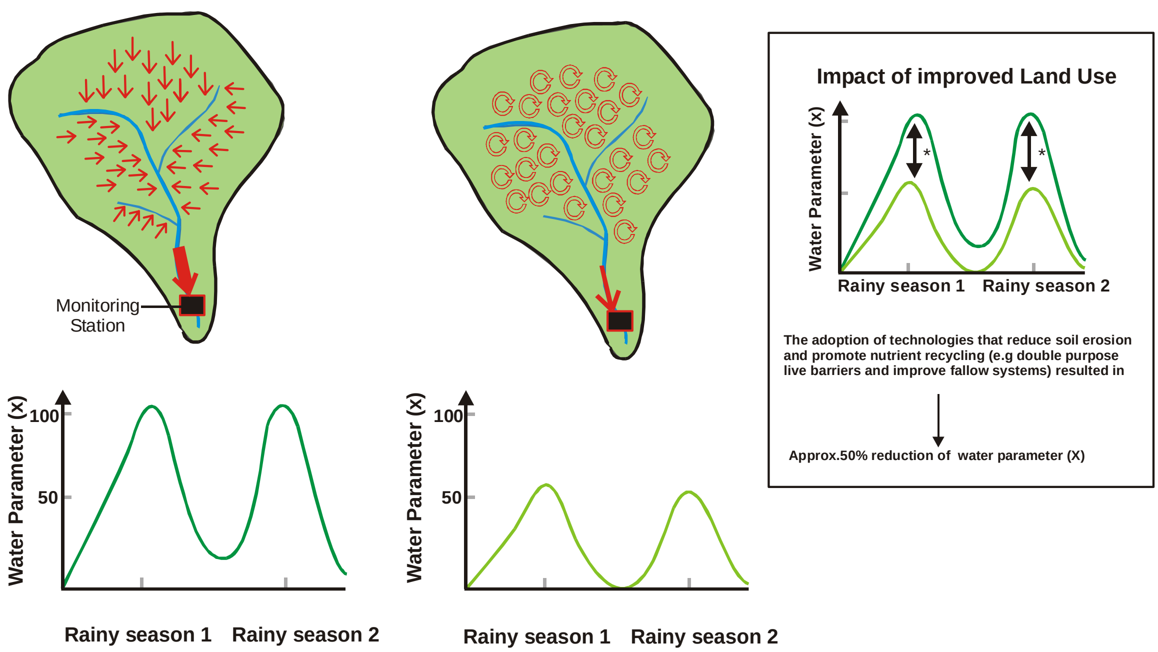


Fig.3 Detection of Nutrient losses in a Watershed under Conventional and Improved Management and a Measure of its Impact (Barrios, 1998)

This approach is based on the notion that soil changes generated by cropping systems within a watershed can be captured by ISQ but the impact of such land use in the watershed as a whole can be detected through water quality monitoring. The challenge consists in establishing robust correlations between

ISQ and indicators of water quality as a way to evaluate soil health at the watershed scale. These concepts will be discussed in further detail in a forthcoming training manual of this series dealing with Local Indicators of Water Quality.

1.5 Soil quality indicators for Eastern Africa

The Eastern African region houses a large proportion of rural poverty which contributes to food production through agricultural systems of low productivity and limited nutrient use efficiency. One of the main objectives of the methodological instruments for decision making in natural resource management is the application of participatory approaches for the ecologically sound intensification of agricultural systems through an efficient and conservative use of the natural resources.

The sustainable use of the soil is of fundamental importance to improve farmers' quality of life.This is particularly relevant for those located in the densely populated highlands where high soil erosion rates, as a consequence of land clearance and the lack of suitable soil conservation methods, is considered to be an important factor accounting for such degradation of arable land. Despite the vast amount of financial resources and efforts made to preserve natural resources, inappropriate soil management continues to be a concern, and has been emphasized by rural development projects.

During the field phase of many development projects, it is very common that several "sustainable" soil management practices are presented to farmers as a set of "solutions" to be implemented in their farms. It is only on few occasions, however, that recommendations emerge as a direct consequence of the community's needs and perceptions about the management of their natural resources. Within this context, the farmer's knowledge about natural resource management is not considered important and is rarely integrated into the development programs.

According to the experience of the researchers who developed this guide, one of the great limitations to farmer participation in the development of sustainable management practices, is the inefficient communication between technicians and farmers. In particular, the lack of a common language and methodological instruments allowing the systematic identification of farmer's knowledge about the soil, and its integration with the technical knowledge derived from soils sciences. This guide is an effort to provide ways to achieve a greater farmer participation in the solution of problems related to natural resource management.

2. OBJECTIVES

- After using this methodological guide:
- Participants will understand the importance of local knowledge in natural resource management.
- Participants will be able to use participatory methodologies to identify and prioritize local indicators of soil quality.
- Participants will be able to integrate local and technical indicators of soil quality.

Expected Results

Through the application of the methodology described in this guide participants should be able to use participatory approaches to include local knowledge, demand and relevance into their natural resource management research and development activities. In addition, participants should be able to use soil quality indicators to diagnose soil constraints, guide the choice of potential soil management strategies and also monitor the impact of such strategies to address identified constraints.

3.To the Users of this Guide

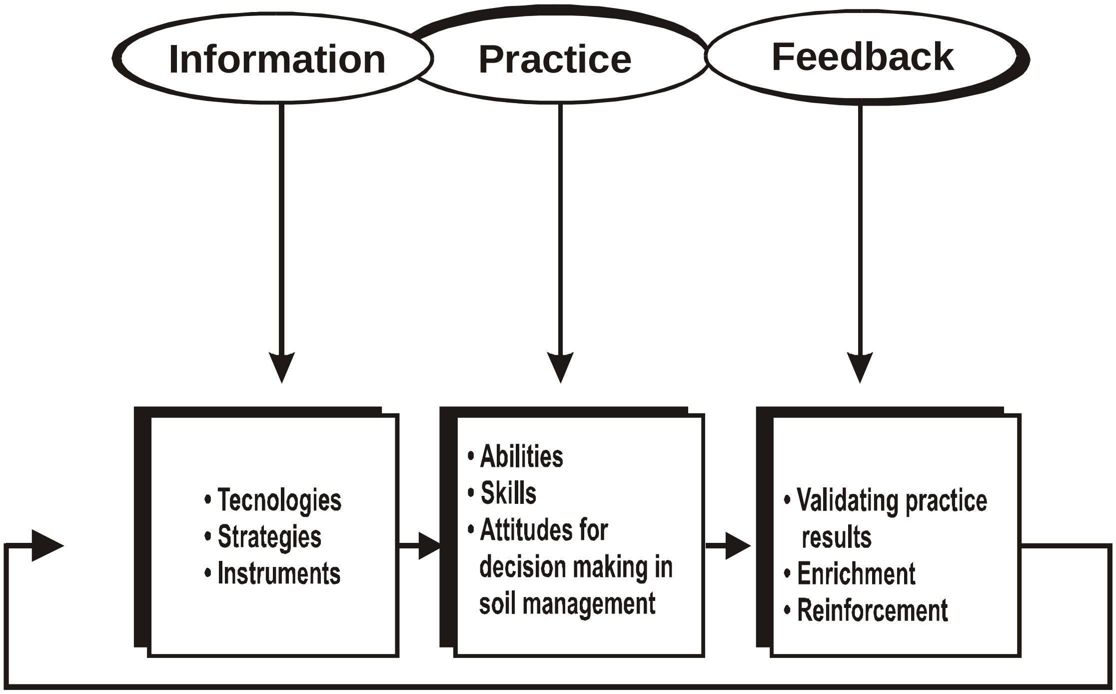
This Guide is the Eastern Africa Version of a previous one published in Spanish under the title "Participatory Method to Identify and Classify Local Indicators of Soil Quality" which has been widely used in Latin America as one of a series of nine guides called “Methodological Tools for Decision Making in Natural Resource Management”.

Two different types of audiences are addressed in this publication. The first is made up of professionals and technicians working with public and private sector agencies and institutions devoted to research, development and training activities in natural resources management. These users may take advantage of the guide to support planning, implementation, follow-up and evaluation of soil management initiatives. It is expected that, once trained in the application of this participatory methodology, they can later disseminate it among hundreds of professionals, technicians and producers, who will in turn adapt it to local soil management projects.

A second group of users is made up of the people from the African watersheds who are the users of natural resources. The local communities, with the support of extension agents from non-governmental organizations and State agencies, shall be able to use the methods and strategies offered here, in order to have an active participation in the management and conservation of soils.

This material has also proved to be very useful for teachers in faculties and schools of agrarian, environmental and natural resources sciences, who can incorporate it to the curricula or to their course programs as they find it suitable.

4. LEARNING MODEL



The guide on local indicators of soil quality contains three major components: (a) the introductory part. It comprises the introduction, the specification of objectives, the description of users, the general structure of the guide, and a series of opening questions followed by answers that the instructor may use to conduct an open discussion with participants about all major aspects of the guide; (b) the body of the guide that contains six sections or instructional sequences that will be later described, and (c) a series of instruments for the trainers to conduct the evaluation activities. Evaluation is made of the participants to assess their intellectual achievement. An evaluation of the trainers' performance is also conducted by the participants to provide them with feedback on their role as facilitators. An evaluation of the training event (workshop) is also carried out.

The learning model used to organize each section follows three sequential steps: information, practice and feedback. This model has proved to be useful in facilitating the learning process. It is geared to learn through practical experiences supported by scientific information and accompanied by peer and instructor feedback. Each learning sequence looks very much like a chapter, but it has a learning structure that contains the following components:

An introductory statement

The learning objectives that the instructor shares with participants at the beginning of each section

A structure of the section that explains all of its major components

A few introductory questions to be used as "ice-brakers" between the audience and the instructor

The scientific information to be shared by the instructor with the participants

One or more practical exercises to be performed by participants sometimes accompanied by a group of farmers. This guide offers a very reach experience in what is called "the soils fair", where participants accompanied by local farmers carry out different analyses of soil samples. These analyses altogether are the bases for a diagnosis of the quality of soils in a given area, and facilitate the formulation of recommendations by the technical personnel to the farmers.

The feedback sheets to help instructors conduct a feedback session on the results of practical exercises.

A summary of the section followed by the bibliography and

The originals for the overhead transparencies the instructor may copy to use as teacher aids.

In summary, this model proposes a training scheme in which information inputs resulting from field research serve as the raw material for developing capacities, skills and attitudes required by the final users of this particular instrument on local indicators of soil quality, to make appropriate decisions related to the management of soils. Feedback information constitutes the final part of each section. It provides an opportunity for instructor and participants to carry out a conceptual and practical synthesis of each aspect under study.

Practical exercises are the main learning axle. They intend to simulate real field experiences. Through these exercises, participants learn to use the instruments, the difficulties emerging from their application, as well as their advantages and opportunities within various decision making environments.

The exercises included in the guide were validated in Africa, after a large range of previous experiences in Honduran, Nicaraguan and Colombian micro-watersheds. Nevertheless, the instructors in other countries and regions are to extract from their own research projects and field experiences, examples and cases to adjust the content and exercises for use in their own contexts.

Uses and adaptations

This guide is by no means a straight jacket to fit the needs of all those who work on soil management. It provides a participatory scheme to approach the problems farmers face in their production activities. Therefore, the users may introduce changes in part or in the whole guide so that the final instrument they use to promote sound soil management practices or to support training activities, is a result of interaction with farmers, experimentation and validation on the field.

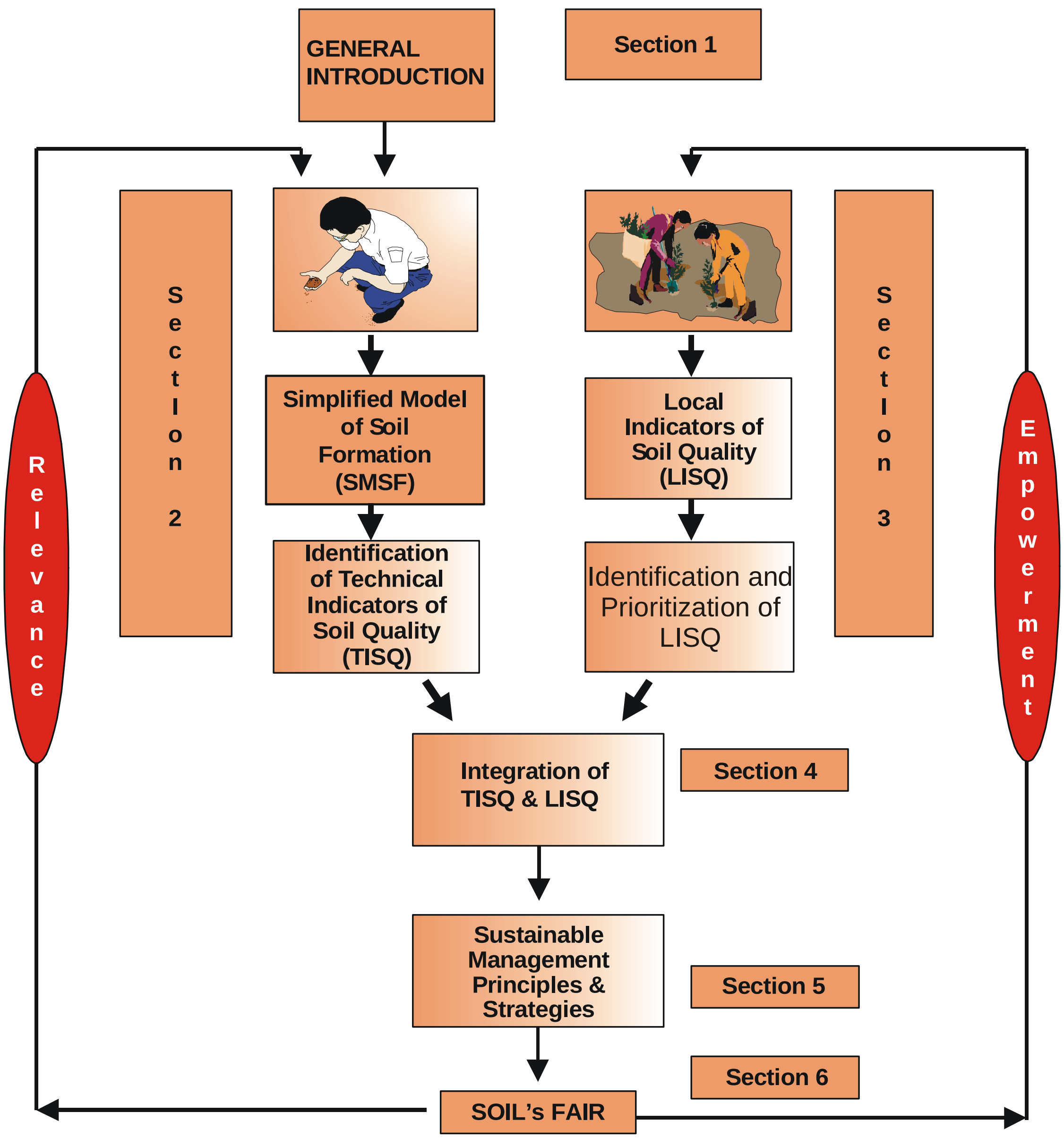
The appendices at the end of the text, designed to help participants deepen in some aspects presented in several sections as well as the exercises, can be adapted or substituted by practices on problems relevant to the local audiences. We also recommend including local, regional or national data both in the feedback sessions and in the appendices. The evaluation instruments (posttest, evaluation of the instructor, evaluation of the event, evaluation of the guide, etc.) can also be adapted to the style in which these activities are carried out in each country.

Finally, an idea to be emphasized is the importance of practice as a learning tool. Therefore, the training sessions are to be assigned the time necessary for participants to have the opportunity to develop the abilities, skills and attitudes expressed in the learning objectives. This way we can improve the chances that training has the expected impact on those who make decisions in soil management practices.

5. STRUCTURE OF THE GUIDE

The following scheme shows the various components of the guide, as well as their mutual relationships.

Structure of the Guide



This training guide is made up of six sections: The first section provides a general introduction about the management of the soil resource in the African context and the ISQ. The second section presents a technical conception of the soil through a Simplified Model of Soil Formation (SMSF) and introduces the technical indicators of soil quality (TISQ). The third section describes the methodology to identify and prioritize local indicators of soil quality (LISQ). The fourth section provides a methodology to construct an effective channel of communication by finding equivalences between TISQ and LISQ which permit a better Extension officier, NGO - farmer communication. The fifth section is concerned with management principles behind potential strategies to solve constraints at the short, medium and long term. The sixth section is devoted to the Soil's Fair which provides a practical exercise to highlight the complementary nature of technical and local indicators of soil quality.

One clear outcome of using this methodological approach is that technical research and development activities would have local relevance as they are related to local demands and perceptions and this will likely increase their adoption rate. On the other hand, there should also be positive impacts on the local knowledge base and community empowerment, as it provides a way for it to be widely understood, assessed and utilized, as well as by building an effective communication channel together.

The approach summarized in the preceeding sections provides the tools to conduct a technical-local classification of the soil, based on modifiable and permanent soil properties, which has the flexibility to work in the plot/farm/landscape (watershed) continuum, while also having the potential to take the stakeholder groups and gender issues dimensions into consideration. This guide then provides a valuable tool to evaluate the impact of the land use change across various spatial scales and social actors.

6. Opening Questions

Self-evaluation
Orientation for the Instructor

The instructor that employs a training participatory methodology starts with a small questionnaire allowing the participants to: (a) be acquainted with the main topics to be approached in the guide; and (b) explore what they know about such topics.

To administer the self-evaluation:

Give each participant or small group of participants the questions listed below.
Give 20 minutes to answer.
Share with the participants the responses given in the feedback information
Allow a brief discussion on each question, without going to deep into each topic.

Questions

1. What is the soil for you?

____

____

____

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2. What do you think is the importance of the soil as a natural resource?

____

3. Could you mention some soil properties and indicate how they are useful to determine its quality?

4. ¿ Could you mention some soil properties that could be modified through management?

5. Which are some of the non-modifiable properties of soils?

6. What methods do you know to evaluate the quality of a soil?

Self-evaluation Feedback information

Orientations for the Instructor

Discuss each question with the participants; to do this, you can ask three participants to give their opinion on each question, before the instructor presents the right answer.

Consider that the responses can be very open; therefore, every opinion is very valuable and must be focused on the topics to be dealt with. Also, at the end, make a summary of all the responses, having as the main objective, to induce the participants to what is expected to be developed with the objectives and outcomes of the present guide.

Sample Answers

To question 1

The soil is a product from rock fragmentation into very fine particles, combined with organic materials that constitute an adequate medium for plants to grow and favorable for the biologic activity.

To question 2

The soil constitutes the basis for fiber and food production on earth and limits the impact of human activities to the environment.

To question 3

Soils have properties that distinguish them from rocks. Such properties can be divided into external and internal properties. The external properties refer to the characteristics of the surrounding landscape in which the soil has been formed (e.g. slope, climate, organisms, time). The internal properties refer to soil profile properties, which are divided among physical, chemical and biological properties. Some soil physical properties are: texture, structure and color. Some of the chemical properties are pH (acidity or alkalinity), organic matter content and the availability of nutrients required by plants. The biological properties are related to the activity of the soil organisms. Soil quality is a relative concept involving the evaluation both of the external and the internal characteristics. For example: a good quality soil in a highland area might be not such a good soil when compared with a good soil in a valley bottom area.

To question 4

Organic matter, pH, nutrient content, presence of organisms.

To question 5

Slope, climate, texture

To question 6

The evaluation of soil quality starts by identifying soil properties which are constraining agricultural production or other potential land use and then monitoring the benefit or not of management practices designed to correct such constraints.

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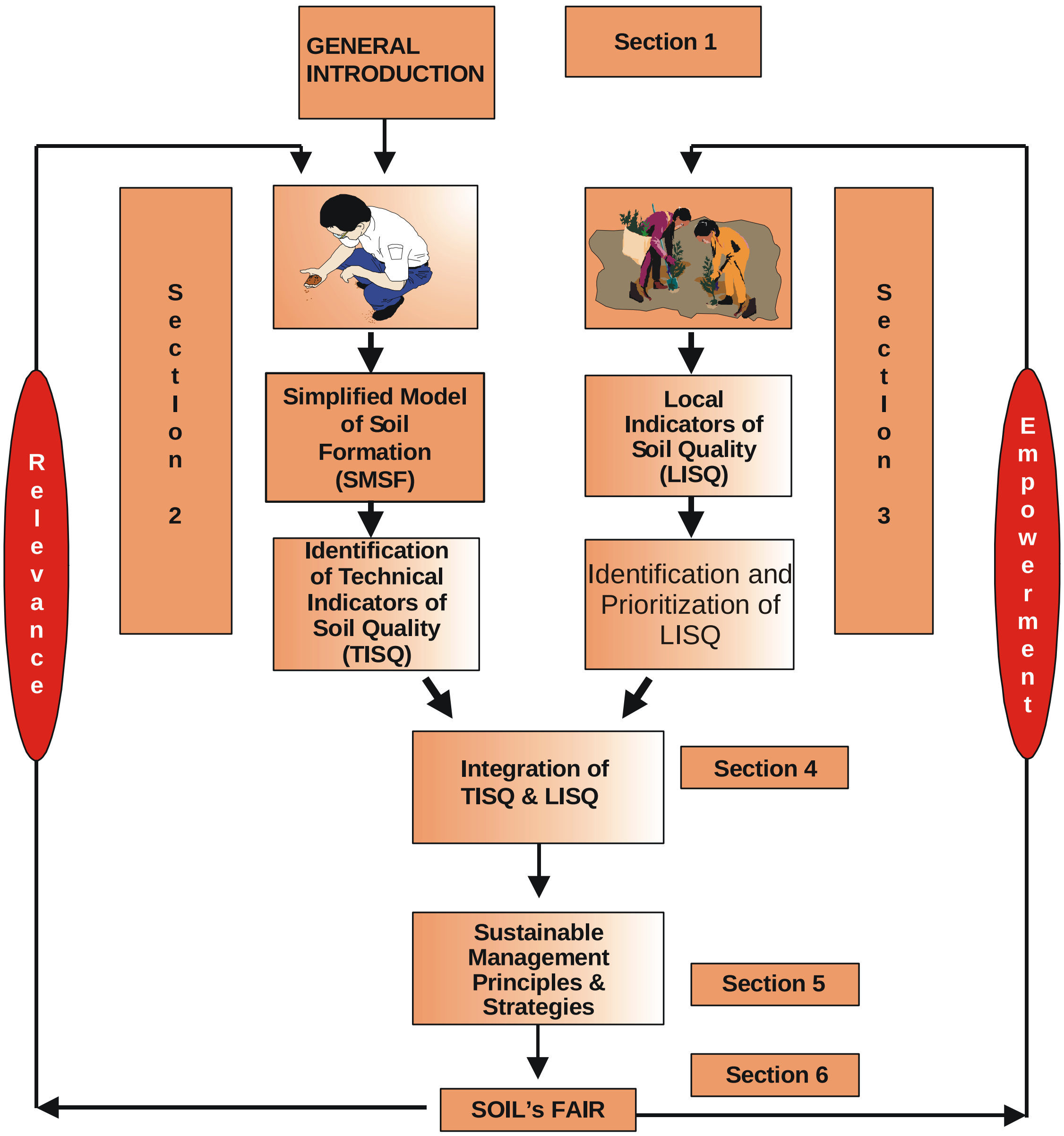
Structure of the Guide



General Objective

Participants will be able to integrate local indicators of soil quality with the diagnostic properties of soils.

Specific Objectives

Differentiate factors and processes that take part in soil formation, using a simplified model.

Describe soil formation factors and processes.

Identify and prioritize local indicators of soil quality in a given area .

Specific Objectives

To identify soil physical properties (texture, colour, structure, depth), chemical properties (pH, nutrient content, organic matter) and biological (organisms) that are related to local indicators of soil quality, as they are prioritized by a community.

To match local indicators soil quality with the diagnostic properties soils.

Self Evaluation

What is a good definition for soil?

How important is soil as a natural resource?
Could you mention a few soil properties and describe their use as soil quality indicators?

Can you mention a few properties of soil that can be modified?

Do you know of properties of soils that can not be modified?

Do you know any methods that are good to evaluate the quality of soils?

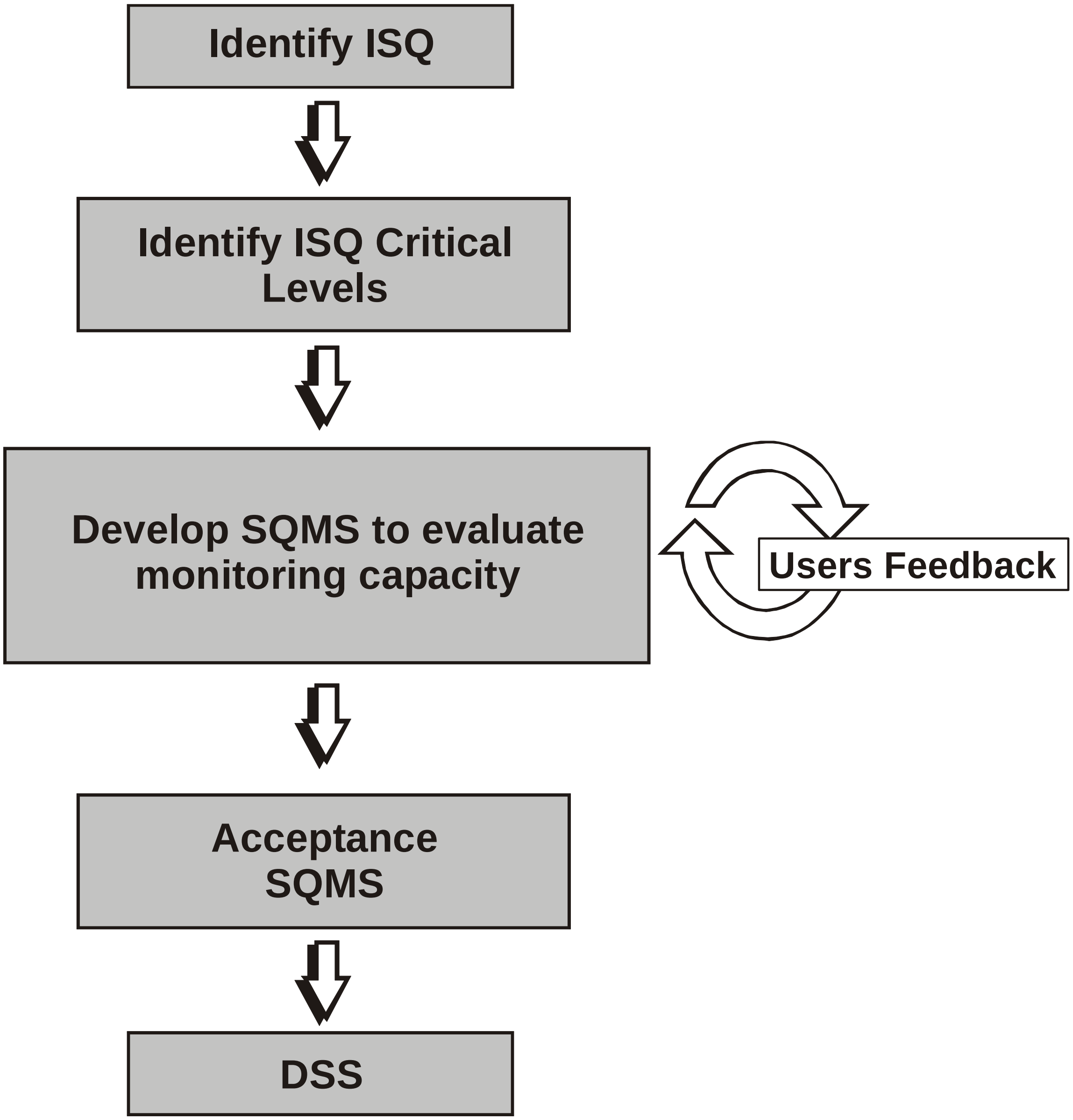


Fig.1 Process leading to the development of a Soil Quality Monitoring System