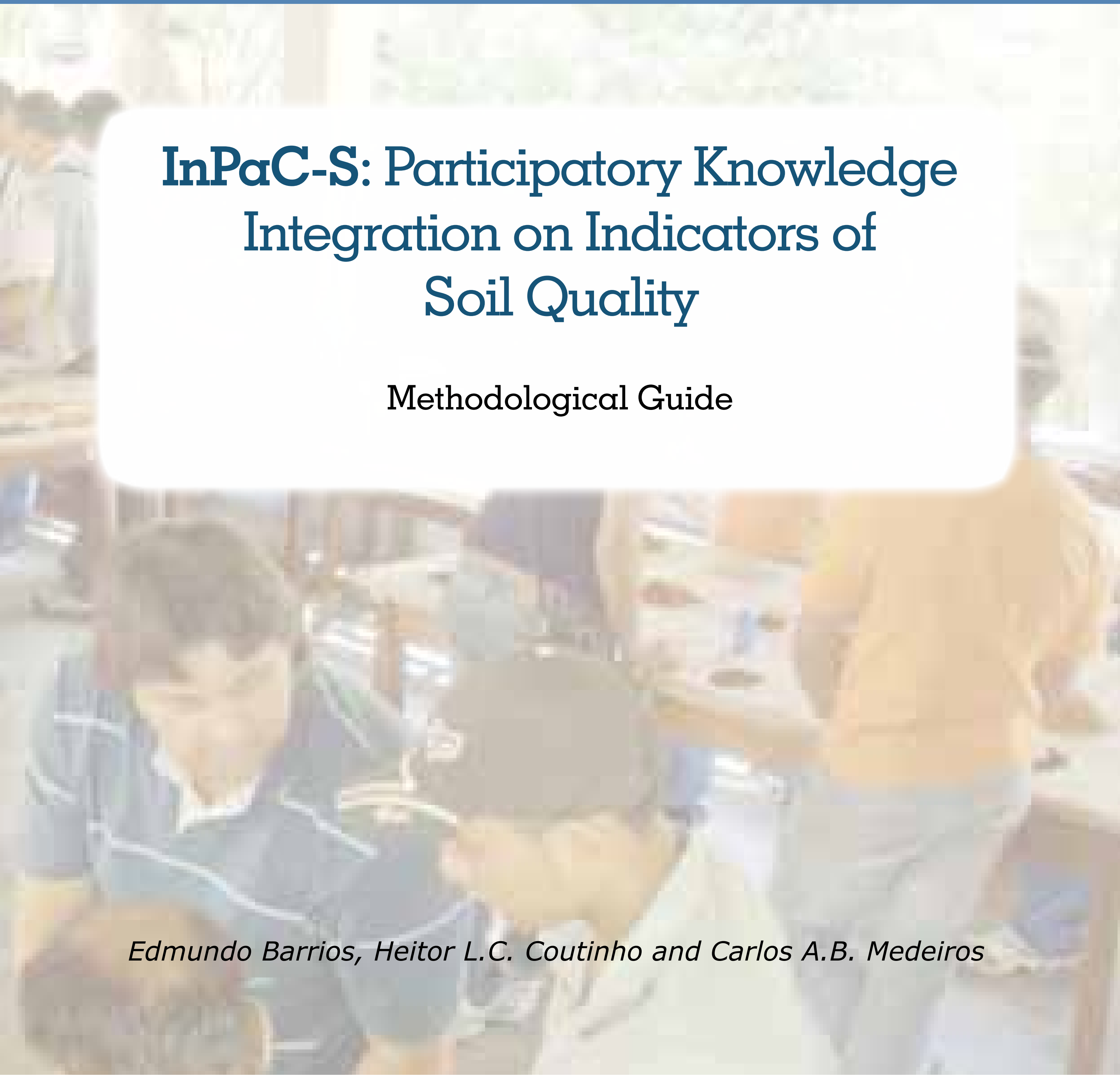

InPaC-S: Participatory Knowledge Integration on Indicators of Soil Quality

Methodological Guide

Edmundo Barrios, Heitor L.C. Coutinho and Carlos A.B. Medeiros

CIAT 45
Centro Internacional de Agricultura Tropical
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Headquartered in Nairobi, Kenya, it operates through six regional offices located in Cameroon, India, Indonesia, Malawi, Peru and Kenya, and conducts research in 18 other countries in the developing world. It receives financial support from about 40 donors comprising governments, private foundations, international organizations and regional development banks. The top ten donors are the World Bank, Canada, the United States of America, the International Fund for Agricultural Development (IFAD), the Netherlands, Ireland, Norway, the United Kingdom, Sweden and the European Union.

Created in April of 1973, the **Brazilian Agricultural Research Corporation (Embrapa)**, linked to the Ministry for Agriculture, Livestock and Food Supply, has the mission of promoting research, development and innovations for a sustainable agriculture that benefits the Brazilian society. In the last three decades, research and technologies generated by Embrapa and its partners have resulted in great transformations of the agricultural business sector and the Brazilian economy.

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Its vision, the importance attributed to human resource development and the capacity to remain linked to scientific advances would allow Embrapa to contribute to maintaining Brazil positioned at the knowledge frontiers in emerging themes like agroenergy, carbon credits and biosecurity, and in areas like biotechnology, nanotechnology and precision agriculture.

The **International Centre for Tropical Agriculture (CIAT)** is a leading not-for-profit organization established in 1970, as one of the four original research centres in the Consultative Group of International Agricultural Research (CGIAR). Its mission is to reduce hunger, poverty and improve human health in the tropics through research aimed at increasing the eco-efficiency of agriculture.

Working in collaboration with hundreds of partner organizations, CIAT is dedicated to developing technologies, innovative methods, and new knowledge that better enable farmers, mainly smallholders, to improve their crop production, incomes, and management of natural resources.

CIAT's headquarters is located near Cali, in southwest Colombia. It is currently working in more than 50 countries worldwide.

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1) Small-scale farmer communities who participated in all the regional workshops and shared their local knowledge:
   - Aldeia São João and Assentamento Santa Lucia (Bonito, MS)
   - São João, Novo Brasil, Nova Olinda and Nossa Senhora do Rosario communities (Igarapé Açu, PA)
   - Olho d'Agua – Pentaurea and Pinheiros communities, and Assentamento Americana (Montes Claros, MG)
   - Gabinete, Oziel and Paulo Freire communities (Campina Grande, PB)
   - Serra Grande, Serrinha and Escada communities (Canoinhas, SC).
2) Researchers and technical staff from Embrapa and other research institutes, technical staff from extension and rural development institutes, university professors, municipal, state and federal government agents, technical staff from various NGOs who participated in the regional workshops and shared their technical knowledge and closely interacted with farmers.

3) The co-leader, regional and local coordinators whose participation was essential for the success of the regional workshops:
   - Heitor L.C. Coutinho – Embrapa Solos (co-leader and Brazilian counterpart)
   - Ayrton J. Garces and Denise Rodrigues – AGRAER (Bonito, MS)
   - Osvaldo Kato and Mauricio Shimizu – Embrapa Amazônia Oriental (Igarapé Açu, PA)

- João R. Corrêia – Embrapa Cerrados and Honório D. Neto - Centro de Agricultura Alternativa do Norte de Minas (CAA) (Montes Claros, MG).
- Amaury Santos – Embrapa Tabuleiros Costeiros and Melchior N.D. da Silva – Embrapa Algodão (Campina Grande, PB).
- Carlos A.B. Medeiros – Embrapa Clima Temperado and Danilo P. Sagaz – EPAGRI (Canoinhas, SC).

The organization and success of the workshops was facilitated by the effective collaboration with on-going research for development projects in the different regions where workshops were conducted, including:

- Formoso River: Integrated Watershed Management and Biodiversity Conservation – GEF/World Bank (Bonito, MS) and Land Use Change in the Rio de La Plata Basin: Linking Biophysical and Human Factors to Understand Trends, Assess Impacts, and Support Viable Strategies for the Future – IAI/CNRII (Bonito, MS)
- Project Tipitamba: Agricultura sem queima com base no plantio direto na capoeira – PPG7/FINEP/CNPq and Project Raízes da Terra - PDA/PADEQ (Igarapé Açu, PA)
- Macro-programa 6 project of Embrapa: Apoio ao desenvolvimento da agricultura familiar e a sustentabilidade do meio rural (Montes Claros, MG)
- Macro-programa 1 project of Embrapa: Transição agroecológica: Construção Participativa do Conhecimento para a Sustentabilidade (Campina Grande, PB and Canoinhas, SC).

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Our intention was to make a complete list of acknowledgements. However, it is possible that we could have failed to mention some key collaborators. We would like to apologize for this oversight and would like to express our sincere thanks.

Preface

The global environment is changing at an alarming rate as a result of human activities. Agriculture represents the dominant form of socio-environmental interaction and consumes more natural resources than any other human activity. The complexity of decision-making associated with the demands of sustainability in agriculture requires new approaches that recognize the intimate and dynamic interactions between humans and the environment, and thus addresses the multiple dimensions and scales of global problems such as land degradation and biodiversity loss, particularly in the context of climate change.

In recent years, more attention has been paid to local knowledge for its important contribution to the design of strategies for sustainable management of natural resources. The importance of soil as a key component of sustainability in agricultural landscapes has led to an increasing demand for indicators that would allow the monitoring of changes in soil quality, as well as the impact on the provision of soil-mediated ecosystem services resulting from changes in land use and intensification of agriculture. The development of a "hybrid" knowledge base, through participatory integration of local and technical knowledge on indicators of soil quality, represents an effort to better understand the complexity of decision-making in natural resource management aimed at maintaining or improving the provision of soil-mediated ecosystem services.

The large geographical area occupied by Brazil, and the inherent diversity of different regions of the country, presented the complex and yet provoking challenge of identifying indicators of soil quality that integrate local and technical knowledge and are of national relevance. Our strategy in addressing this complexity involved the construction of knowledge sharing spaces in different regions of Brazil. These activities involved intense interactions between Embrapa researchers and representatives of farmer communities, technical assistance and rural extension services (public bodies and NGOs), and universities.

We hope this methodological guide will foster the integration of local knowledge into soil quality monitoring systems and support decision-making processes aiming at the sustainable management of natural resources in agricultural systems and landscapes.

The Authors

CHAPTER 1

GENERAL INTRODUCTION

1.1 Reasons for developing this methodological guide

This capacity building and participatory training guide aims to strengthen institutions that support rural communities in making decisions related to soil management. The methodological approach herein presented includes a set of tools that facilitate the integration of the knowledge of farmers on soil quality and its management, with the technical knowledge generated by soil science and agricultural research. A considerable part of this participatory approach involves an increasing exchange of knowledge and experiences between technical professionals (agricultural researchers, extension and rural development agents, and academics) and farmers through the joint construction of an effective channel of communication, and the development of skills for participatory consensus building.

The sustainable use of natural resources is a major challenge in Brazil and the rest of the world because of the need for strategies that make it possible to maintain or increase agricultural productivity without sacrificing other benefits that society obtains from ecosystems and which make life on the planet possible (MA, 2005). Soil degradation is one of the main obstacles to the achievement of food security in rural areas of Latin America. A high proportion of tropical soils are characterized by low levels of fertility as a result of acidity, low levels of organic matter, nutrient deficiency, frequent water stress and a high susceptibility to erosion (Sanchez, 1976; Resende et al., 2002). The poor management of these soils has aggravated these limitations to an alarming degree. Land degradation is the main cause of the vicious cycle that leads rural farmers, and especially small-scale farmers, into situations of low quality of life with high indebtedness, further reducing job opportunities in the rural areas.

Another major challenge is to tackle soil degradation using a methodological approach that fosters the development of systems for monitoring soil quality as a means to guide the sustainable management of agricultural soils. The participatory research basis of this approach aims to determine the essential components of soil quality monitoring systems that make them relevant, economically viable and technically accessible to the different actors involved in land and soil management. These monitoring systems, comprising indicators that allow the early diagnosis of soil degradation processes, are more efficient since it has been established that prevention costs are considerably lower than the cost of recovering degraded soils (INRM, 2001). The integration of local and technical knowledge in the generation of indicators has been identified as a promising strategy for achieving an appropriate balance between the need for precision and relevance (Barrios et al., 2006). The development of effective systems for monitoring soil quality will provide support to decisions about its management, taking into consideration increases in productivity while maintaining the capacity of agricultural ecosystems for the provision of other benefits to society.

1.2 The living soil and environmental quality standards

Soil is a living and dynamic resource whose condition affects agricultural production as well as the functioning and integrity of ecosystems (Doran and Zeiss, 2000). Soil is also a natural resource crucial for our survival, due to its important role in nutrient cycling, and as a regulator of the availability and quality of water, in flood control, as well as in filtering and decomposition of contaminants (MA, 2005). Soil is formed by the weathering of rocks over hundreds of years. Thus, the management of this practically non-renewable resource must be carried out with the utmost care and insight, in order to prevent soil degradation and loss of capacity for agricultural production, and for the provision of other services from agricultural ecosystems for future generations.

The scientific community has developed systems of indicators, which have established critical levels for monitoring air and water quality. In contrast, considerably less attention has been paid to soil and its quality. Therefore, farmers, extension and rural development agencies, NGOs, the scientific community, and policy makers have recognized the need for indicators of soil quality (ISQ) (Ritz et al., 2009).

1.3 Ecosystem services

There are different definitions for the concept of ecosystem services, also referred to as environmental services in some publications. This methodological guide defines ecosystem services as "all those benefits that society receives from ecosystems" (Figure 1.1). This definition was put forward by the Millennium Ecosystem Assessment (MA, 2005), an initiative coordinated by the United Nations Environment Programme

(UNEP), involving more than 1,360 scientists from 95 countries and led by a multi-sectoral committee that included representatives of international institutions, governments, indigenous communities, NGOs, and private enterprises. The main objective of the MA was to evaluate the consequences of ecosystem changes on human welfare, and to establish the scientific basis for actions needed to enhance the conservation and sustainable use of ecosystems to ensure their continued contributions to human wellbeing. During this global assessment the fundamental role played by biological diversity in the provision of ecosystem services was ratified.

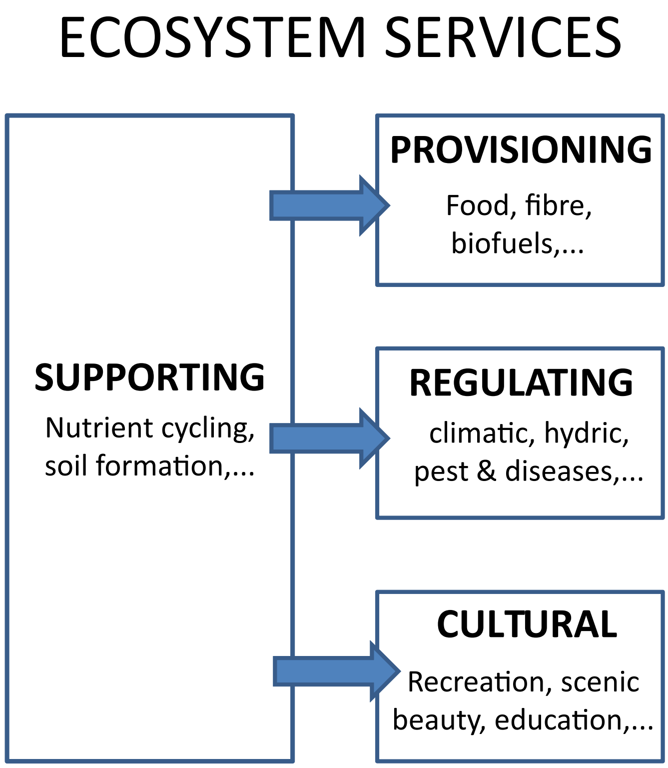


Figure 1.1 : Classification of soil-mediated Ecosystem Services (Adapted from MA, 2005)

According to MA (2005), ecosystem services can be classified as: PROVISIONING services, those associated with the provision of goods (e.g. food, fibre, bio-fuels); REGULATING services, those that promote the regulation of ecosystem processes vital for humanity (e.g. climate regulation, flood control, erosion control, biological control of pests and diseases, detoxification of pollutants), as well as CULTURAL services which are not associated with material benefits (e.g. recreation, scenic beauty, cultural uses). It is important to note that all the aforementioned services depend on SUPPORTING services, those life support services available on the planet (e.g. nutrient cycling, soil formation) (Figure 1.1). Soil contributes to all different types of ecosystem services and for further information we recommend that reviews by Barrios (2007) and Kibblewhite et al. (2008) be consulted.

1.4 Soil quality as a diagnostic and monitoring tool

Soil quality has been defined in many ways. In this guide we adopt the definition of Doran and Parkin (1994) which states that:

Soil quality is its capacity to be functional within limits defined by the ecosystem and land use, preserving the biological productivity and environmental quality, and promoting the health of plants, animals and human beings.

“Soil health”, often used interchangeably with “soil quality”, is defined here as an integrative property that reflects the capacity of soil to respond to different agricultural uses and management, so that it continues to support agricultural production and the provision of other ecosystem services (Kibblewhite et al., 2008).

Since soil maintains a unique balance between physical, chemical and biological factors, indicators of soil quality should include a combination of these, especially in situations where some parameters integrate the three factors and their functions. An example is the rate of water infiltration into the soil, which is influenced by the soil physical characteristics (especially its texture), by soil chemistry (the relationship between surfaces of soil minerals defined by the type of clay), and porosity, which can be influenced by the biological activity of soil organisms such as earthworms and termites. Biological indicators or bio-indicators of soil quality are inherently integrative because they simultaneously represent changes in physical, chemical and biological properties of the soil. This feature allows bio-indicators to detect small changes in soil quality, and thus their great potential for early diagnosis of processes of land degradation.

According to Doran and Safley (1997), in order to be useful to farmers, extension and rural development agents, researchers and policy makers, indicators of soil quality (ISQ) must be:

- Practical and easy to use under field conditions
- Relatively precise and easy to interpret

- Relatively economical
- Sufficiently sensitive to reflect the impact of soil use and management, and long-term climatic changes, but not so sensitive as to be affected by short-term climatic patterns
- Able to integrate physical, chemical and biological characteristics and processes, and be useful for estimating soil properties or functions that are difficult to measure
- Able to give good correlations between ecosystem processes, plant and animal productivity, and soil health
- Ideally part of existing soil databases

The selection of a set of ISQ, and their use for the development of a Soil Quality Monitoring System (SQMS) is illustrated in Figure 1.2. Initially, the most important ISQ are identified based on the existing local and technical knowledge. A selected group of ISQ is then chosen to be part of the SQMS and evaluated by users with reference to critical levels, sensitivity, consistency and user-friendliness as influenced by their use in different locations, production systems and social settings. The evaluation of the SQMS by users, and the feedback of any shortcomings found in this phase, will allow for the necessary adjustments to be made so that it can be accepted as a tool for the diagnosis and monitoring of soil quality. Once the SQMS is approved by the users, it can become part of the Decision Support System (DSS) tool for natural resource management.

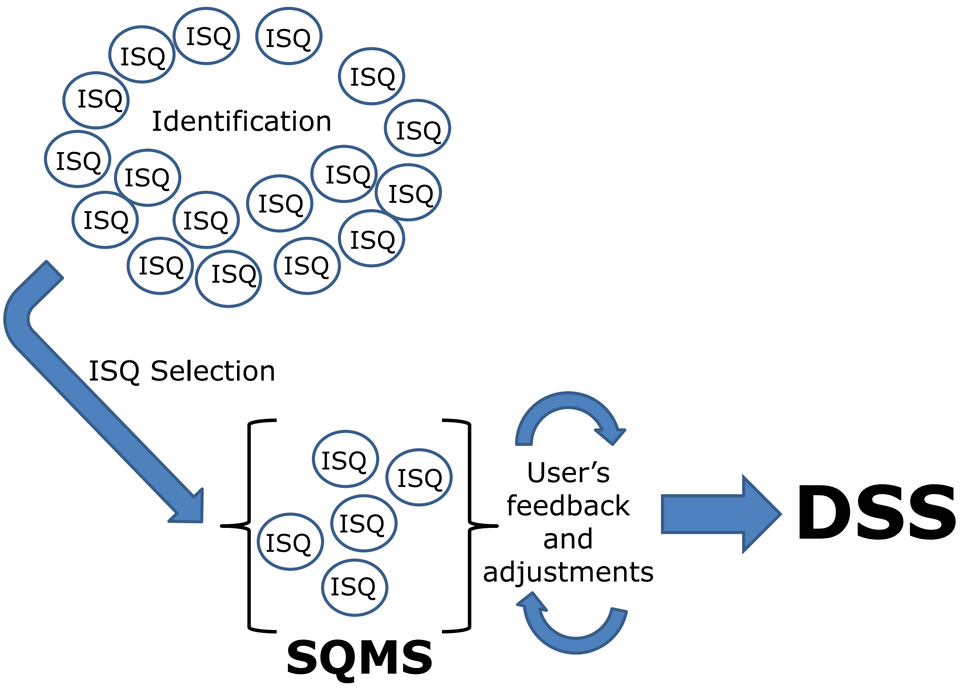


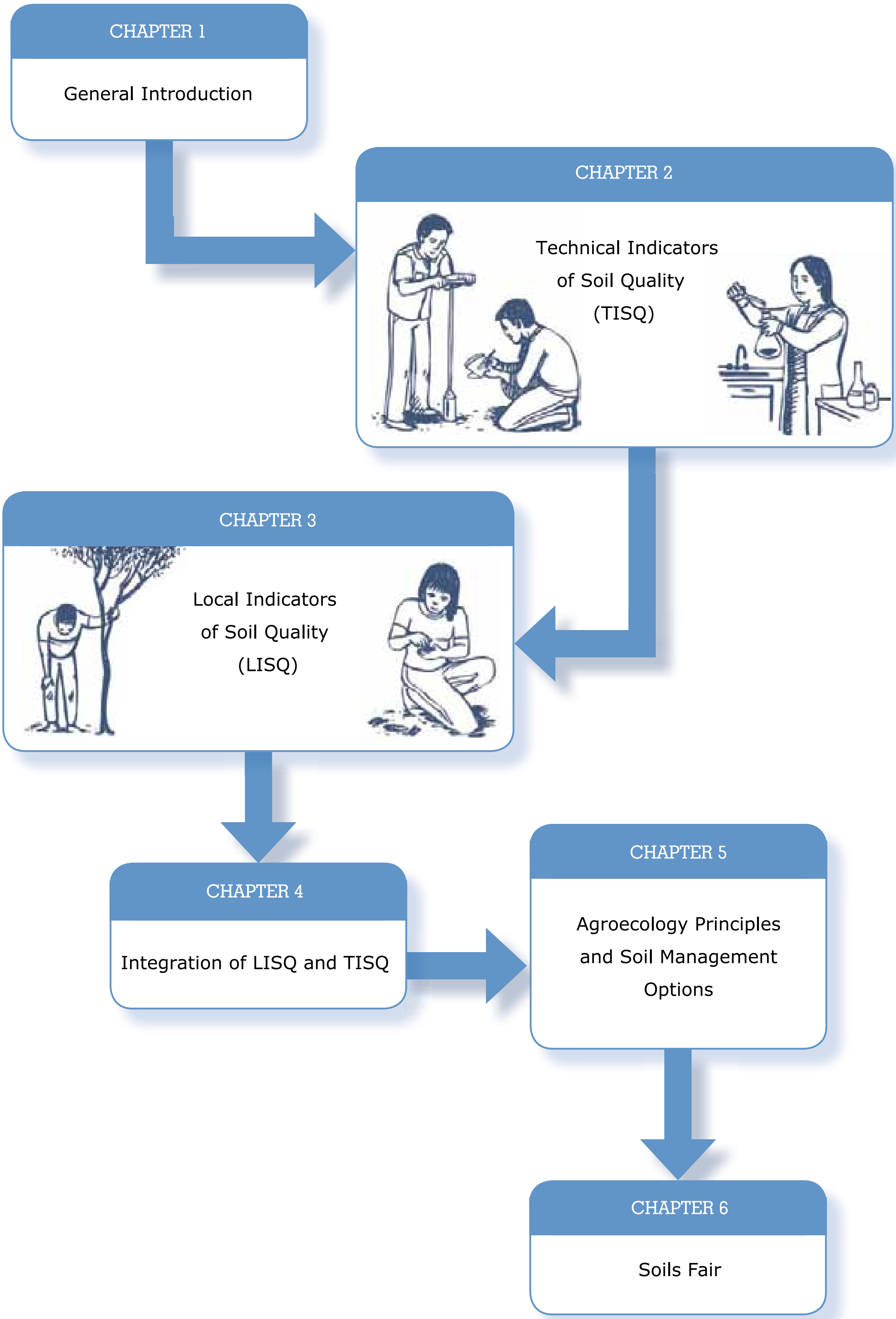
Figure 1.2 Developing Soil Quality Monitoring Systems (SQMS) as a Decision-Support System (DSS)

This methodological guide focuses on the first phase of the process, which is the identification of indicators that can be used by farmers, extension and rural development staff, NGOs, researchers and educators. It describes a participatory methodology for the integration of local and technical knowledge on indicators of soil quality, facilitating farmer consensus about which soil-related constraints should be tackled first, and about which agroecology management principles should guide the selection of soil management options to address such constraints. This methodology was developed from experience with communities of low-input small-scale farmers. The methodology is, however, applicable in any soil-based production system.

The main objective of the InPaC-S methodology is to include local knowledge, reflected in local indicators of soil quality, as part of soil quality monitoring systems to support decision-making processes during the management of natural resources. While the InPaC-S methodological guide and tools have been designed to be used sequentially during intensive training-of-trainers five day workshops, the methodological tools can be used indipendently and are flexible to be adapted to different contexts and time demands.

1.5 Structure of the methodological guide

The following figure summarizes the structure of the methodological guide.



The methodological guide *InPaC-S: Participatory Knowledge Integration on Indicators of Soil Quality* comprises six chapters. Chapter 1 provides a general introduction which highlights the soil as a living resource that provides benefits to society in the form of ecosystem services. It discusses the importance of soil quality as a tool for diagnosis and monitoring, and describes a series of methodological tools for building up a knowledge sharing space. Chapter 2 presents technical concepts of soil using a simplified version of Hans Jenny's model of soil formation. The main aim here is to generate a common base of technical knowledge among the workshop participants. It also presents Technical Indicators of Soil Quality (TISQ) that are most frequently used. Chapter 3 gives a detailed description of participatory methodological tools used to identify, classify and prioritize Local Indicators of Soil Quality (LISQ). Chapter 4 presents the methodological tools used for integrating local and technical knowledge and for establishing relationships between indicators and soil properties, as well as their potential for modification through management over time. Chapter 5 focuses on the modifiable soil properties and presents participatory methodological tools for the identification of agroecology principles and management options that address the soil quality constraints, depending on the farmers' capacity to use inputs. Chapter 6 provides a detailed description of the structure and the functioning of the Soils Fair as a key knowledge sharing tool for the participatory integration of knowledge in practice.

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1.7 InPaC-S Methodological Tools

BUILDING THE KNOWLEDGE SHARING SPACE

DYNAMIC #1 PERSONAL INTRODUCTION AND ASSESSMENT OF EXPECTATIONS

Objective: Getting to know the participants and their expectations of the workshop.

Materials: air-filled balloons (rubber balloons), strips of white paper (2.5 x 21 cm), pens.

a) All participants form a circle, standing or seated on chairs.
b) Give each participant a balloon, a strip of white paper and a pen.
c) Each participant should physically describe himself or herself (without indicating their name) on one side of the strip of white paper, and on the other side of the paper strip should state their expectations of the workshop.

d) Upon completion of the task, the strip of paper is rolled up and inserted into a rubber balloon.
e) Inflate the rubber balloon to the full, tie a knot, and place it on the floor at the centre of the circle of participants.
f) One participant will choose one of the balloons at random, burst it using a pen, and then proceed to collect the rolled

piece of paper inside it. They will first read out the self-description information contained on the paper strip. Once read, the rest of the participants try to guess the person to whom the description corresponds. After being identified, the person comes to the centre of the circle of participants and reads out his or her expectations.

g) The person then chooses the next balloon, to initiate another identification; this sequence is repeated for each of the participants.

DYNAMIC #2 MUTUAL INTRODUCTION OF PARTICIPANTS

Objective: Getting to know the background and experience of the participants.

Materials: note pads, pens.

a) Divide the participants into groups consisting of two persons per group.
b) Partner 1 describes to partner 2, his/her personal and professional interests, work experience, and something that is not found in their CV.
c) Partner 2 does the same for partner 1.
d) Partner 1 describes partner 2 in the plenary session to all the other participants. Then partner 2 in turn describes partner 1 in the same way.

DYNAMIC #3 WHAT DO WE KNOW ABOUT SOILS?

Objective: Knowledge sharing on soils and their management among technical professionals of different backgrounds and experience.

Materials: note pads, pens, rectangular coloured cards (12.5 x 23 cm), dark ink markers (Pillot type), Kraft paper, masking tape, brown paper, transparent adhesive tape (cellotape).

Divide the participants into groups of 5-6, depending on the total number of participants. The ideal number for working groups is five to ensure that there will be enough time to discuss all the results. Proceed with the numbering of the participants in the order from 1 to 5. People bearing the same number are grouped together to form different working groups, which meet in different parts of the room.

For all workshop activities requiring working groups the division of the groups will vary to enable participants to interact with new people each time.

Each working group is given the following list of questions:

1. **How would you define SOIL?**
2. **What is the importance of SOIL as a natural resource?**
3. **List the properties of SOIL that you know?**
4. **Which SOIL properties can be modified by management?**
5. **Which SOIL properties can't be modified by management?**
6. **What methods for evaluating SOIL quality do you know?**

Each question is discussed by members of the group and after reaching a consensus a consolidated response is written on one side of the cards using the broader side of the marker pen tip, bearing in mind that they should be legible from a distance of 3m. The coordinator/facilitator organizes the preparation of a paper board by joining sheets of kraft brown paper with cellotape. A matrix is drawn on the kraft paper board where columns correspond to each working group, and rows to the six questions. Working group contributions are discussed in plenary and the collective technical knowledge shared among participants with different backgrounds and experience.

DYNAMIC #4 CROSS-COUNTRY WALK ACROSS FARMER COMMUNITY

Objective: A cross-country walk that allows workshop participants a first contact with the socio-environmental context of a farmer community that will be involved in the workshop activities.

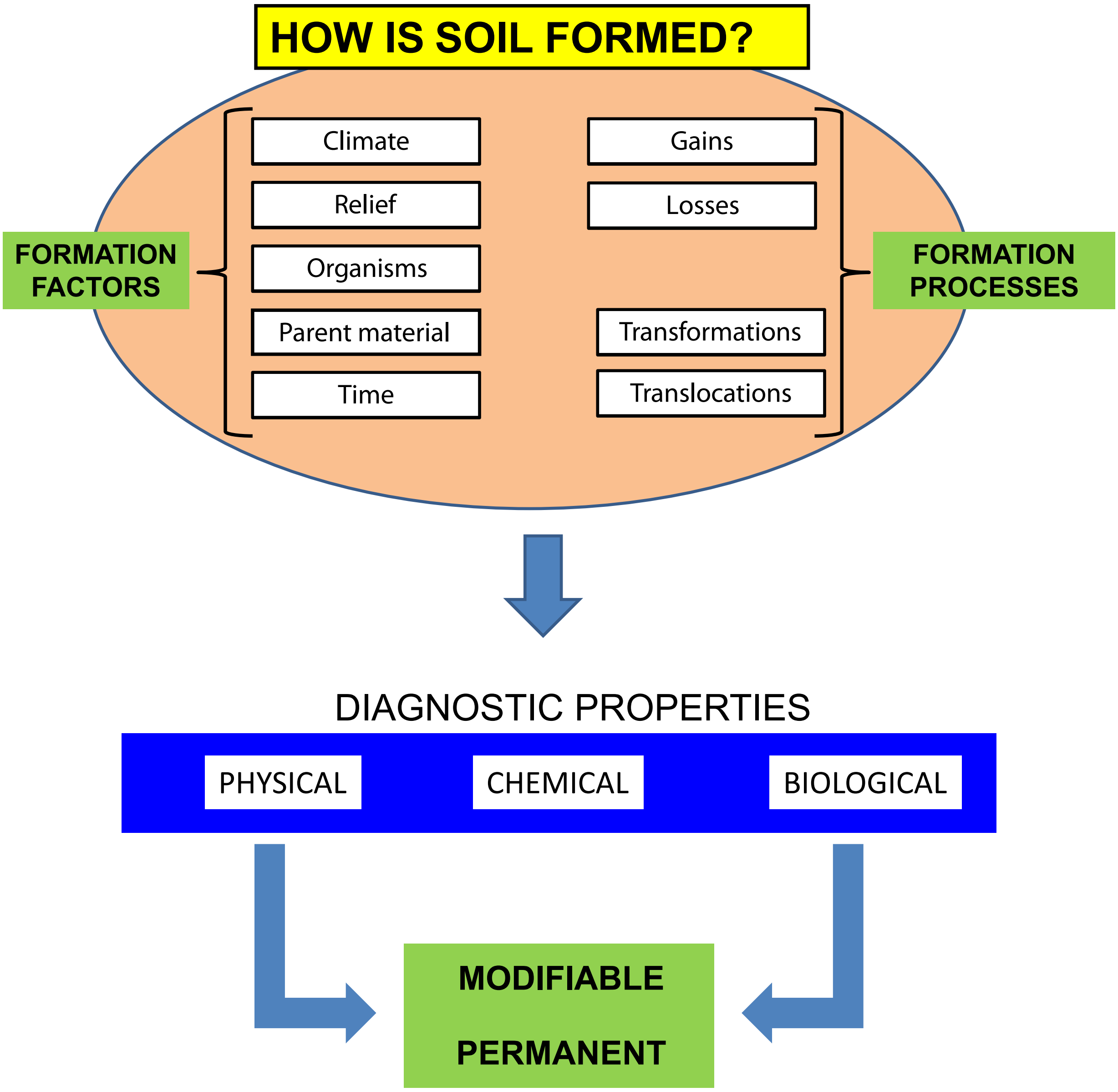
a) The route of the cross-country walk is planned in advance by the workshop coordinators in conjunction with farmer community leaders. The cross-country walk allows the familiarization with different land uses and the soil types predominant in the community. A map is drawn beforehand by members of the community to inform the participants on the route of the cross-country walk. Ideally, the local coordinator has a map of the region that permits the workshop participants to locate their position in the local geography. If possible, also print a Google Earth map of the location.

b) On arrival to the community the first step is to meet local leaders. Once assembled, make a round of introductions of the participating technical staff indicating their names, institution and place of work and then give the local leaders an opportunity to introduce themselves.

c) Initiate a cross-country walk guided by community leaders. This walk will allow for a first relaxed interaction among all workshop participants and farmer community members.

CHAPTER 2

TECHNICAL INDICATORS OF SOIL QUALITY



2.1 Introduction

Soil is one of the most important natural resources because of the benefits it generates for society through its role in the production of food, fibre, biofuels, and the provision of other ecosystem services.

Soils consist of solids (minerals and organic matter), liquids and gases, which are differentiated from their parent material following the influence of climate, topography, and living organisms through time (Jenny, 1941, 1980). Soil serves as the support for plant roots, has the ability to hold water and nutrients that can be used by plants, and is inhabited by a very large and varied biological community which enables it to perform diverse additional functions that are beneficial to society and the environment. The process of soil formation is very slow, and thus the importance and necessity of implementing good agricultural practices for its management and conservation.

Changes in the soil produced by natural processes or human influence modify its quality. The evaluation of soil quality will depend on the perspectives of the various users of this resource. Modern concepts of soil involve two basic sources of knowledge. First, knowledge accumulated over time by farmers was the only information available before the development of modern science. This knowledge has often not been sufficiently appreciated as an important source of information on soils and its relationship to management (Barrios et al., 2006). Second, there is soil science knowledge acquired by applying the scientific method to the study of soil, which considers soil properties in relation to its role in agricultural ecosystems, including its formation, morphology and classification (Lal, 2005).

This methodological guide promotes integrated knowledge about the agricultural use of soil through both technical concepts and terminology, and farmer experience, so that farmers, extension and rural development agents, researchers and academics can share knowledge, understand and analyze the origin, evolution and distribution of soils, as well as how soil use and management influences the provision of food and other services to society. In this chapter, we present a theoretical framework using a simplified model of soil formation based on modern concepts of soil science, define the most important soil properties and illustrate different types of soil-mediated ecosystem services.

2.1.1 Objectives

At the end of this chapter, workshop participants will be able to:

- Differentiate between the various factors and processes influencing soil development through the Simplified Model of Soil Formation.
- Describe the factors and processes influencing soil formation.
- Identify physical, chemical and biological soil properties, and differentiate between modifiable and permanent properties.
- Understand soil as a source of ecosystem services critical for the survival and wellbeing of humanity.

2.2 Importance of soil

Soil is important as a natural resource because:

- It constitutes the foundation for renewable natural resources (flora and fauna).
- It provides food for society and is a basic resource for the survival of the poorest populations.
- It acts as a filter for waste generated as a result of human activities.
- It holds water available for crops and supplies underground water reservoirs.
- It is not a renewable natural resource considering the human generation time frame.

It is also a medium in which plants grow because:

- It serves as an anchor for their roots.
- It provides water.
- It provides mineral nutrients.
- It provides air for the roots to respire.

2.3 Factors and processes of soil formation

The natural development of soils in the landscape involves the formation of distinct overlaid horizontal layers. Each distinct layer is known as a soil horizon. In contrast to the underlying bedrock, horizons have been modified through interaction with climate, topography and living organisms over time. Horizons differ in their physical, chemical and biological properties. Soil is formed as a result of the evolution of soil horizons through various transformative factors and processes. Understanding the process of soil formation is useful to understanding soil suitability for various uses.

2.3.1 Factors of soil formation

Factors of soil formation are those agents responsible for its development, which include the climate, parent material, relief, living organisms and time (Jenny 1941, 1980; Lal, 2005).

Simply put, the type of soil developed in a specific location depends on the period of time over which the parent material (bedrock), in a defined topography, has been exposed to the influence of climate and living organisms. For example, in a place with a cold and dry climate, and with a rugged topography, the evolution of the soil would be mainly determined by relief, water availability and the low substrate temperatures which are less favourable for the growth of organisms, including plants and animals.

Climate

The climate is considered to be the most important factor in soil formation and evolution, with temperature and precipitation (rainfall) constituting the most influential components. Its effects are directly related to the dynamic control of the physical, chemical and biological processes (especially the production and decomposition of organic matter).

Relief

Relief, also referred as topography, contributes to soil formation through its effect on soil erosion and drainage (it speeds up or slows down the process of soil formation). For example, the soil profiles in areas with steep slopes are generally shallow, as a result of the high rate of erosion. On the other hand, soils in valleys show deeper and more developed soil profiles resulting from the tendency to accumulate sediments as a result of erosion from the surrounding mountains. Good soil drainage in mountainous and rugged areas, in contrast to that of the low and flat areas with drainage limitations, favours faster processes of soil formation.

Parent material

It is made up of the substrate and materials that develop into soil. Most soils have their origin in the mineral parent material, which is derived mainly from weathering of the 'bedrock'. Other soils are developed in organic deposits, especially of plant origin, formed in swamps and floodplains, and this gives rise to parent materials with different composition and resistance to degradation.

The parent material influences the physical and chemical characteristics of soil, but the best correlation is with texture. Those parent materials with high quartz content mainly generate sandy soils while the weathering of rocks and sediments generate soil of fine textures. The same type of parent material may result in the development of various soil types depending on the nature of other factors, particularly climate. For example, basaltic rocks generate mainly Oxisols and Alfisols (Latossolo Vermelho and Nitossolo – Brazilian System of Soil Classification, SiBCS, 2006) in the humid tropics, and Vertisols (Vertissolo – SiBCS, 2006) in semi-arid tropics.

Living organisms

Organisms that live in the soil can influence its development, either directly or indirectly. Those with direct influence include higher plants, vertebrates, and soil macro- and micro-organisms. Plants mainly contribute through the addition of organic matter to soil; this contribution varies in quantity and quality depending on the plant communities. Plant roots can hold soil together and prevent erosion, contribute to the physical disintegration of solid materials in the soil (weathering), extract and recycle nutrients within soil horizons, and leave a network of channels after their death and decomposition which favour soil drainage. Some vertebrates, including rabbits and moles make holes and mix soil horizons. Soil macro- and micro-organisms have a strong influence on soil formation due to their role in the development of soil structure, the decomposition of organic matter and the redistribution and recycling of nutrients, as well as the transformation of these nutrients into the mineral forms necessary for plant nutrition.

Time

The degree to which the other factors of soil formation described above are expressed is a function of the time over which they have operated. In general, soil in alluvial deposits has not had as much time to develop as the soils formed in other landscapes. Most developed soils, as those found in humid tropical plateaus, generally have deeper profiles, are more weathered, contain horizons of greater thickness, are more structured, and generally present nutrient deficiencies as a result of leaching losses.

2.3.2 Processes of soil formation

These are the processes that create the conditions allowing the same group of soil forming factors to generate different soil types from the same parent material. The processes of soil formation include **gains**, **losses**, **transformations**, and **translocations**, which occur over time within the profile of the parent material as a result of natural processes and those generated by human action.

Soils *gain* from different types of depositions, both beneficial (e.g. nutrients) and harmful (e.g. toxic waste) for its development. These depositions may be liquid or solid, mineral or organic. There is a relationship between gain and *loss* processes, where agents which affect one of the processes irremediably affects the other process. For example, while wind and water erosion produce (loss) of soil they also generate deposits (gain) of soil materials downstream. *Transformations* are the modifications of soil minerals and organic particles generated by biophysical and chemical processes, while *translocation* is a process that involves the physical movement of constituents in the soil profile, as in the case of clay illuviation.

Examples of natural processes and of those generated by human action are given below.

Natural processes

- Movement of the soil particles and nutrients in the landscape through water erosion and deposition.
- Wind erosion (wind) and dust deposition.
- Enrichment and depletion of soil nutrients by the movement of water.
- Clay movement inside the soil profile.
- Nutrient absorption by deep rooting plants.
- Biological nitrogen fixation.
- Soil aggregation as a result of earthworm activity.

Processes generated by human action

- Importing of mineral and organic fertilizers to countries and regions.
- Transportation of manure and waste to agricultural landscapes.
- Transportation of agricultural products from the field to towns and cities.
- Burning of vegetation and agricultural waste.

2.4 Indicators of soil quality and soil properties

Indicators of soil quality relate to the use capability and ease of management of soils, and can be considered measures of soil fertility. Indicators of soil quality are intimately related to physical, chemical and biological properties of the soil (Lal, 2005).

2.4.1 Physical properties

These are soil properties that can be determined by the senses of sight and touch. When observing the colour of the soil, for example, one can make a rough estimate of the organic matter and iron content, as well as of drainage. By using one's fingers to feel the soil, one can estimate the type and size of soil particles. The physical properties of soil are mainly determined by the relative abundance of particles of different sizes, and can be divided in two groups:

- Primary properties: texture, structure, colour, consistency, density and temperature.
- Secondary or derived properties: aggregation, porosity, aeration, water retention capacity, compaction and effective depth.

Texture

The weathering of rocks and minerals creates a great diversity of particle sizes, from stones to gravel, sand, silt and clay. Soil texture refers to the relative proportion of sand, silt and clay in the soil. Texture is responsible for the potential fertility, aeration, permeability, effective depth and moisture characteristics of soils. Sandy soils, for example, will absorb and release water very easily, and thus permit rapid infiltration and water absorption by the plants. They also have a reduced capacity to adsorb nutrients. Clay soils, on the other hand, can retain water and nutrients for longer periods of time but may have limited aeration. Loam soils have intermediate characteristics between clay and sandy soils and are better suited for most crops.

Structure

Soil particles are typically grouped together to form aggregates. The shape, size and arrangement of aggregates determine the structure of the soil. Soil structure is influenced by the composition and content of organic matter, iron oxides and hydroxides, biological activity, and type of clay. It has an effect on water absorption, drainage, aeration and root growth, and can be modified in the surface soil horizons either through tillage or application of organic materials during cultivation.

Colour

Colour is probably the soil property that is most easily recognizable. Soil colours range from black to almost white, and from red to yellow. It is possible to indirectly estimate soil characteristics such as organic matter and iron content, humidity and parent material, by looking at the colour of soil.

Consistency

Consistency is the soil's resistance to deformation under specific humidity conditions. It is determined in relation to the adhesive and cohesive properties of the soil mass. It is the indicator of soil quality that is more closely related to the type of clay present in it, and has an important influence on the tillage operations, and on the rooting depth of plants.

Density

This property refers to the mass (weight) per unit volume of soil. It is important to differentiate between particle density and bulk density. The former refers only to the volume of solid particles in the soil while the latter refers to the volume of solid particles and the pore space between the particles. Soils have different densities due to differences in texture, type of clay minerals and organic matter content. Properties such as water retention and gaseous exchange are related to bulk density, which in turn depends on the number and shape of the pores.

Temperature

Temperature is an indication of quantity of solar energy that reaches the earth's surface. Soil chemical processes and activities of soil organisms are greatly influenced by temperature. In tropical regions, very high or very low temperatures, as well as rapid changes in daily temperature, influence the rate of soil formation.

Aggregation

The combination of primary particles (sand, silt and clay) with organic materials from different sources (plant residues), and the products of the activity of soil macro- and micro-organisms generates secondary particles called aggregates. The stability of the aggregates when in contact with water during rainy events is an important indicator of the structural stability of soil and therefore its resistance to erosion. The mean aggregate diameter is an integrated measure of the balance between aggregate forming processes (linked to organic matter and nutrient storage) and aggregate disrupting processes (linked to erosion losses, leaching and increased agricultural mechanization through tillage). Aggregates can be divided into macro-aggregates (large aggregates, which are affected by tillage) and micro-aggregates (small aggregates that are not affected by tillage).

Porosity

Porosity, also known as the pore space, is the portion of soil not occupied by solid particles but occupied by air and water. The arrangement of the soil particles and aggregates determines the amount of pore space. Soils have approximately 50% porosity which is important for water retention and flow, gas diffusion, root growth, temperature regulation and soil biological activity. The pore space in soils is composed of macro-pores (large) and micro-pores (small).

Aeration

This property refers to the amount of gaseous flow in the soil. It is determined by the quantity of macro-pores (> 0.05 mm) in the pore space, which facilitate the movement of gases used or released by plant roots and through the activities of soil organisms.

Water holding capacity

This property is related to the amount of water that the soil is capable of retaining, and which is available to plants. This property may vary depending on texture differences, changes in organic matter content and the nature and size of soil pores. Fine textured soil (e.g. clay), with high organic matter content and higher proportions of micro-pores can hold more water for a longer period of time, compared with coarse textured soils (e.g. sand), with low organic matter content and a reduced number of micro-pores

Compaction

Compaction is the result of changes in soil porosity due to intensification and long term impacts of agricultural practices. Compaction reduces the total pore space and increases bulk density. Tillage operations are aimed at increasing the pore space and reducing bulk density.

Effective depth

This indicator relates to the depth to which the roots of plants can reach without encountering physical and chemical limitations. Deep soils allow both downward and lateral root penetration and thus increase the soil potential to supply water and nutrients to plants. This is one of most important properties for determining the agricultural potential of soil.

2.4.2 Chemical properties

Chemical properties indicate the contents of organic and inorganic soil components and their influence on agricultural productivity. The most important chemical indicators are pH, organic matter content and cation exchange capacity.

pH

pH is a measure of acidity or alkalinity of the soil on a scale from 1 to 14. pH values less than or equal to 6 are considered acidic while those higher than or equal to 8 are considered alkaline. Soil with a pH of 7 is considered neutral. pH has a direct influence on physical, chemical (e.g. nutrient availability) and biological (e.g. microbial activity) characteristics that influence crop growth.

Organic matter

Organic matter is composed of a mixture of dead roots, plant residues and soil organisms at various degrees of decomposition. It has a significant impact on the physical, chemical and biological properties of the soil. Organic matter contributes to good soil structure that allows the storage of water and nutrients for plants. It also facilitates the life and growth of soil organisms by providing energy-rich carbon compounds, nitrogen for the synthesis of proteins, as well as other nutrients. Some soil nutrients are largely found in the organic matter, including most of the nitrogen, a significant proportion of phosphorus, and smaller amounts of sulphur. During organic matter decomposition these nutrients are released and become available to plants. Therefore, the amount and type of organic material can significantly influence the amount and availability of these nutrients in the soil. Organic matter also affects the colour of the soil. A darker colour usually indicates higher organic matter content compared to lighter coloured soil at similar levels of soil moisture.

Cation exchange capacity (CEC)

Surfaces of soil colloids (e.g. humus as part of organic matter and clay minerals in the soil) have negative charge which enables them to 'magnetically hold' nutrients that are positively charged (e.g. cations such as K^+, Ca^{++}) on their surfaces. This is important for reducing nutrient losses due to leaching. Nutrients held in colloids can be exchanged with those dissolved in the soil solution surrounding them. Due to differences in colloid structures, soils have different capacities to hold or adsorb cations. The cation exchange capacity, or CEC, is a measure of the ability of the soil to hold cations. It is also an indirect measure of negative charges in the soil, associated with the organic matter and clay content.

On the other hand, negatively charged nutrients (e.g. anions NO_3^-) are repelled by the negative charge of humus and clay minerals thus remaining in the soil solution and increasing the potential for leaching losses.

The process of cation adsorption by colloids from the soil solution and their release into soil solution is called cation exchange. This process is very important for plant nutrition. When the soil is not able to release the nutrients required by plants it becomes necessary to use fertilizers. A part of the nutrients applied through fertilization is absorbed by plants, another part is retained in colloids and the remaining portion is lost from the system in liquid or gaseous form.

2.4.3 Biological properties

The biological properties of soil are related to the abundance (number of individuals), diversity and activity of organisms that inhabit it. Soil organisms (e.g. earthworms, termites, ants, fungi, bacteria, etc.) have an important role to play in the decomposition of organic materials, because they fragment, ingest and excrete these substances and thus influence soil physical and chemical properties. While the activity of soil macro-organisms is the easiest to observe (e.g. worm casts, termite mounds, ant nests, etc.), the activity of soil micro-organisms is usually difficult to observe. Nevertheless, there are micro-organisms such as nitrogen-fixing bacteria, which when associated with the roots of leguminous plants stimulate them to form easily identifiable rounded structures called root nodules.

Biological properties are directly or indirectly affected by other soil properties such as temperature, moisture, pH, organic matter content and nutrient availability. The activity of soil organisms and plants is usually more intense under conditions of higher mean temperature and humidity as is the case in many tropical soils.

2.4.4 Permanent and modifiable soil properties

An alternative way of classifying soil quality indicators is in accordance with the time necessary to modify them through agricultural management. Soil properties may be classified as permanent or modifiable. A permanent property is that which is determined by the parent material and soil forming factors that cannot be changed easily in the short or medium term. Soil texture is considered a permanent property since it would be very difficult to change the relative distribution of soil particle sizes. A modifiable property, on the other hand, is one which can be changed significantly by soil management. An example is the reduction of organic matter content in the soil due to the higher rates of mineralization caused by burning, tillage, etc.

2.5 Soil-mediated ecosystem services

Following the Millennium Ecosystem Assessment classification (MA, 2005), soils contribute to provisioning, regulating, cultural and supporting ecosystem services (Barrios, 2007; Kibblewhite et al., 2008, Barrios et al. 2012).

Provisioning services: These include the contribution of soils to the production of food, timber, fibre and biofuels in agricultural landscapes.

Regulating services: Soil serves a very important function as a regulatory centre for many ecosystem functions that generate benefits to society. Soil regulates water fluxes by regulating the speed and amount of water movement through the soil profile, mainly by creating equilibrium between the infiltration rate and the water holding capacity of soil. In soils with good infiltration and water holding capacity, water movement is gradual. In soils with low infiltration and water holding capacity (e.g. compacted soils), the movement of water occurs primarily by rapid and uncontrolled surface flow, thus causing flooding. Soils also contribute to the regulation of greenhouse gas emissions, through different mechanisms that promote sequestration of carbon and organic nitrogen inside aggregates that are the building blocks of soil structure. This physical protection would limit their exposure to soil organisms that can transform them into CO_2 or nitrogen oxides (e.g. NO, NO_2, N_2O) respectively. By percolating through the soil, water quality is regulated by means of filtering and modification of toxic and non-toxic materials and products. In this way it also contributes to the wellbeing of society. Additionally, soil plays a role in the regulation of pests and diseases in agricultural landscapes because many soil organisms contribute to their biological control when a part of their life cycles takes place in the soil.

Cultural services: The cultural services generated by soil include its educational value to society, its ability to serve as context for ecotourism and recreation, and also as a source of inspiration due to the scenic beauty it offers, in addition to the spiritual and religious significance which it has for some cultures.

Supporting services: These are fundamental services necessary for the production of any of the other services mentioned above. Generally, these have indirect impacts (e.g. production of oxygen by photosynthesis) and may occur over long periods of time (e.g. soil formation). The recycling of water and nutrients is a critical ecosystem service that is essential for life in the planet, with obvious examples in agriculture. An example of a soil management system with significant delivery of support services is the no-till system. Since it is based on organic cover and minimum disturbance of the soil, it promotes the development and activity of the organisms involved in organic matter decomposition and nutrient cycling (supporting services), erosion control (regulating services), and crop production (provisioning services).

In the last four decades, provisioning services of food that depend on the soil increased by 170%, and the production of wood and fibre (e.g. cotton, jute, wool, etc.) increased by approximately 60% (Palm et al., 2007). These large increases in provisioning services have undoubtedly contributed to the economic wellbeing of society. Unfortunately, such increases have been achieved at a high cost to future generations on account of the impact of these increases on soil degradation and many of its regulating and supporting services (MA, 2005). Soil quality will significantly influence the continuous capacity to generate the different kinds of ecosystem services mentioned above.

2.6 Summary

In this chapter we have reviewed the factors and processes of soil formation, and identified the most important physical, chemical and biological properties of the soil. We also discussed different types of soil-mediated ecosystem services, and highlighted the importance of judicious soil use and management for maintaining a balance between the provision of different services that do not compromise the wellbeing of present day society and that of future generations.

In the next chapter, through a series of participatory methodological tools, we will generate a list of local indicators of soil quality in order of importance and in Chapter 4 these local indicators will be integrated with technical indicators of soil quality. That integration will enable us to develop a common language between farmers and technical professionals, which is essential to foster knowledge sharing.

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2.8 InPaC-S Methodological Tools

BUILDING A COMMON FOUNDATION OF BASIC TECHNICAL KNOWLEDGE ON SOIL

DYNAMIC #5 FACTORS vs. PROCESSES OF SOIL FORMATION

Objective: To understand soil formation as the result of the interactions among five key factors: **CL**imate, **O**rganisms, **R**elief, and **P**arent material and **T**ime through different natural processes (abbreviated as: **CLORPT**).

Materials: Exercise #1 and #2 handouts, pens.

a) Introduce Exercises #1 and #2 in plenary.

b) Divide the participants into working groups (up to 5-6 people per group).

c) Distribute a copy of Exercises #1 and #2 to each group.

d) In Exercise #1 each working group evaluates different terms as factors or processes, and once consensus is reached marks the selected answer with an X.

e) Exercise #2 after discussion and consensus building the group identifies and writes on the first line which of the five factors of soil formation corresponds to each picture and then identify four components for each factor and write them above each of the four lines that follow.

f) Each group will present their answers for Exercises #1 and #2 in plenary.

g) Compare the answers of each group with the answers found in Annex 2.

h) Discuss the responses in plenary.

FACTORS AND PROCESSES OF SOIL FORMATION

EXERCISE#1

	Factors	Processes
Climate		
Soil loss		
Temperature		
Rainfall		
Wind speed		
Cloudiness		
Soil gains		
Humidity		
Relief		
Parent material		
Organisms		
Flora		
Fauna		
Translocations		
Luminosity		

EXERCISE#1

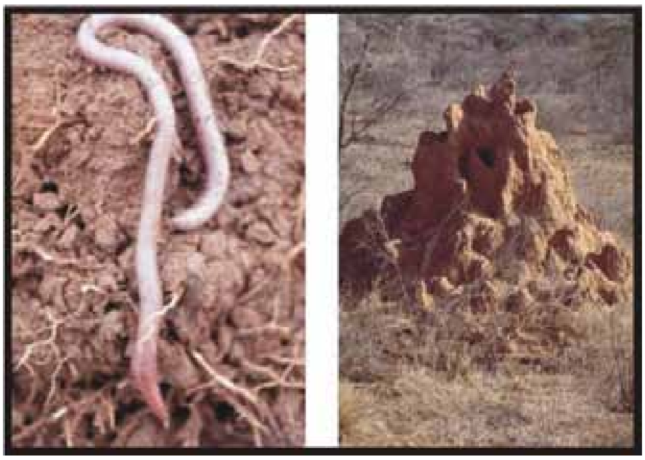
	Factors	Processes
Slope		
Valley		
Mountain		
Geology		
Erosion		
Burning practice		
Alluvial deposition		
Incorporation of plant residues		
Transformations		
Clay movement		
Clay mineralogy		
Microorganisms		
Soil evolution		
Forest		
Pasture		

EXERCISE#2

FACTORS OF SOIL FORMATION

____

1. ____________________________
2. ____________________________
3. ____________________________
4. ____________________________



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1. ____________________________
2. ____________________________
3. ____________________________
4. ____________________________

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1. ____________________________
2. ____________________________
3. ____________________________
4. ____________________________

EXERCISE#2

FACTORS OF SOIL FORMATION

1.______________________________

2.______________________________

3.______________________________

4.______________________________

1.______________________________

2.______________________________

3.______________________________

4.______________________________

DYNAMIC #6 UNDERSTANDING ECOSYSTEM SERVICES

Objective: To build awareness and understanding on the different services that the ecosystems provide and which make life possible on the planet, putting emphasis on the fundamental role played by the soil.

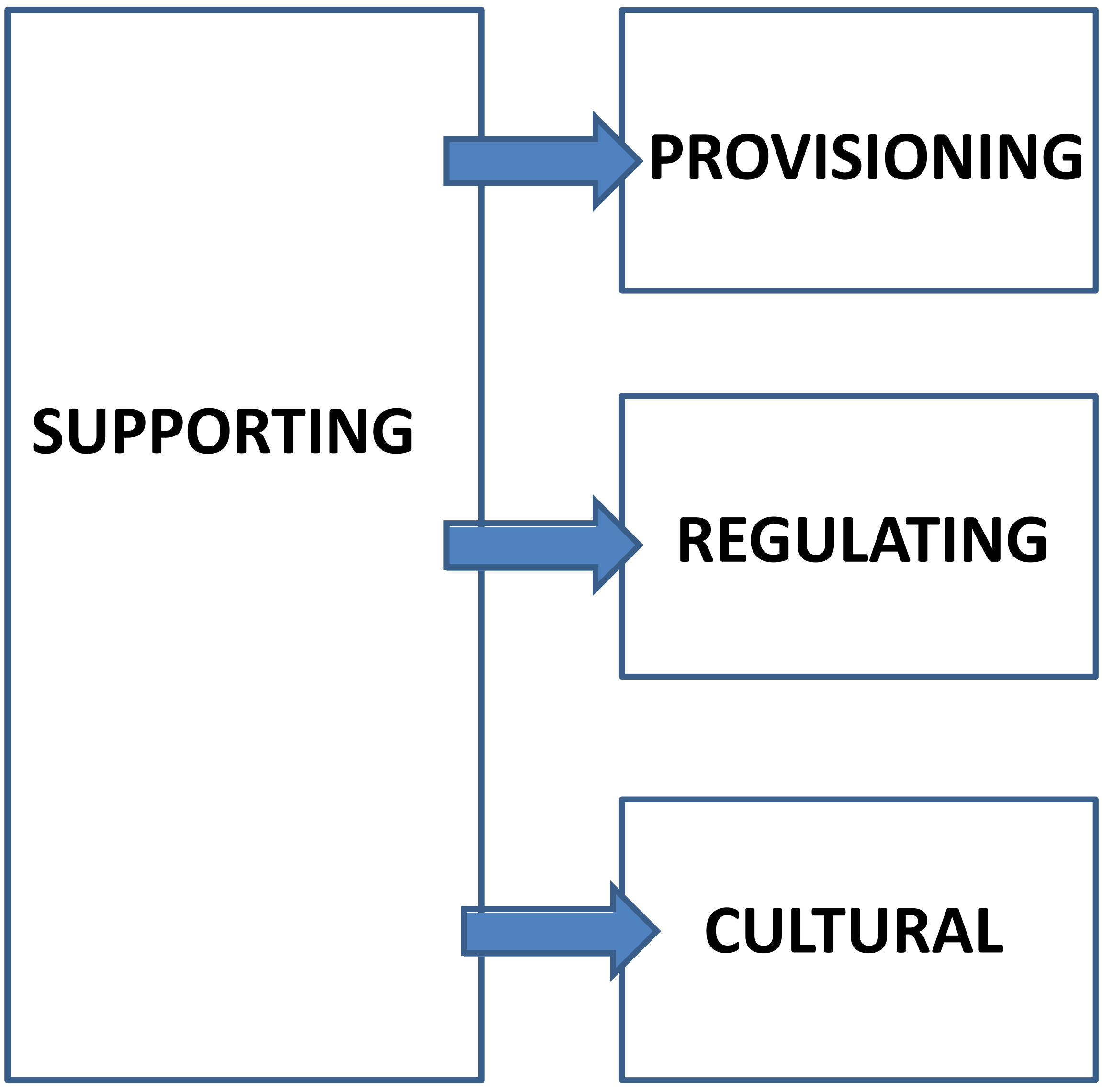
Materials: Forms for Exercise #3, pens.

a) Introduce Exercise #3 in plenary and refer to Figure 1.1 for the different types of ecosystem services.
b) Split the participants into groups (up to 5-6 per group).
c) Distribute a copy of Exercise #3 to each group.
d) The groups will hold discussions on the type of ecosystem service for each example given on the first column and write on the second column the corresponding service: (e.g provisioning, regulating, cultural or supporting).

e) Each group will present their responses from Exercise #3 in plenary.
f) Compare group answers for each group with the answers found in Annex 2.
g) Discuss the responses in plenary.

EXERCISE#3

ECOSYSTEM SERVICES



EXERCISE#3

	Type of Service
Pollination	
Soil formation	
Fibre production	
Rainfall	
Nutrient cycling	
Production of building materials	
Biological control of pests and diseases	
Water purification	
Scenic beauty	
Control of greenhouse gas emissions	
Photosynthesis	
Flood control	
Recreation and educational area	
Food production	
Climate regulation	

DYNAMIC #7 INDICATORS OF SOIL QUALITY

Objective: To understand the concept of indicator and what makes a good or poor indicator of soil quality.

Materials: Rectangular coloured cards (12.5 x 23 cm), dark ink markers (Pillot type), Kraft brown paper, masking tape, transparent adhesive tape (cellotape).

a) Split up the participants into groups of 5-6 people and request them to answer the following questions:

   1. What is an indicator?

   2. Give examples of indicators that you know

   3. What are the characteristics of a good indicator?

   4. What are the characteristics of a poor indicator?

b) Facilitators coordinate the preparation of a paper board by joining sheets of Kraft brown paper with cellotape. A matrix is drawn on the Kraft paper board where columns correspond to each working group, and rows to the four questions.

c) Each question is discussed by members of the group and after reaching a consensus a consolidated response is written on one side of a single card, using the broader side of the marker pen tip, bearing in mind that they should be legible from a distance of 3m.

d) One group member will read each card in plenary and then another group member will affix the card on the paper board matrix using masking tape.

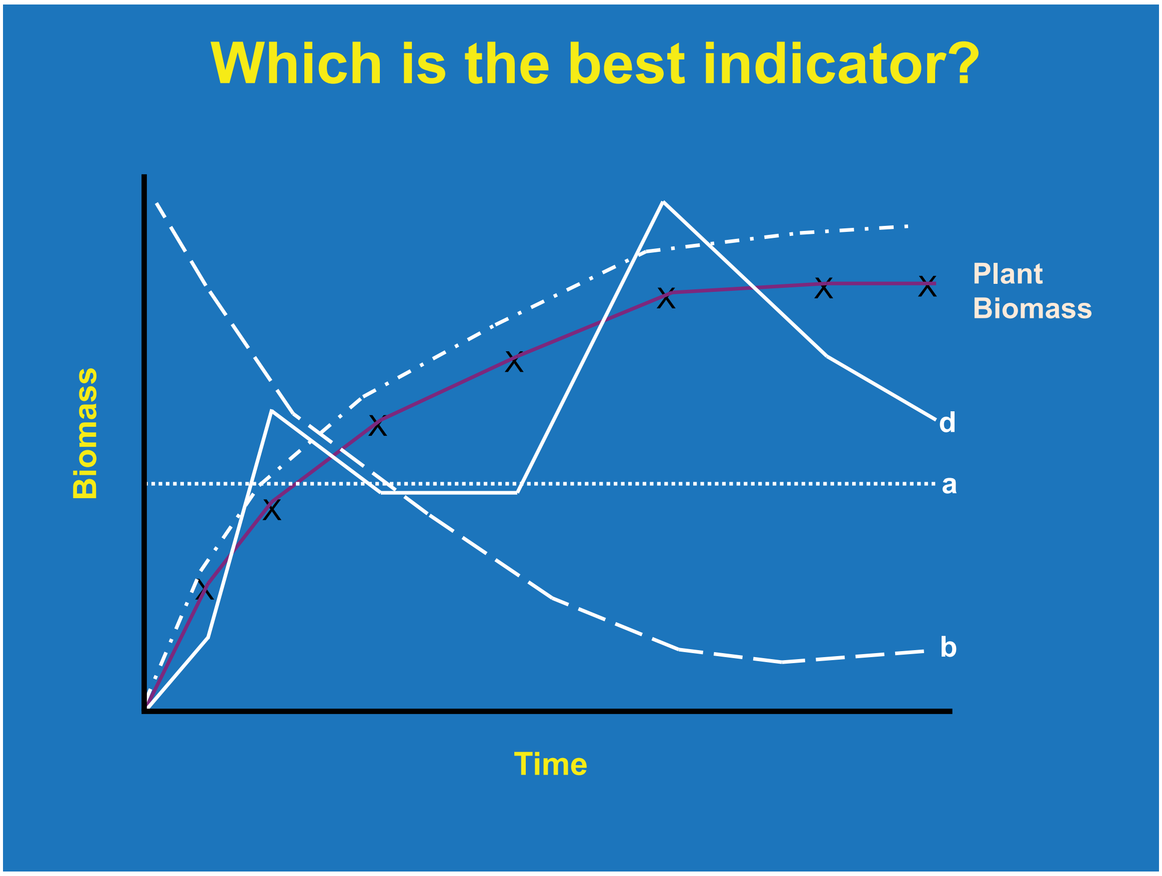
DYNAMIC #8 INDICATORS OF SOIL QUALITY

Objective: To understand the characteristics of a good indicator of soil quality.

Conduct Exercise # 4 in plenary using PowerPoint. Project the graph on the screen or wall to examine the behaviour of different soil quality indicators relative to plant biomass.

a) Split the participants into groups (up to 5-6 per group).
b) Distribute a copy of Exercise #4 to each group.
c) The groups will hold discussions and agree on the best indicators of plant biomass and justify their answers
d) In addition, they will highlight the limitations of the other indicators.
e) They will then present their responses in plenary.
f) Compare the answers of each group with the answers found in Annex 2.
g) Discuss the responses in plenary.

EXERCISE#4



What response curve represents the best soil quality indicator as related to plant biomass?

Evaluate each response curve using a score from 1 to 4, considering that the best indicator = 1 and the worst = 4. Write your response in the lines below.

a) ________________
b) ________________
c) ________________
d) ________________

CHAPTER 3

LOCAL INDICATORS OF SOIL QUALITY

3.1 Introduction

Local knowledge results from the integration that farmers make from their observations of responses by natural and managed ecosystems to different factors that can affect soil productivity (Barrios et al., 2006). This knowledge represents a cultural resource that is rapidly being lost largely due to the exodus of rural youth to the cities and the aging and death of experienced farmers. With the motivation of preserving and using this important cultural heritage, the objective of this methodological guide, and this chapter in particular, is to introduce a participatory approach to facilitate communication and knowledge sharing between small-scale farmers and technical professionals, to identify the nature and content of local knowledge about the soil and its management, and to facilitate the dissemination and use of this valuable knowledge in land management decision-making.

Local and technical knowledge share a common set of basic concepts, but each knowledge system has gaps that can often be filled by the other system (Figure 3.1).

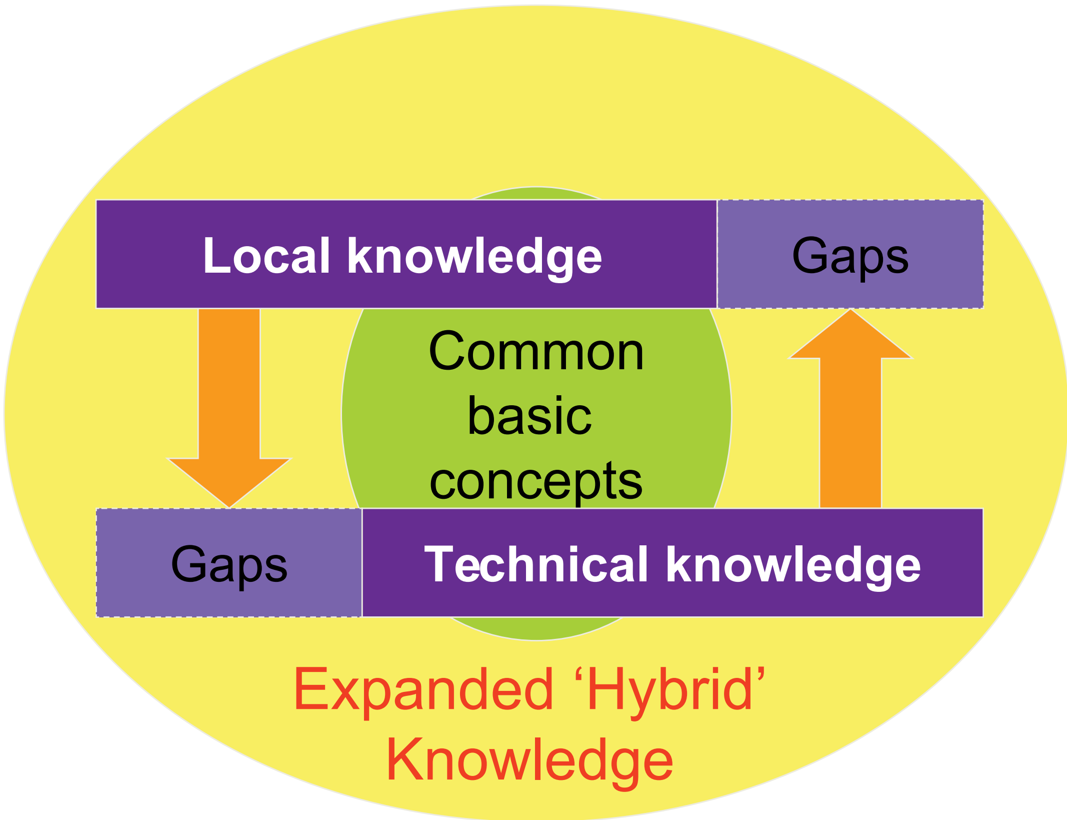


Figure 3.1 Conceptual model highlighting the complementary nature of local and technical knowledge, generating an expanded "hybrid" knowledge that is more relevant and comprehensive (Adapted from Barrios et al. 2006).

New research efforts for agricultural development should seek a balance between scientific accuracy and local relevance, thus giving rise to an expanded “hybrid” knowledge. This hybrid knowledge is generated through a process that facilitates the integration of local and technical knowledge, which is the focus of the participatory approach and tools used in this guide.

The integration of farmers’ experiences with technical knowledge enables a better understanding of the soil and its response to management thus improving decision-making in the field. There are many management practices known and implemented by farmers to improve and sustain agricultural productivity. A better understanding of the importance of these soil management practices, through effective communication facilitated by a common language shared by farmers and technical professionals, will certainly promote a wider adoption of good management practices.

3.1.1 Local indicators

Local indicators correspond to the local language terminology traditionally used by farmers to describe soil characteristics that they can easily understand. Finding concurrence and complementarity between local and technical indicators is an important aspect of this methodological guide. Creating compatibility between the local and technical language, allows farmers and technical professionals to share a common language and communicate more easily about the soil resource and its management.

3.1.2 Objectives

At the end of this chapter, workshop participants will be able to:

- Identify local indicators of soil quality used by farmers.
- Group together local indicators that are related to same soil characteristic.
- Prioritize local indicators of soil quality based on their order of importance.
- Describe the methodology used to identify, classify and prioritize local indicators of soil quality to others.

3.2 Participatory methodologies to identify, classify and prioritize local indicators of soil quality

The following will detail participatory methodological tools that will guide the identification, classification and prioritization of the local indicators ordinarily used by farmers in their evaluation of soil quality. Through this process, the criteria used by farmers to identify and evaluate soils, as the most important indicators are systematically defined.

There are five key steps in the participatory methodology for generating a prioritized list of local indicators of soil quality together with the farmer community, namely: i) introducing the Field Day Activity to the leader(s) of the farmer community, ii) identifying local knowledge on indicators of soil quality, iii) classifying local indicators of soil quality, iv) prioritizing local indicators of soil quality by farmers in working groups, and v) summarizing the farmer community priorities on local indicators of soil quality using the Synthesis Matrix tool.

3.2.1 Introducing the Field Day Activity to representatives of the farmer community

An introductory presentation of the Field Day Activity to the leader(s) of the farmer community is fundamental to ensure farmer participation. Please note that this introductory presentation to local leaders may need to be done more than once before the date set for the Field Day Activity to ensure active participation of the farmer community. It is important to explain to the local leadership that the goal of the Field Day Activity is to learn from farmers about their experience in soil fertility management. The local knowledge identified during the Field Day Activity will be used to complement the relevant technical knowledge during the rest of the workshop, before collectively formulating recommendations on good agricultural practices in their production systems. It is important to highlight that all information generated will be shared with the farming community during the Soils Fair on the last day of the workshop. The Field Day Activity must then be described in a simple and brief manner as the identification of local indicators of soil quality, their classification and ranking according to their order of importance. This explanation must be repeated at the beginning of the Field Day Activity with all participants.

The use of analogies or examples known to farmers facilitates understanding of the overall goal of the Field Day Activity. For example, a common activity in the daily life of small-scale farmers is the visit by public health officials to the community to carry out preventive health care. In the local clinic, the persons with symptoms (e.g. fever, headache, body ache) would like to know what is ailing them and how they can be cured. To this end, the doctor makes an initial rapid examination of the patient first by listening carefully to the oral description of the symptoms, evaluating a series of visual indicators of the person's health (e.g. status of eyes, ears, throat, etc.), and also using rapid indicators such as weight, height, body temperature and blood pressure. These indicators allow the doctor to make a quick initial diagnosis and recommend basic treatment, which may include a change of diet or of the amount or type of exercise, some medication, etc. Often the initial examination and treatment is enough to resolve a large proportion of the health problems. In some cases, however, depending on the seriousness of the initial diagnosis, the doctor may need to advise the patient to undergo a series of laboratory tests to deepen and confirm the results of the initial examination. Laboratory tests are a series of technical measures or human health indicators, such as blood tests (e.g. levels of hemoglobin, cholesterol, glucose, uric acid, etc.), and others. When the initial rapid diagnosis is not enough to resolve the health problem, a more complete diagnosis allows doctors to decide on additional therapeutic needs of the patient.

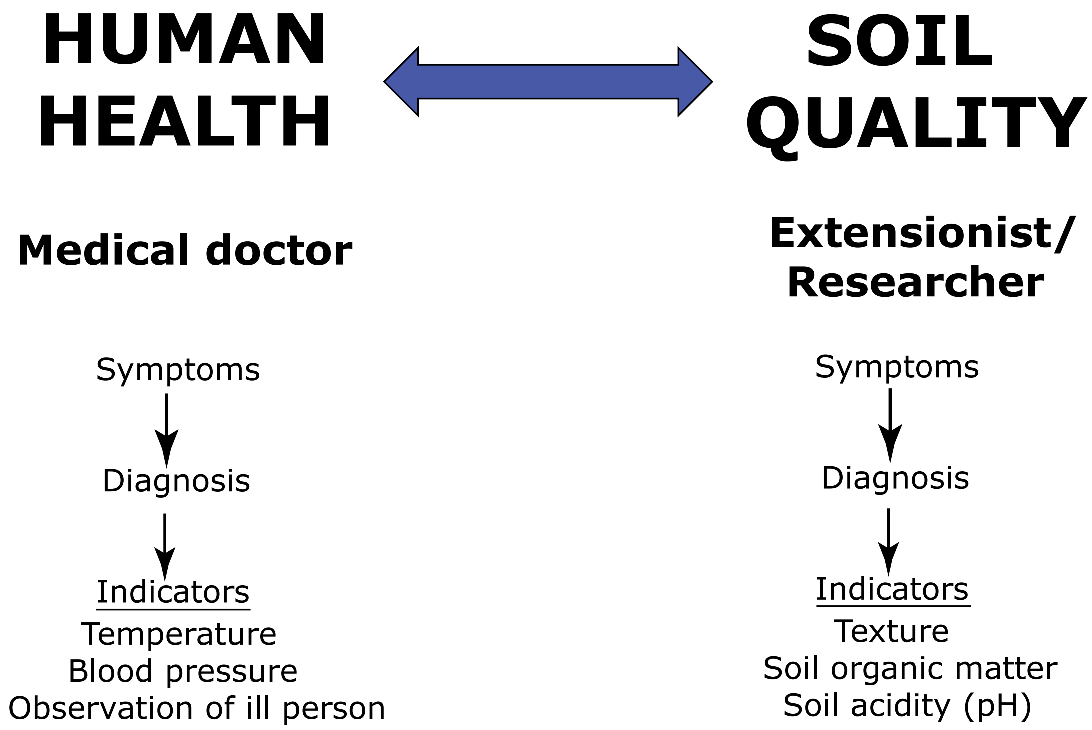


Figure 3.2 Similarities between human health and soil quality assessment approaches.

Similarly, in the participatory methodology presented in this chapter, we are interested in assessing soil quality which is a measure of natural resource health (Figure 3.2). That is, we want to better understand how soil quality is influenced by agricultural, livestock or forestry use, and by soil management (e.g. tillage vs. no-tillage, type of fertilization, etc.). Like the medical doctor in the local clinic, many farmers have considerable field experience, and in the course of their lives have observed different symptoms in the soil, vegetation, crops and on small soil animals, which can serve as local indicators of soil quality. These local indicators allow farmers to quickly assess soil quality in the field. When necessary, in combination with technical indicators it is possible to make a more complete and comprehensive diagnosis, and therefore support better informed choices among different soil use and management options.

3.2.2 Identification of local indicators of soil quality

During the identification of local indicators of soil quality, farmers representing communities in the study area are divided into five or six working groups (> 3 farmers/group). Farmers can be grouped by interest group (e.g. those belonging to the same community, according to the position of their farms in the landscape: upland vs. floodplain farmers, according to the type of agricultural management: farmers using chemical fertilizers vs. organic farmers, etc.) or by gender (e.g. groups of men separate from those of women), which permits a stratified analysis of the information generated. Differences in perception observed among the different groups are often important in informing soil management decision-making processes. Technical professionals, participating in the Field Day Activity, are distributed equitably among the different working groups. The facilitators should ensure that a list of farmers participating in each of the working groups is prepared. This record will be useful for activities outlined later on in the methodology (section 3.3, 'Case Studies').

Note

It is very important to ensure that that during this activity the discussion focuses on soil quality and identification of local indicators. Avoid shifting attention to other local characteristics, which are not directly related to the quality of the soil.

Each working group will receive two sheets of flipchart paper, 50 rectangular coloured cards, three dark paint markers (Pillot type), and a roll of masking tape. They should select one member as a rapporteur during the session. Each working group will also receive a list of key questions to guide the discussion with farmers on soil use and management as related to soil quality. The use of a common list of key questions is aimed at facilitating the systematization and comparability of local information collected by the working groups. The suggested order of questions comes from experience in using the methodology with different types of farmers in different socio-ecological contexts, starting with simple questions and progressively increasing their complexity, as well as looking at possible hypothetical scenarios.

Key questions:

1) **What do you grow in your farm? How do you select the areas where to plant your crops?**
2) **Do you think that there are different types of soil in your farm? How do you differentiate them?**
3) **How do you know if the soil is good or poor for agriculture? What do you prefer to plant on good soil and what do you plant on the poor soil?**

4) What information did your parents and grandparents use to choose the planting areas?

5) How do you know when the soil is tired? How do you know when it has been fallowed long enough and is ready for cultivation?

6) If a friend were to buy a new plot for agricultural use, what recommendations would you make regarding the soil?

7) Do you think it is possible to change the quality of the soil through management?

8) In situations where there is little or no input addition possible, which would be the best management options to improve soil quality?

9) Which would be the best management options, under medium/high availability of inputs, to improve soil quality?

10) How would you monitor, in the long run, the soil quality changes in your farm?

Each local indicator identified in the farmers' responses should be noted immediately by the technical staff in the working group.

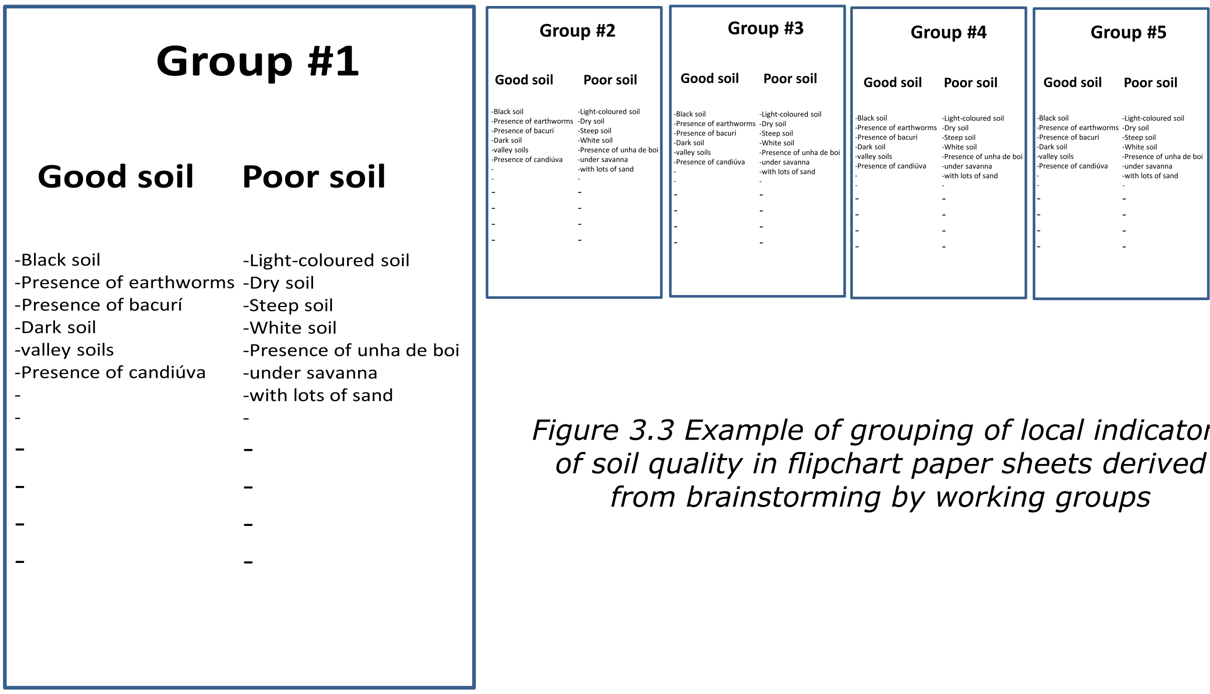


Figure 3.3 Example of grouping of local indicators of soil quality in flipchart paper sheets derived from brainstorming by working groups

After completing this process of brainstorming all the information collated should be summarized by the rapporteur on a sheet of flipchart paper, where indicators of good soil are grouped on the left half of the paper and those of poor soil are grouped on the right half of the paper (Figure 3.3). After completing this activity the results for all groups are affixed to a flat surface (e.g. a wall), which is visible for the plenary session when the classification and synthesis of information generated by all the working groups is completed.

While comparing the results obtained by different working groups it is possible to spot those indicators that are common to different groups, which suggests a more frequent use in contrast with those indicators that appear only once. Next, it is necessary to write each indicator identified on a single rectangular word card which will be used in the next activity (Figure 3.4).

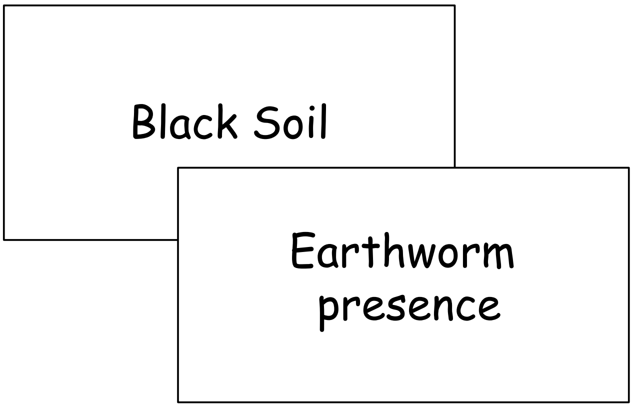


Figure 3.4 Example of cards including local indicators of soil quality identified by farmers.

3.2.3 Classification of local indicators of soil quality

The classification of local indicators of soil quality identified during farmer brainstorming in the previous activity is critical and will affect the quality of information generated, so it is important to follow the next steps as accurately as possible.

3.2.3.1 In a plenary session gather all the cards containing the local indicators of soil quality that were prepared by the working groups in the previous stage (3.2.2), and affix them with masking tape on a flat surface (e.g. wall, blackboard). This way the working groups will easily see all the information that has been generated to this point.

3.2.3.2 Group the local indicators which describe the same soil characteristic together (Figure 3.5), for example:

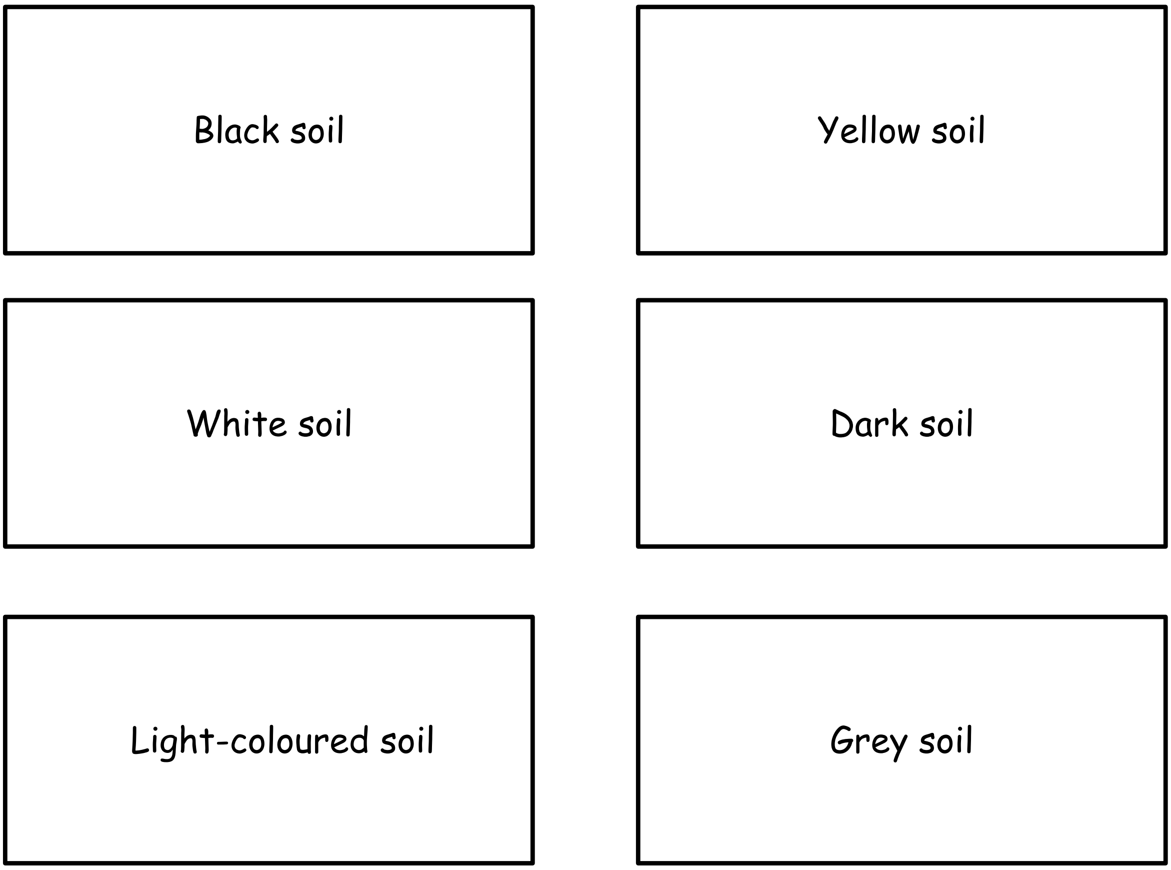


Figure 3.5 Grouping of cards including indicators associated with the same soil characteristic.

3.2.3.3 Once all the different indicators generated by the working groups for each soil characteristic are grouped, facilitators should guide the preparation of synthesis cards for indicators of each soil characteristic.

Using the previous example, we start by preparing new cards drawing a diagonal line from bottom left side to upper right side on one face of the card. On the left side of the line, we include local indicators associated with soils considered good. For example, black or dark soils are usually considered indicators of good soils. Similarly, to the right of the line we place the local indicators associated with poor soils. Grey, white, yellow and light-coloured soils, for example, are usually considered to have low fertility (Figure 3.6).

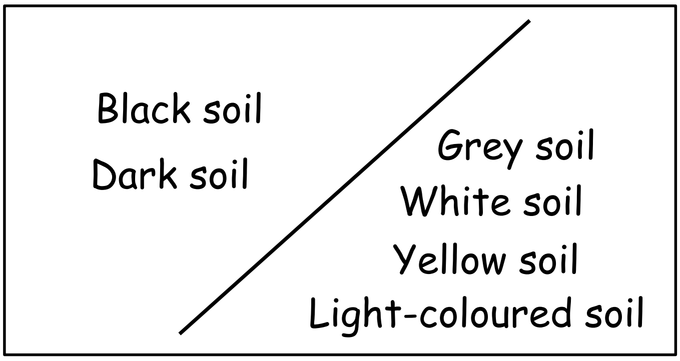


Figure 3.6 Example of an indicator synthesis card.

Note

The display of indicators that refer to attributes associated with good soils, as well as those associated with poor soils, highlights the different ways farmers describe indicators of soil quality. If during the brainstorming session, an indicator has only been recorded in relation to good soils, the opposite version for the same indicator is constructed for poor soils in the most simple and straightforward way. For example, if we find only the indicator 'soil with earthworms' associated with good soils, we then generate the opposite version namely 'soil without earthworms' corresponding to poor soils. Likewise, if we only find the indicator 'light-coloured soils' associated with poor soils, we generate the opposite version namely 'dark- coloured soils' corresponding to good soils.

3.2.3.4 Once the indicator synthesis cards summarizing indicators of each soil characteristic have been completed, one full copy of all the synthesis cards is prepared for each working group. The rapporteurs of each group, with help from other participants, will reproduce the information contained in each of the synthesis cards.

3.2.3.5 Upon receipt of the complete set of their synthesis cards by each working group, the respective rapporteur will write at the back of each card, on the lower right side, the number that represents their working group (e.g. G1, G2, etc.) (Figure 3.7). For example:

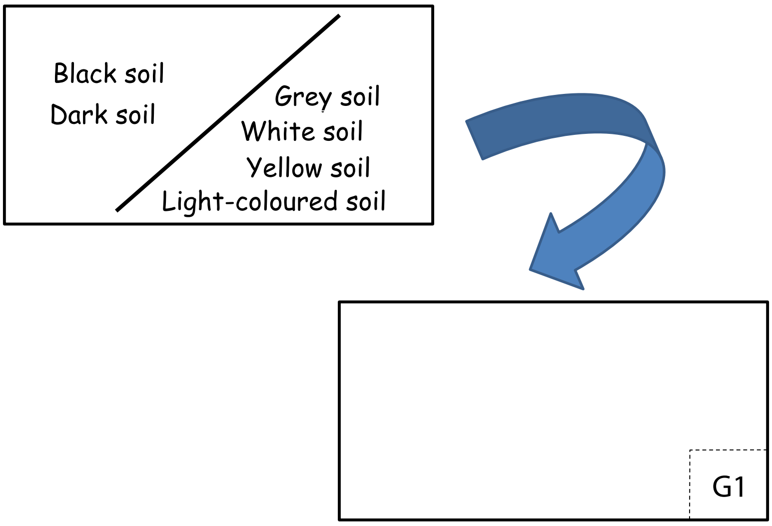


Figure 3.7 Location of group information at the bottom right corner on the back of the synthesis card.

3.2.4 Prioritization of local indicators of soil quality by farmers in working groups

The next activity is for farmers in working groups to rank the local indicators of soil quality based on their importance or priority.

3.2.4.1 Farmers in each working group should reach a consensus on how to divide the synthesis cards into three groups, each group having, if possible, the same number of cards (Figure 3.8). First, the synthesis cards bearing the indicators considered of higher importance are separated into one group, then those synthesis cards with indicators considered of lower importance are separated into a second group, and finally the remaining synthesis cards represent the group of indicators of medium importance.

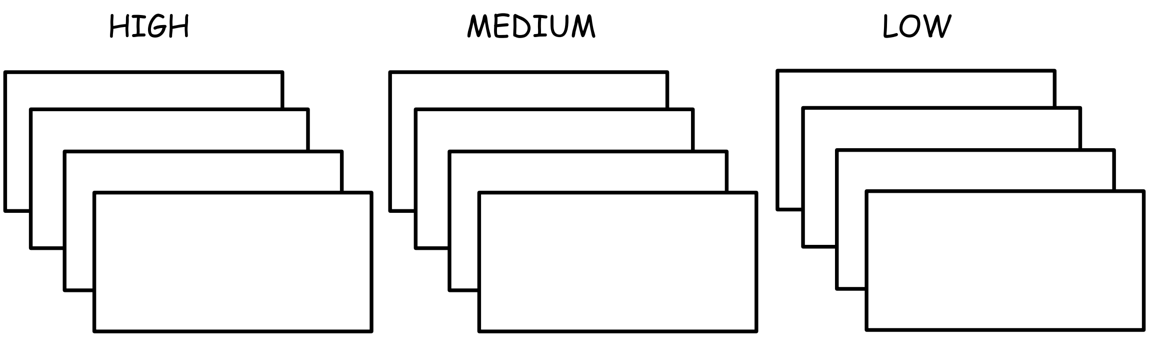


Figure 3.8 Initial distribution of synthesis cards into three levels of importance.




Once this initial classification is concluded, the set of synthesis cards considered of higher importance is further ranked by farmers in each working group respectively (Figure 3.9). First, farmers agree on the synthesis card containing the most important indicator. Then, the synthesis card containing the second most important indicator is selected and placed in sequence after the first one, and in a similar way the third and fourth most important indicators of this group are selected and arranged (e.g. numbers 1-4).

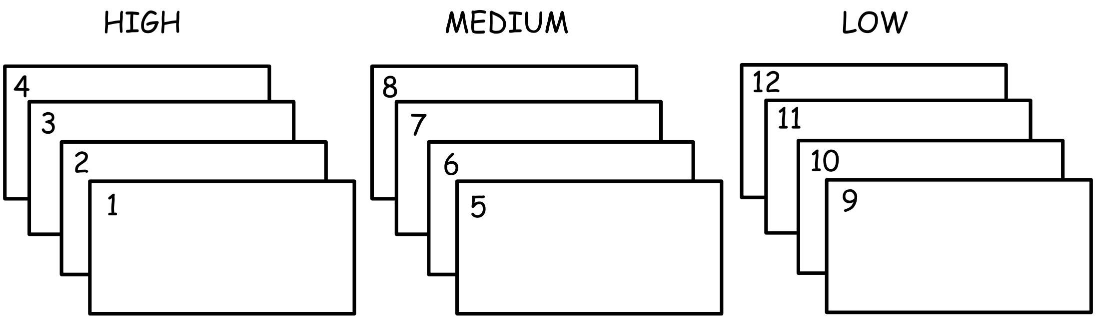


Figure 3.9 Final prioritization of synthesis cards.

The same procedure is followed with the synthesis cards of medium and low importance, assigning a number corresponding to their priority level respectively, from 5-8 and 9-12 in this hypothetical example.

3.2.4.2 Before moving on to the next activity we must include at the centre, on the back of each synthesis card, the number indicating the level of priority attributed to each of them by farmers in each working group respectively (Figure 3.10), as shown below:

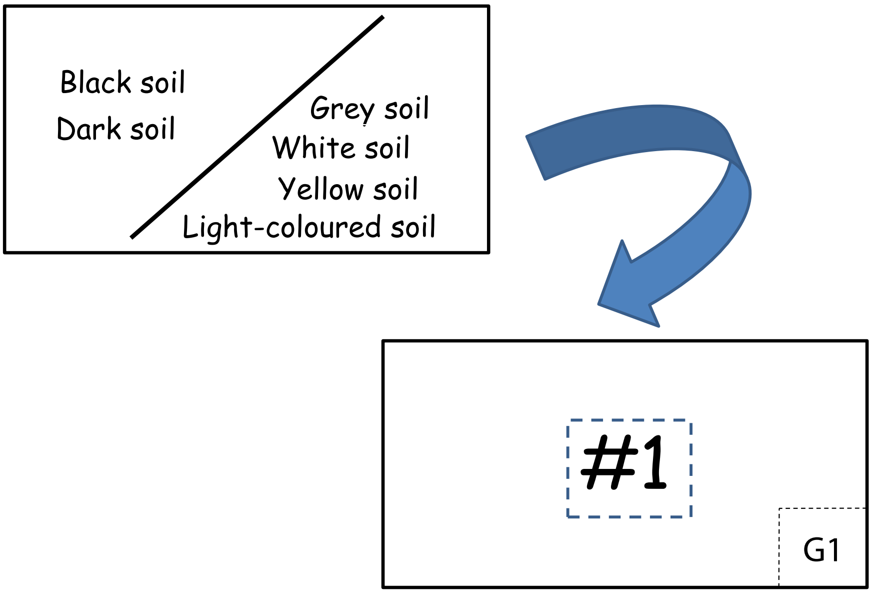


Figure 3.10 Location of priority information given by G1 at the centre on the back of the synthesis card.

3.2.4.3 At the end of the previous activity, all the local indicators of soil quality would have been prioritized by each working group, in a way that reflects the perception of the farmers. In the following example, we show a set of indicators from different regions of Brazil that have been prioritized by a hypothetical working group that we shall refer to as G1 (Group 1),

The following is a list of indicators prioritized by the hypothetical group G1:

1. Black, dark soil/ grey, white, yellow, light-coloured soil
2. Bacuri, candiúva, urtigão/Lixeira, unha de boi (local plant names)
3. Soil under forest vegetation/Soil under savanna vegetation
4. Moist soil (lowland)/Dry soil (upland)
5. Presence of earthworms/Presence of ants, termites
6. Soil with little sand/Soil with lots of sand
7. Soil with no stones/Soil with stones
8. Gentle slope/Steep slope

3.2.5 Summarizing farmer community priorities on local indicators of soil quality

While each working group completes the priority setting of synthesis cards, a Synthesis Matrix will be prepared. The Synthesis Matrix is used to summarize all the information generated by the different working groups.

3.2.5.1 Construction of Synthesis Matrix of farmer community results

Prepare a large paper board by joining together several sheets of Kraft brown paper with cellotape as shown in the diagram below (Figure 3.11).

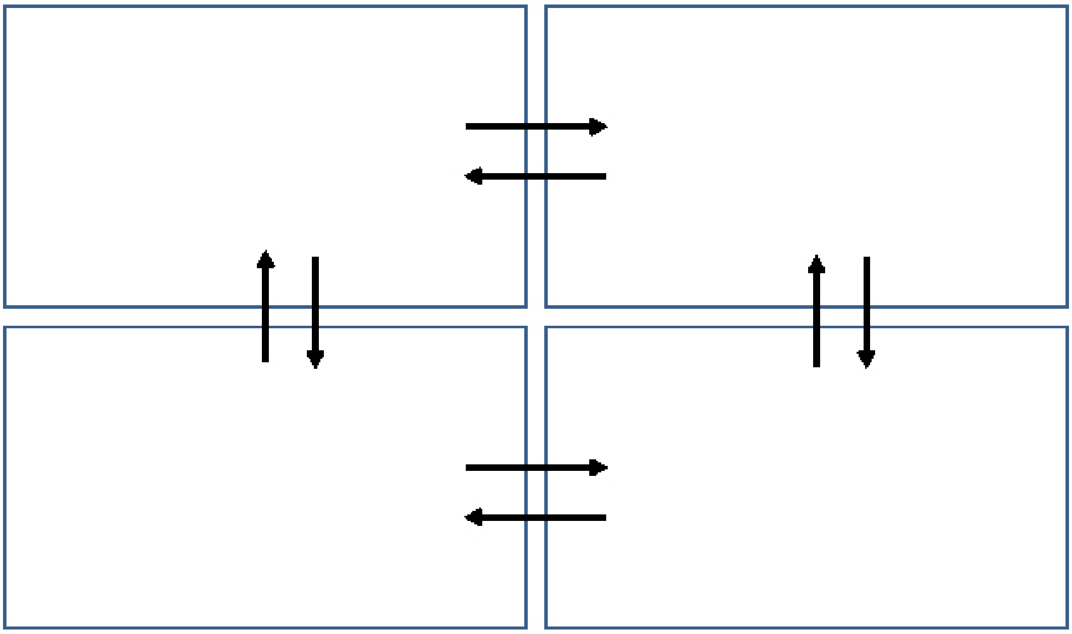


Figure 3.11 Preparation of paper board using Kraft brown paper sheets.

Vertical and horizontal lines are then drawn to create the Synthesis Matrix of results (Figure 3.12).

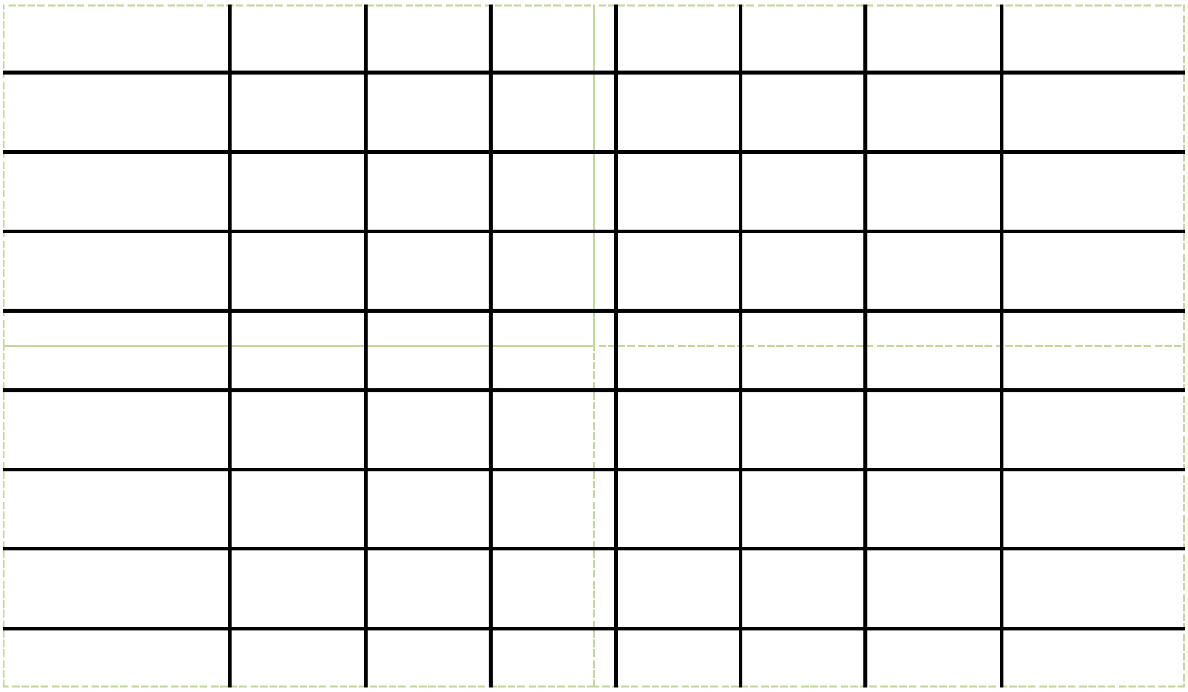


Figure 3.12 Drawing the Synthesis Matrix on the Kraft paper board.

The Synthesis Matrix should contain the indicators in the first column (from example in 3.2.4.3), followed by separate columns for recording the results of each working group, a column for the sum of scores for each indicator, and a last column that will indicate the final order of importance and labeled priority column (Figure 3.13). The total number of columns will depend on the number of working groups. The total number of rows depends on the total number of indicator synthesis cards, representing soil properties, recognized by farmers.

Indicator	G1	G2	G3	G4	G5	Total	Priority

Figure 3.13 Structure of the Synthesis Matrix.

Always affix the synthesis cards used by G1, on the indicators column (first column) following the order of importance set by farmers in G1. In the second column we add the priority scores for G1. Simply start with the number 1 to denote the indicator synthesis card of greatest importance, then number 2 to the second most important, and in a sequence of decreasing continuous numbers down to the least important.

Indicator	G1	G2	G3	G4	G5	Total	Priority
Black, dark soil / grey white, yellow, light-coloured soil	1	2	2	2	1		
Bacuri, candiuva, urtigão / Lixeira, unha de boi	2	3	4	1	4		
Soil under forest vegetation / Soil under savanna vegetation	3	1	1	3	3		
Moist soil (lowland) / Dry soil (upland)	4	5	3	5	2		
Presence of earthworms / Presence of ants and termites	5	6	8	7	7		
Soil with little sand / Soil with lots of sand	6	4	5	4	5		
Soil with no stones / Soil with stones	7	8	6	8	6		
Gentle slope / Steep slope	8	7	7	6	8		

Figure 3.14 Example of a Synthesis Matrix including results from prioritization of local indicators of soil quality by farmers in different working groups (hypothetical example).

In order to record the prioritization results given by Group 2 (G2) in the Synthesis Matrix it is not necessary to stick the cards all over again as was done with group G1. Instead, one of the participants from G2 will read out their results in the plenary session, while another will write these results in the third column of the table labeled 'G2'. The other groups will repeat this procedure for the subsequent columns. Thus, the second column will always contain the indicator results of G1 arranged in order of importance from the highest to lowest, while the results of other groups will be arranged in the subsequent columns always using the first column displaying all the indicators collected as a reference (Figure 3.14).

Once all the information generated by the different working groups is recorded in the Synthesis Matrix, the next column labeled 'Total' includes the sum of the priority scores per row given by all working groups to each synthesis card. Thus, for the score assigned to the indicator with highest priority according to G1, we would add the score given by each group in the second row. (In the example of Figure 3.15 the total value would be equal to 8). The same procedure is applied to the other indicators.

Indicator	G1	G2	G3	G4	G5	Total	Priority
Black, dark soil / grey white, yellow, light-coloured soil	1	2	2	2	1	8	
Bacuri, candiuva, urtigão / Lixeira, unha de boi	2	3	4	1	4	14	
Soil under forest vegetation / Soil under savanna vegetation	3	1	1	3	3	11	
Moist soil (lowland) / Dry soil (upland)	4	5	3	5	2	19	
Presence of earthworms / Presence of ants and termites	5	6	8	7	7	33	
Soil with little sand / Soil with lots of sand	6	4	5	4	5	24	
Soil with no stones / Soil with stones	7	8	6	8	6	35	
Gentle slope / Steep slope	8	7	7	6	8	36	

Figure 3.15 Example of a Synthesis Matrix including results from prioritization of local indicators of soil quality by farmers in different working groups (hypothetical example).

Finally, in the last column, the mean order of importance for each indicator is recorded representing the overall priority for the farmer community. The highest priority is always assigned the number 1, and corresponds to the lowest total score in the previous column. Similarly, the lowest priority always corresponds to the highest total score in the previous column (Figure 3.16).

Indicator	G1	G2	G3	G4	G5	Total	Priority
Black, dark soil / grey white, yellow, light-coloured soil	1	2	2	2	1	8	1
Bacuri, candiuva, urtigão / Lixeira, unha de boi	2	3	4	1	4	14	3
Soil under forest vegetation / Soil under savanna vegetation	3	1	1	3	3	11	2
Moist soil (lowland) / Dry soil (upland)	4	5	3	5	2	19	4
Presence of earthworms / Presence of ants and termites	5	6	8	7	7	33	6
Soil with little sand / Soil with lots of sand	6	4	5	4	5	24	5
Soil with no stones / Soil with stones	7	8	6	8	6	35	7
Gentle slope / Steep slope	8	7	7	6	8	36	8

Figure 3.16 Example of a Synthesis Matrix including results from prioritization of local indicators of soil quality by farmers in different working groups (hypothetical example).

3.2.5.2 Final list of local indicators of soil quality prioritized by the farmer community

1. Black, dark soil/ grey, white, yellow, light-coloured soil
2. Soil under forest vegetation/Soil under savanna vegetation
3. Bacuri, candiúva, Urtigão/Lixeira, unha de boi
4. Moist soil (lowland)/Dry soil (upland)
5. Soil with little sand/Soil with lots of sand
6. Presence of earthworms/Presence of ants, termites
7. Soil with no stones/Soil with stones
8. Gentle slope/Steep slope

3.2.5.3 Strategy to be followed in case some indicators show the same priority level

In instances where some indicators show the same level of priority, it will be necessary to reclassify these indicators during plenary with the help of the farmers. In the following example, three indicators identified by farmer communities in Brazil will be used to illustrate the procedure that can be followed. First, draw a Double-Entry Matrix on a sheet of flipchart paper or Kraft brown paper and list the indicators on the first row and also on the first column maintaining the same order as in the first row (Figure 3.17).

Indicator	**Soil with little sand / Soil with lots of sand**	**Soil with no stones / Soil with stones**	**Gentle slope / Steep**
Soil with little sand / Soil with lots of sand		Soil with little sand / Soil with lots of sand	Soil with little sand / Soil with lots of sand
Soil with no stones / soil with stones			Soil with no stones / soil with stones
Gentle slope / Steep slope			

Figure 3.17 Double-Entry Matrix with indicators showing the same priority score (hypothetical example).

The next step is to ask farmers (in plenary) to make one-on-one comparisons between the indicators as follows: Which indicator is more important, "Soil with little sand/Soil with lots of sand" or "Gentle slope/Steep slopes"? and cast a vote. In this example "Soil with little sand/soil with lots of sand" was considered the most important by most farmers in plenary. Thus, the indicator is written at the intersection of row 2 and column 3. Comparing the different indicators on a one-on-one basis we arrive at the results shown in Figure 3.17. "Soil with little sand/Soil with plenty of sand" is more important than "Soil with no stones/Soil with stones", and "Gentle slope/Steep slope" is less important than "Soil with no stones/ Soil with stones". These results are then transferred to a Frequency Table (Figure 3.18). The blocked cells in the Double Entry Matrix in Figure 3.17 correspond to redundant information that is disregarded.

Indicator	Frequency	Priority
Soil with little sand / Soil with lots of sand	2	1
Soil with no stones / soil with stones	1	2
Gentle slope / steep slope	0	3

Figure 3.18 Frequency table used to summarize results generated in the Double-Entry Matrix.

In Figure 3.18 we find that after farmer consensus, following the one-on-one comparisons, the indicators that initially showed the same level of priority have now been ranked in order of importance. Finally, the following order of priority is obtained:

1. Soil with a little sand/Soil with lots of sand
2. Soil with no stones/Soil with stones
3. Gentle slope/Steep slope

After carrying out this additional prioritization exercise and making the necessary corrections, the final list of Local Indicators of Soil Quality prioritized by the farmer community can be generated. This final list will be used in subsequent activities and shared with the community, together with technical inputs and recommendations, during the Soils Fair on the last day of the workshop.

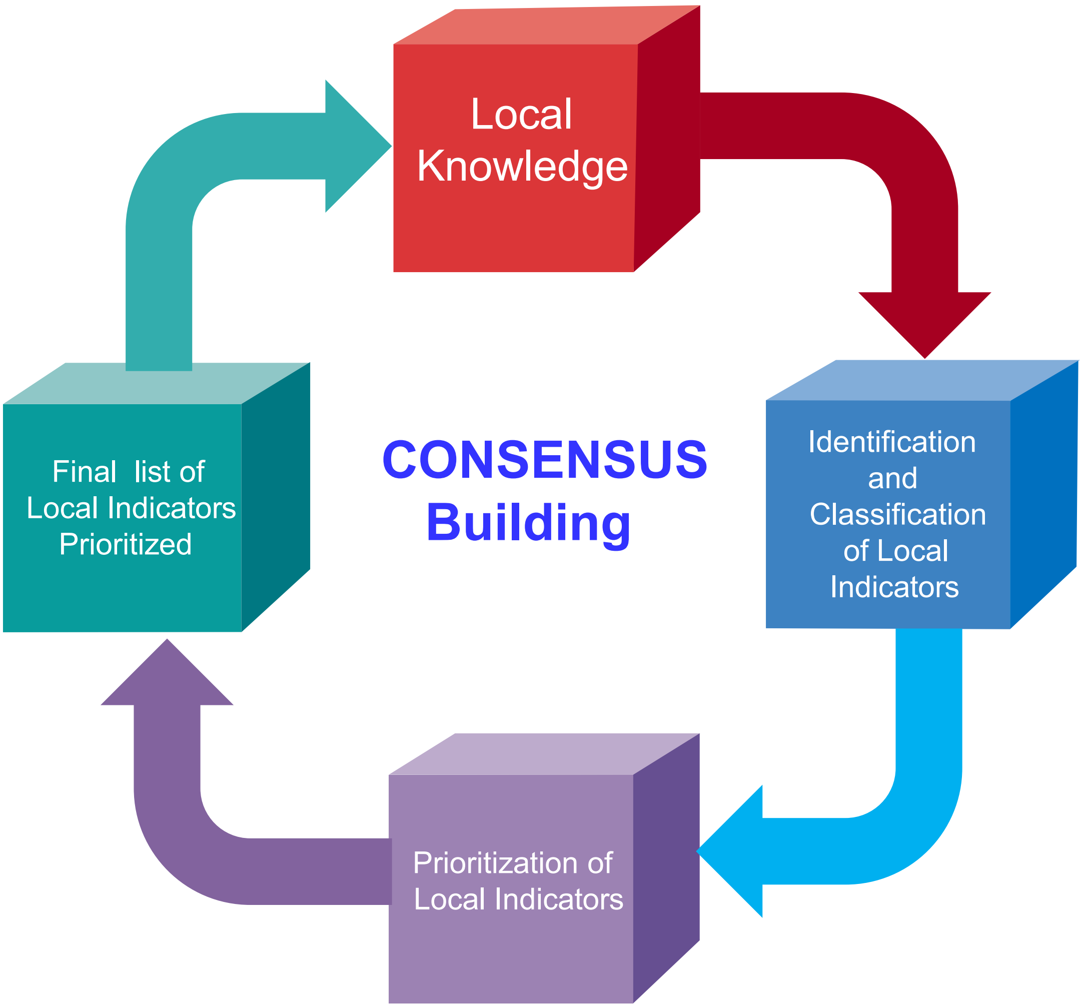


Figure 3.19 Synthesis of key methodological steps in chapter 3.

3.3 Case studies

This participatory approach makes it possible to gradually build up new knowledge sharing channels between technical professionals and farmer communities, thus facilitating the recognition of the importance of local knowledge and practices. The increased contact also allows a better understanding of individualities within farmer communities and the wealth of perceptions about the soil and its management, including those on practices that have not yet been studied and which are widely used by farmers. The main purpose of encoding the working groups and their cards is to allow tracking of important sources of local knowledge contributions during working group activities. It is well recognized that local knowledge is not uniformly distributed in the farmer community, and that some people have more curiosity, experience and knowledge than others. The activities in the previous section will facilitate the selection of key farmers to carry out more in-depth case studies.

The case study activities will provide more opportunities for in-depth learning on local indicators of soil quality and a better understanding of the context in which they are used by farmers. Farmers identified to be important sources of information in the community are selectively targeted as potential key informants and asked if they would be interested in participating in case studies. Once the participation of each key informant is confirmed, a visit is made to their farm to initiate the case study using a questionnaire prepared for this purpose.

The questionnaire for case studies (Annex 3) can be applied by reading it together with the farmer and obtaining responses. However, experience gained in practice and reflected in the literature indicates that this approach hardly creates a comfortable and relaxed atmosphere for the respondent in which information can be shared as freely and easily as possible between the interviewee and interviewer.

The approach that we propose involves a more casual encounter with farmers in the form of informal conversations and semi-structured interviews carried out during the visit to their farms. This approach has been shown to be even more effective when the interviewer has detailed knowledge of the questionnaire and may thus progressively bring into the conversation different topics and questions of interest.

The questionnaire for case studies includes the following topics in order:

1) Farm participatory mapping: Using a sheet of flipchart paper and markers of different colours, the farmer draws a map illustrating the various features of the farm to be visited (with assistance from the interviewer if needed). Emphasis is put on different soil types present and their distribution and boundaries, current and past use, management, slope, etc. This information is later confirmed during a farm walk when different soil types are identified along with their current uses. Other biophysical aspects of the farm context are also noted.
2) Knowledge about soil: This topic allows the identification of characteristics known and used by the farmer to describe and distinguish each type of soil.
3) Management practices: Allows the identification of crops, tillage activities, fertilization used, conservation practices, etc.
4) Soil organisms: The idea is to identify beneficial or harmful organisms (plants, insects and other small animals) found in the different soils identified earlier and understand how they vary as a result of changes in soil quality associated with different soil types, uses and management.

5) Factors that guide the decision-making process: The objective is to identify potential indicators that can provide relevant information about soil quality and be useful to the decision-making process on soil use and management.
6) General information: In this part of the questionnaire a few examples of different hypothetical scenarios are introduced which include several aspects already mentioned in earlier topics, and the way they occur in nature. Here it is possible to confirm the depth and quality of the information collected so far.
7) Specific information about the property: This section includes questions that may be sensitive if made at an earlier stage in the case study, such as the situation of land ownership, whether the land was inherited, purchased or leased, information on the family, charcoal production, etc.
8) Collection of soil samples related to each case study: Representative samples of soil types described by the farmer are collected and, if possible, geo-referenced using GPS technology. The laboratory analysis of these samples will help establish a direct relationship between local and technical indicators of soil quality.

3.4 Summary

This chapter introduces the importance of the knowledge held by small-scale farmers on soils and their management, as well as how local soil quality indicators can guide good soil management. By using participatory methodological tools, local indicators of soil quality are first identified together with farmers. Then the farmers, assisted by technical workshop participants, classify local indicators into groups based on the soil properties they represent. Finally, the order of importance of local indicators is defined through a process of consensus building among farmers in each working group. The list of prioritized local indicators of soil quality, resulting from farmer consensus building, will be used as the source of local knowledge during integration with technical knowledge in Chapter 4.

3.5 References

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3.6 InPaC-S Methodological Tools

PARTICIPATORY METHODOLOGICAL APPROACH - LEARNING BY DOING

DYNAMIC #9 CLASSIFYING AND PRIORITIZING LOCAL INDICATORS OF SOIL QUALITY AND USING THE SYNTHESIS MATRIX TOOL

Objective: Learning by using the methodological sequence, how to classify and prioritize local indicators of soil quality that have already been identified by small-scale farmer communities from different biomes in Brazil.

Materials: note pads, pens, rectangular coloured cards (12.5 x 23 cm), dark ink markers (Pillot type), Kraft brown paper, Flipchart paper sheets, masking tape, transparent adhesive tape (cellotape).

a) Split up into groups (of up to 5-6 persons per group).
b) Give each group 12 cards, 3-4 markers, one sheet of flipchart paper.

CLASSIFICATION

c) Show the working groups a set of local indicators of soil quality for good soils. These should be written on the left half of the flipchart paper.

Example of local indicators of “Good” soil include:

- Soil with earthworms
- Dark soil
- Soil with gentle slope
- Deep soil
- Black soil
- Soil with Bacuri (native plant)
- Soil with Embauba (native plant)
- Soil after fallow
- Fertile soil
- Humid soil
- Soft soil
- Soil under thick forest vegetation
- Soil with clay
- Soil with Aroeira (native plant)

d) Show the working groups a set of local indicators of soil quality for poor soils. These are written on the right half of the flipchart paper.

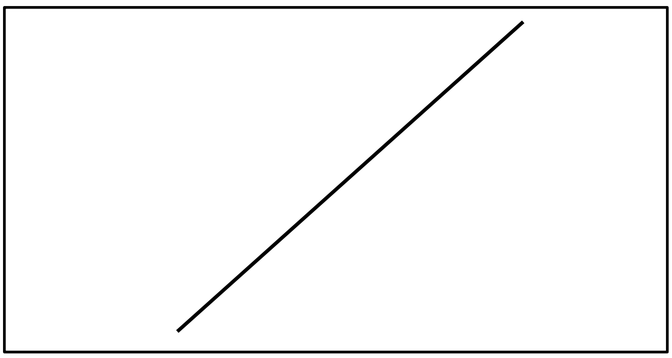
Example of local indicators of "Poor" soil include:

- White soil
- Compacted soil
- Grey soil
- Yellow soil
- Soil with Unha de boi (native plant)
- Soil with Lixeira (native plant)
- Non-fertile soil
- Soil with erosion
- Light-coloured soil
- Soil under grassland vegetation
- Shallow soil
- Soil with Taquara (native plant)
- Tired soil

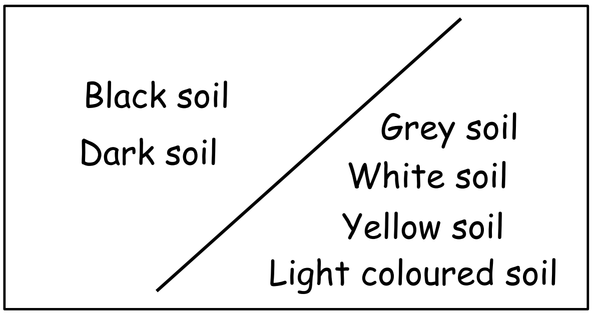
e) Affix the sheet of flipchart paper on the wall so that the group can begin the process of classification and synthesis of indicators related to the same soil characteristics.

f) It is recommended that at the beginning of the discussion each group uses a paper pad and once consensus is reached the information is transferred to the cards.

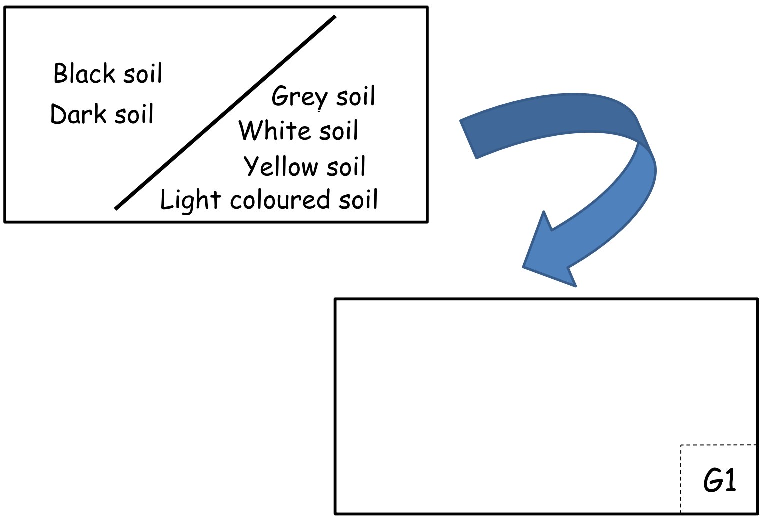
g) In preparing the indicators synthesis cards a diagonal line is drawn from the lower left side to upper right side of each card.



h) For each soil characteristic identified by farmers include indicators that correspond to good soils on the left of the diagonal line and on the right side those corresponding to poor soils.



i) Once the synthesis cards are ready, proceed to include the number identifying the respective working group on the back of the card at the lower right corner (e.g. G1, G2, etc.). For example:



j) Once indicators have been classified fully by each working group, all results are discussed in plenary session. Compare the differences and similarities in the way indicators have been classified.

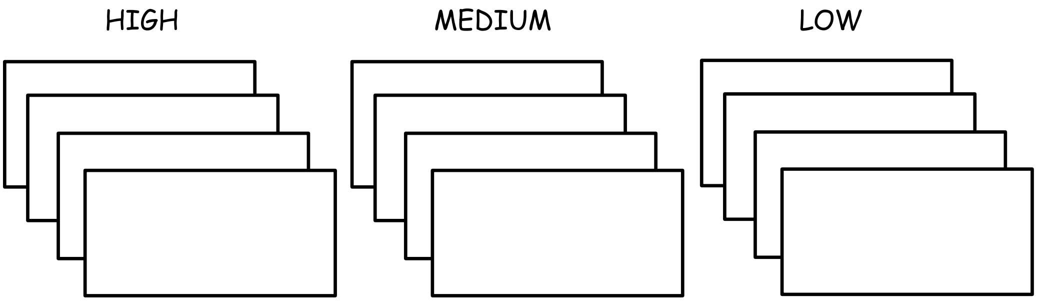
k) Proceed to compare working group responses with correct answers found in Exercise #5 of Annex 2.

l) Each group prepares a copy of all the 12 synthesis cards using the correct answers, and where possible, taking advantage of the cards prepared in activities h) and i).

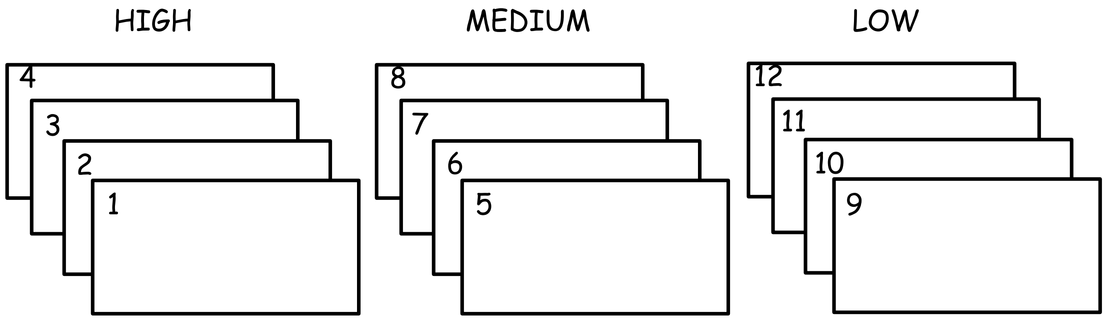
PRIORITIZATION

m) Start the process of ranking of indicators by dividing synthesis cards into three groups. First, select the four synthesis cards with the four most important indicators. Secondly, select the four cards with the four least important indicators. The remaining four cards will consequently have four indicators of medium importance.

n) Place the synthesis cards in the order indicated below before ranking the indicators according to their importance in each group.



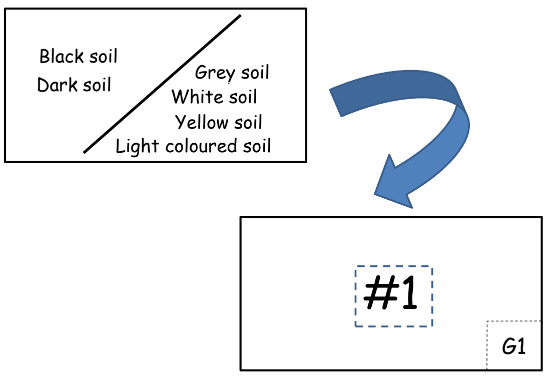
o) Once this initial division is done, synthesis cards considered of higher importance are further prioritized within each group starting with the card having the indicator of highest importance. Then the card with the indicator of second highest importance is identified and placed in the second position, and the same procedure is followed for cards with indicators of third and fourth levels of importance.



p) Follow the same process with the indicators of medium importance identifying the most important card in this group, which now takes the fifth place, the next one in importance takes the sixth place, and so on with the following cards taking seventh and eighth places respectively.

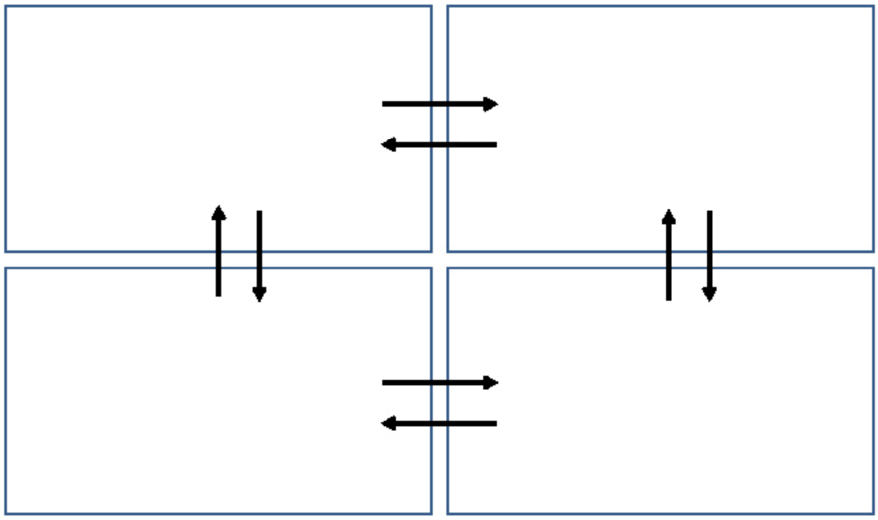
q) Finally, with the group of synthesis cards of lower importance, follow the same procedure. The most important indicator of the lot taking ninth position, and the rest of the cards follow in the tenth, eleventh and twelfth positions respectively.

r) Before the next activity, write in the back at the centre of each card, the number indicating the order of importance given to each one during the prioritization process, as shown in the following example, where we again use results from G1:



PREPARATION OF THE SYNTHESIS MATRIX OF RESULTS

s) Prepare a paper board by joining sheets of Kraft brown paper with cellotape as shown in the diagram below and then affix it to a wall.



t) Draw vertical and horizontal lines with a dark ink marker to make the Synthesis Matrix of results.

Indicator	G1	G2	G3	G4	G5	Total	Priority

u) Attach the G1 synthesis cards, in order of importance, in the first column of indicators. In the second column, write the order of priority given by the G1, that is, simply write number 1 to indicate the most important indicator, and number 2 for the next one and so on up to the indicator of least importance according to the classification of G1.

v) Record the order of importance given by G2 having one of participants from the group read results in the plenary session while another writes them in the third column of the table. G3, G4 and G5 will do the same in the fourth, fifth and sixth columns, respectively.

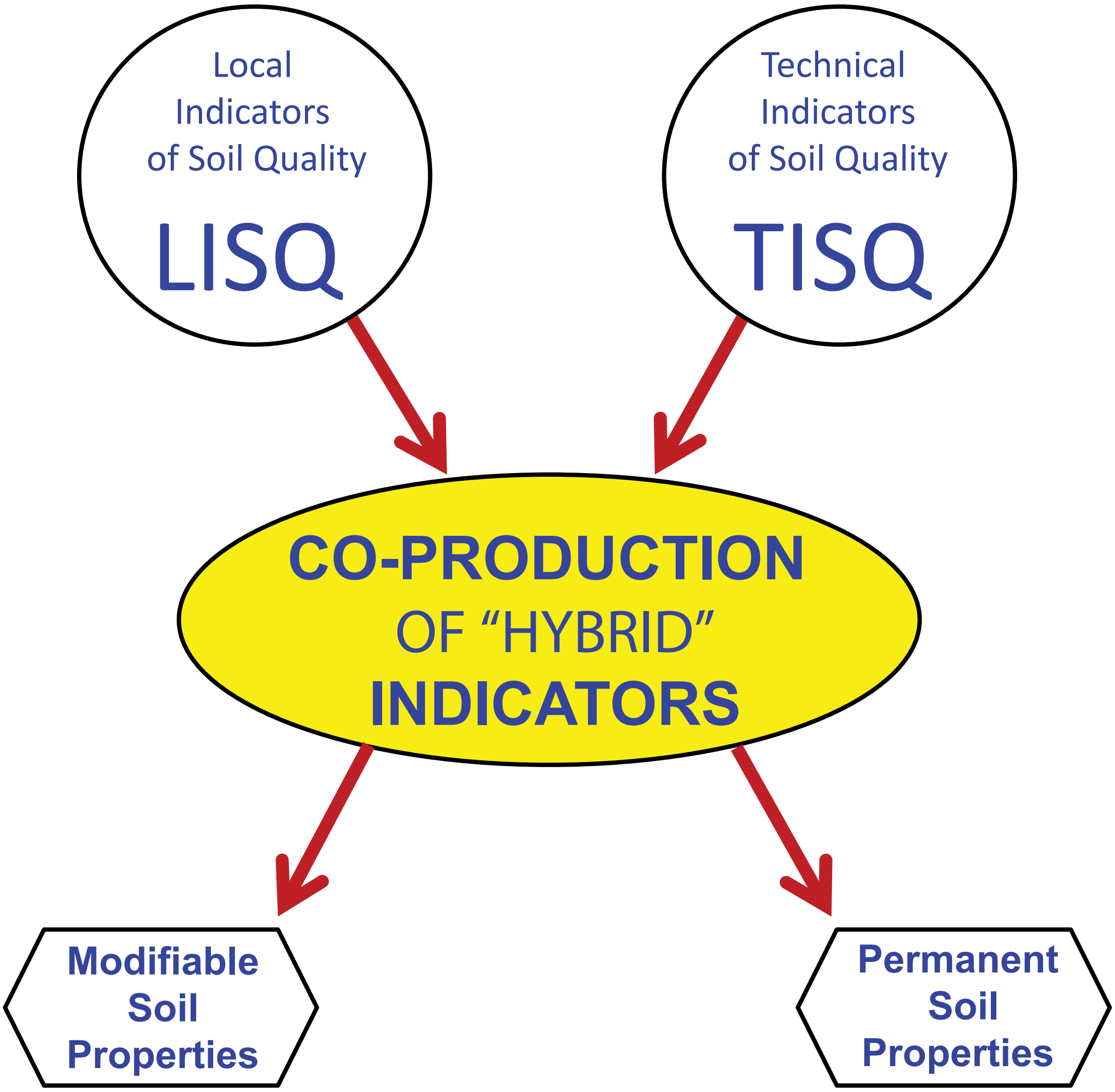
w) Calculate the total score for each indicator in the seventh column by adding up the score per row assigned by the different groups.

x) Finally, we establish the order of importance for the local indicators of soil quality that is noted in the eighth column. A higher level of priority is associated with a smaller number in the seventh column, and vice versa.

y) The prioritized list of local indicators of soil quality indicators is thus generated.

CHAPTER 4

INTEGRATION OF LOCAL AND TECHNICAL INDICATORS OF SOIL QUALITY



4.1 Introduction

In Chapter 2 the most commonly used technical indicators of soil quality (TISQ) were identified and categorized. In Chapter 3 a participatory methodology was described and applied for the identification, classification and prioritization of local indicators of soil quality (LISQ) used by farmers. In this chapter we will describe and use a methodological tool for linking and integrating local and technical indicators of soil quality, and also assess the modifiable or permanent nature of soil properties described by such indicators.

4.1.1 Objectives

At the end of this chapter, workshop participants will be able to:

- Link local and technical indicators of soil quality
- Link local indicators to soil properties
- Differentiate between indicators associated with modifiable or permanent soil properties.

4.2 Linkages between local and technical indicators of soil quality

The theoretical framework used for comparing local and technical indicators of soil quality is based on the concept of soil as a natural entity organized as a continuum through the landscape instead of a discrete unit limited to an individual farm. This concept is critical to understanding how the intrinsic properties of soil are more closely related to the environment in which it was formed, than to agricultural management practices.

When understanding the soil as a resulting product of formation factors and processes (see Simplified Model of Soil Formation in Chapter 2), and distinguishing between soil properties that are modifiable through management from those that are permanent, the linkage between local and technical knowledge becomes easier to establish. This has to do with the fact that attributes and characteristics inherited from the factors of soil formation usually generate permanent properties; while those attributes that are conditioned by environmental processes, such as the acquisition and loss of nutrients, usually generate properties that are modifiable. For example, while farmers often consider relief as an attribute which affects soil quality, soil fertility is seen as a characteristic of soil quality that can be modified by the use of inputs (e.g. fertilizers) or by management practices (e.g. incorporation of green manures, improved fallows).

The preceding discussion introduces the Integration Matrix as a tool for integrating the local knowledge on indicators of soil quality with recognized technical attributes and properties.

4.3 Integrating local and technical indicators of soil quality and making linkages to soil properties using the Integration Matrix tool

Using the final list of local indicators of soil quality prioritized by the farmer community in the Synthesis Matrix (Chapter 3) we will begin building an Integration Matrix for indicators of soil quality.

4.3.1 Building an Integration Matrix for indicators of soil quality

Prepare a large paper board by joining together several sheets of Kraft brown paper with cellotape as shown in the diagram below (Figure 4.1).

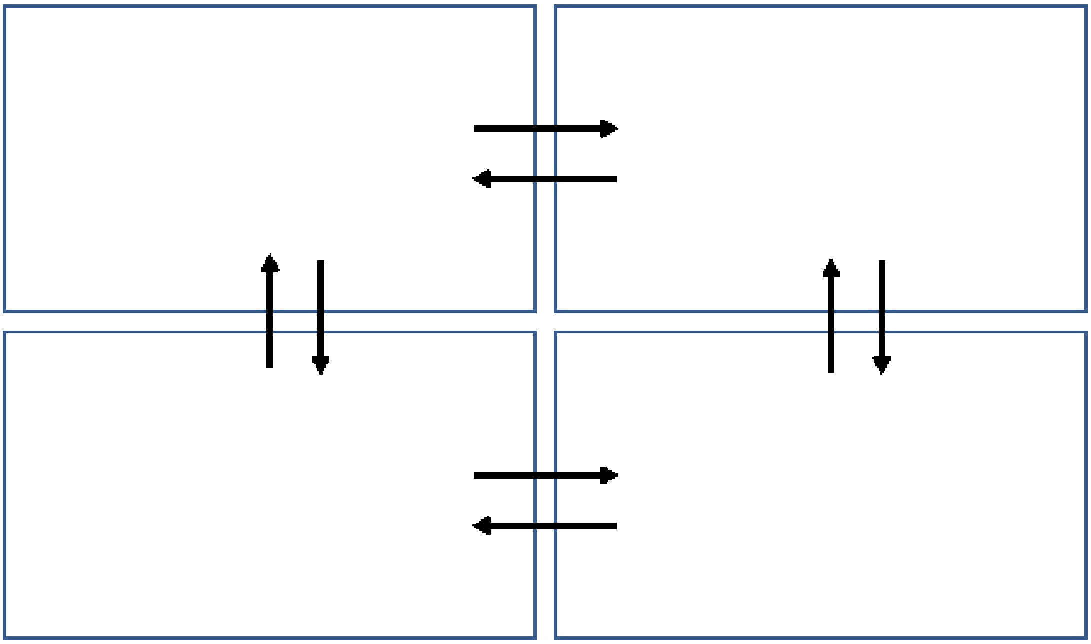


Figure 4.1 Preparation of paper board using Kraft brown paper sheets.

Vertical and horizontal lines are then drawn using dark ink markers to create the Integration Matrix for Indicators of Soil Quality (Figure 4.2).

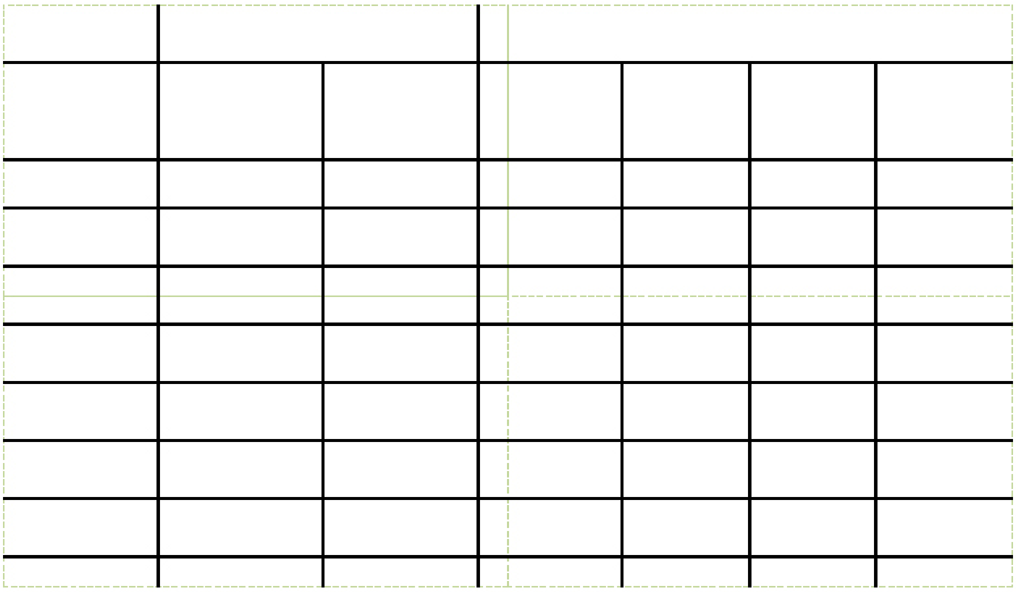


Figure 4.2 Drawing the Integration Matrix on the Kraft paper board.

The Integration Matrix has a first column for priority scores arranged in order of importance from highest to lowest, and a second column for the local indicators associated with each priority score respectively. The third column is used for the technical indicator that best describes each local indicator. The next four columns are used to describe (using an X) the type of soil property with which each indicator is associated considering its modifiable or permanent nature in response to management. For modifiable indicators we consider the short term to be less than two years, medium term from two to six years, and long term more than six years (Figure 4.3).

Priority	Indicator		Soil property type			
	Local	Technical	Modifiable Short term < 2 yrs	Modifiable Medium term 2-6 yrs	Modifiable Long term > 6 yrs	Permanent

Figure 4.3 Structure of the Integration Matrix.

Priority	**Indicator**		**Soil property type**			
	Local	**Technical**	**Ms**	**Mm**	**Ml**	**P**
1	Black, dark soil / grey, white, yellow, light-coloured soil					
2	Soil under forest vegetation / soil under savanna vegetation					
3	Bacuri, candiuva, urtigão / Lixeira, unha de boi					
4	Moist soil (lowland) / dry soil (upland)					
5	Soil with little sand / soil with lots of sand					
6	Presence of earthworms / Presence of ants and termites					
7	Soil with no stones / soil with stones					
8	Gentle slope / Steep slope					

Figure 4.4 Example of Integration Matrix including results from prioritization of local indicators of soil quality by farmer community (hypothetical example).

The aim of integration is to link the local indicators to technical indicators, and not the other way around (Figure 4.4). In this way, the technical indicators that best represent each of the LISQ used by farmers to classify the soils are defined (Figure 4.5).

Priority	Indicator		Soil property type			
	Local	Technical	Ms	Mm	Ml	P
1	Black, dark soil / grey, white, yellow, light-coloured soil	Soil colour / Soil organic matter content				
2	Soil under forest vegetation / soil under savanna vegetation	Phyto-physiognomy natural soil fertility				
3	Bacuri, candiuva, urtigão / Lixeira, unha de boi	Indicator plants				
4	Moist soil (lowland) / dry soil (upland)	Soil humidity				
5	Soil with little sand / soil with lots of sand	Soil texture				
6	Presence of earthworms / Presence of ants and termites	Soil macrofauna				
7	Soil with no stones / soil with stones	Stoniness				
8	Gentle slope / Steep slope	Slope				

Figure 4.5 Example of Integration Matrix including results from prioritization of local indicators of soil quality and their technical indicator equivalents.

The final step of this activity is to classify each of the indicators already identified and prioritized as indicators of modifiable or permanent soil properties. In Chapter 2 we have seen that permanent soil properties include attributes such as relief, soil texture or clay type, that do not change with time as a result of management. In contrast, modifiable properties can be changed through management practices.

Figure 4.6 shows integrated soil quality indicators and their classification as indicators associated with modifiable or permanent soil properties.

Priority	Indicator		Soil property type			
	Local	Technical	Ms	Mm	Ml	P
1	Black, dark soil / grey, white, yellow, light-coloured soil	Soil colour / Soil organic matter content		X		
2	Soil under forest vegetation / soil under savanna vegetation	Phyto-physiognomy natural soil fertility			X	
3	Bacuri, candiuva, urtigão / Lixeira, unha de boi	Indicator plants		X		
4	Moist soil (lowland) / dry soil (upland)	Soil humidity	X			
5	Soil with little sand / soil with lots of sand	Soil texture				X
6	Presence of earthworms / Presence of ants and termites	Soil macrofauna		X		
7	Soil with no stones / soil with stones	Stoniness				X
8	Gentle slope / Steep slope	Slope				X

Figure 4.6 Example of Integration Matrix of local and technical indicators of soil quality characterizing the modifiable or permanent nature of the soil property associated with each indicator.

4.4 Summary

In this chapter we described the methodology for integrating LISQ and TISQ and for developing a common language for both farmers and technical professionals. This common language will be of great use to technical professionals when surveying farmer perceptions about soils constraints at their farms. Besides, the development of a common language helps in understanding which of the soil constraints identified by farmers are modifiable through management within a given timeframe and effort, and which ones are of a permanent nature. Modifiable soil properties and soil management principles and options will be considered in greater detail in Chapter 5.

4.5 InPaC-S Methodological Tools

PARTICIPATORY METHODOLOGICAL APPROACH - LEARNING BY DOING

DYNAMIC #10 INTEGRATING LOCAL AND TECHNICAL INDICATORS OF SOIL QUALITY USING THE INTEGRATION MATRIX TOOL

Objective: Build an Integration Matrix for local indicators and their technical equivalents, and link each of these indicators with respective soil properties of modifiable or permanent nature.

Materials: note pads, pens, rectangular coloured cards (12.5 x 23 cm), dark ink markers (Pillot type), Kraft brown paper, Flipchart paper sheets, masking tape, transparent adhesive tape (cellotape).

This activity is conducted in plenary and involves a discussion with all workshop participants for consensus building on:

a) Technical indicators that best describe the local indicators identified during the Field Day Activity and prioritized in the Synthesis Matrix (Chapter 3)

b) A description of the modifiable or permanent nature of the soil property represented by each indicator. For modifiable soil properties estimate how long it would take to generate measurable changes using the respective indicator. Refer to short term being less than 2 years, medium term between 2-6 years, and long term more than 6 years, considering two scenarios: i) no input use and ii) with use of inputs.

PREPARATION OF THE INTEGRATION MATRIX

a) Prepare a large paper board by joining together several sheets of Kraft brown paper with cellotape as shown in the diagram below (Figure 4.1) and affix to a wall.

b) Draw vertical and horizontal lines with a dark ink marker to prepare integration matrix for local and technical indicators of soil quality

Priority	Indicator		Soil property type			
	Local	Technical	Modifiable Short term < 2 yrs	Modifiable Medium term 2-6 yrs	Modifiable Long term > 6 yrs	Permanent

INCLUDING INFORMATION COLLECTED IN THE INTEGRATION MATRIX

c) Include the numbers indicating the order of importance in the first column. In the second column, affix the local indicators synthesis cards that were identified, classified and prioritized from highest to lowest importance.

d) Discuss in plenary which would be the technical equivalent that would most adequately describe each of the local indicators.

e) Discuss the modifiable or permanent nature of soil properties associated with different indicators in plenary. Mark those indicators associated with permanent soil properties with an X.

f) Continue the discussion on indicators associated with modifiable soil properties and estimate how long it would take to generate measurable changes using the respective indicator and mark all with an X. Refer to short term being less than 2 years, medium term between 2-6 years, and long term more than 6 years, considering two scenarios: i) no input use and ii) with use of inputs.

CHAPTER 5

AGROECOLOGY PRINCIPLES AND INTEGRATED SOIL FERTILITY MANAGEMENT OPTIONS

5.1 Introduction

In Chapter 4, the local and technical indicators were integrated to generate what can be termed as a technical-local soil quality assessment system. These integrated indicators of soil quality were also divided into two groups depending on their linkage to modifiable or permanent soil properties.

In this chapter we focus on the indicators associated with the properties of soil that can be modified through management. Initially, we will highlight agroecology management principles relevant for addressing the soil constraints identified together with farmers. This will be followed by the selection of integrated soil fertility management options designed to address key soil constraints identified while keeping in mind different capacities of input use by farmers. We will be distinguishing between short, medium and long term management strategies to address soil constraints identified. The active participation of farmers during the identification, classification and prioritization of local soil quality will facilitate joint identification of relevant management strategies and promote their wider adoption in agricultural systems and landscapes.

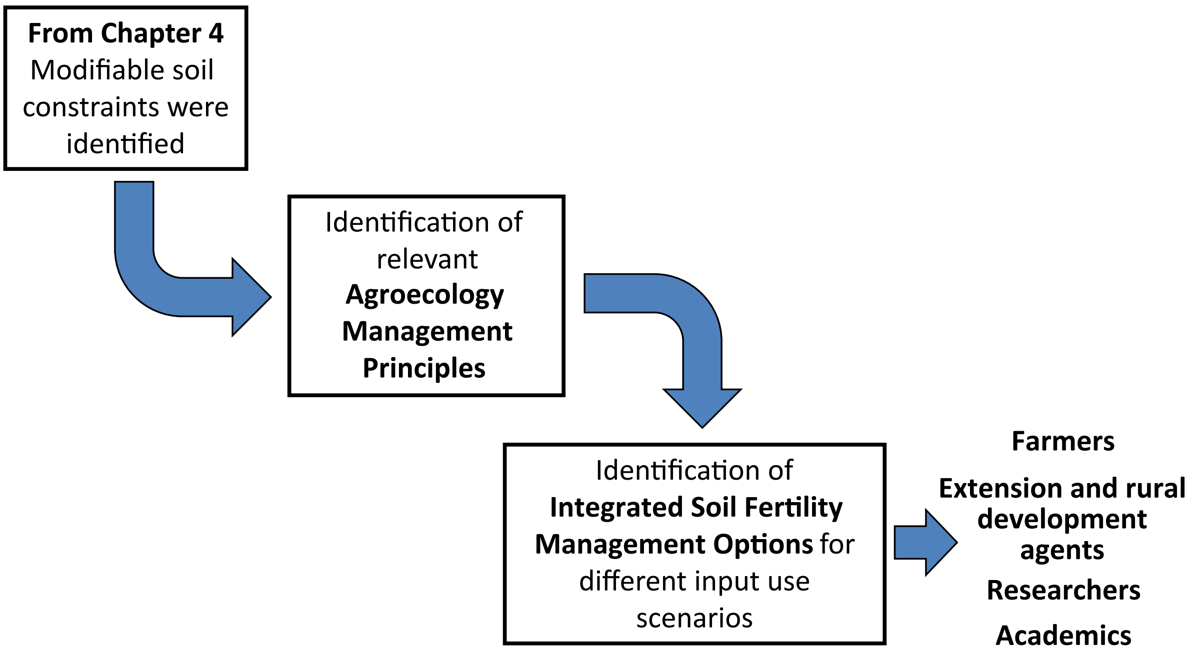


Figure 5.1 Key goals in Chapter 5

5.1.1 Objectives

At the end of this chapter, workshop participants will be able to:

- Differentiate between soil properties that are modifiable in the short, medium and long term.
- Identify agroecology management principles useful to address short, medium and long term soil constraints.
- Identify short, medium and long term management options associated with different soil quality levels and input use by farmers.
- Understand the positive and negative impacts of soil use and management by farmers on different soil-mediated ecosystem services.

5.2 Classification of modifiable soil properties

Modifiable constraints found in soil properties can be improved by management. Examples include the low availability of water and nutrients, low or high pH, bulk density, and low organic matter content in soil. A distinction is made between the soil constraints that can be modified in the short, medium and long term, based on the time required to achieve a significant reduction in the constraint identified. Some soil constraints are not easy to modify. For example, a limitation in effective soil depth (i.e soil depth with no limitations to root growth) can be modified more or less rapidly depending on the nature of the cause of the given limitation (e.g. if root growth is limited by a chemical barrier or by soil compaction). Furthermore, it is important to consider that the capacity to use inputs will likely influence the management options and time required to address soil constraints identified. There are social and cultural factors that may also limit or determine the time required for addressing soil constraints. Some of these include availability of labour, resource allocation or beliefs associated with certain plants or crops. For purposes of this methodological guide, we will consider the following:

Short term = less than 2 years
Medium term = between 2 and 6 years
Long term = more than 6 years

The distinction between the short, medium and long term is necessary to facilitate the prioritization of management strategies that will be possible based on the farmer's capacity to use inputs.

5.3 Agroecology management principles

The adaptation of ecological concepts and principles to the design and management of sustainable agroecosystems is defined as the applied science of Agroecology (Altieri, 1987). In this chapter the focus is on key agroecology management principles as a basic guide during the identification and selection of integrated soil fertility management options that reduce dependence on external inputs, and also increase the efficiency of their use (Altieri and Nichols, 2005; Embrapa, 2006).

Key agroecology management principles include:

1) Optimizing the use of local resources available

Improved use of local organic resources is aimed at increasing the use of nutrients of plant and animal origin, particularly in small-scale farming with little or no capacity to use chemical fertilizers. On average, the combined application of nitrogen fertilizer and organic materials can result in higher levels of productivity than when each is applied alone (Chivenge et al., 2011). This synergistic effect is due to an increased capacity of the soil to stock up nutrients with the addition of the organic materials, and also a more synchronized release of nutrients with crop demands, thus resulting in a more efficient use of the nutrients applied, and lower production and environmental costs. Additionally, it allows for a reduction in external input dependence, particularly those of a non-renewable nature, such as chemical fertilizers.

2) Minimizing the loss of soil, nutrients, water and energy in agroecosystems

The reduction of soil and nutrient loss caused by erosion, the management of soil to reduce evaporative water loss, and the reduction of energy losses caused by high dependence on and lack of efficiency in the use of mineral fertilizers are examples of actions required to control losses in agroecosystems. The promotion of nutrient recycling by strategically combining crops, nitrogen fixing and deep rooting trees, and livestock in agroecosystems also contributes to an increased efficiency of small scale agriculture by complementing or replacing the use of external inputs.

3) Optimizing favourable soil conditions for plant growth

Improved management of organic resources, and its contribution to soil organic matter formation, is also linked to the development of improved soil conditions for plant growth. Soil organic matter influences different processes associated with soil fertility, including the release of nutrients, the exchange of cations, aggregation, and moisture retention capacity (Lal, 2005). Soil organic matter is also a source of energy and nutrients for soil organisms. Enhanced soil organic matter content is strongly correlated to increased biological activity.

4) Genetic and species diversification in agroecosystems

Agrobiodiversity is considered here as both intra-species for plants and animals (e.g. different varieties within each crop), and inter-species (e.g. increase of the total number of species on farm). The increase and conservation of biodiversity, both in time and space, constitutes a key strategy for the prevention of pests and diseases, as well as in the adaptation to environmental changes in agricultural landscapes (McNeely and Scherr, 2002).

5) Encourage beneficial biological interactions and synergies between agrobiodiversity components

A better understanding of the biological interactions between soil organisms and plants highlights the importance of promoting synergies such as biological nitrogen fixation by bacteria associated with leguminous plants and the benefits of arbuscular mycorrhizal fungi that are associated with most plants (Siqueira and Franco, 1988). Likewise, the biological control of pests and diseases can be promoted by the active conservation of biological control agents, such as natural enemies and predators.

The application of agroecology management principles by small scale farmers can be carried out through several management practices. Each of these will have different impacts on both the productivity and the adaptability to environmental and economic changes. The impacts largely depend on the constraints and opportunities defined by local water, soil and biodiversity resources, as well as links to market dynamics. The purpose of the application of these principles is to encourage strategic integration of agroecosystem components in such a way as to increase biological and economic efficiency, while preserving biodiversity that is necessary for sustainable increase in productivity and resilience of production systems.

5.4 Integrated soil fertility management options

The management of soil fertility is not a simple problem, on account of the simultaneous influence of biophysical and socioeconomic factors, which limit the sustainability of agroecosystems. It is not only a problem of nutrient deficiency, but often also of the inadequate use of crops and cropping systems, access to degraded lands with limited response to soil fertility management, and economic policies that are inconsistent with sustainability goals. Thus, management of soil fertility requires an integrated approach which recognizes that there are short, medium and long term management options, and that the adoption of these options depends on the capacity of the small-scale farmers to efficiently manage their natural resources as well as using agricultural inputs.

Tables 5.1, 5.2 and 5.3 show, respectively, a synthesis of soil constraints that can be modified in the short, medium and long term, and also management principles and possible strategies to minimize the effect these constraints. The management options are presented, starting from those that require the use of little or no inputs to those that require more inputs and costs.

Soil constraints	Management principles	Management options
Low nutrient availability	Replenish nutrient depleted soils	Use crops with lower nutrient demands. Apply soluble inorganic fertilizers like urea (N) and potassium chloride (K) during each cropping season. Application of soluble phosphorus (P) fertilizers is both a short-term and medium-term solution because of residual effects.
Low soil pH	Maintain soil pH between 6 and 8	Use crops tolerant to acid soils. Liming offers a solution at the short, medium and long term for crops with limited tolerance to soil acidity, while rock phosphate, in addition to providing P, also raises the soil pH, having a double effect in the short, medium and long term.
Pest and diseases	Preserve soil biological integrity and foster biological control	Diversify cropping systems in time and space (e.g. crop rotations, agroforestry). Strategic application of biocides.
Noxious plants	Control of noxious plants	Use of mulching or cover crops. Physical removal. Use of selective herbicides.
Low water availability	Conservation of soil humidity	Maintain organic soil cover (mulching) and use of no-tillage management. Collection of rain water and irrigation.
Compaction/ low water infiltration	Avoid soil compaction	Use vigorous deep-rooted plants as cover crops (e.g. forage turnip, rape, pigeonpea). Breaking soil compacted layer using animal traction. Deep tillage/sub-soiling avoiding use of heavy machinery.

Table 5.1 Soil constraints, management principles and management options in the short term.

Soil constraints	Management principles	Management options
Low soil organic matter content	Maintain adequate soil organic matter content	Manage regeneration of natural vegetation through pruning and use biomass as organic soil cover. Use of other organic residues, green manures, improved fallows, adding nitrogen fixing plants to natural regeneration, no-tillage systems.
Soil structure loss	Maintain good soil structure	Manage regeneration of natural vegetation through pruning and use biomass as organic soil cover. Use of other organic residues, green manures, improved fallows, adding nitrogen fixing plants to natural regeneration, no-tillage systems.
Abundance of stones	Maintain a stone-free soil	Remove stones from the soil and place them as erosion control barriers following contour lines.

Table 5.2 Soil constraints, management principles and management options in the medium term.

Soil constraints	Management principles	Management options
Nutrient poor soils	Improve the capacity of soil to provide nutrients	Use integrated soil fertility management strategies for the recuperation of nutrient poor soils. Replenish nutrient stocks by applying inorganic fertilizers (e.g. rock phosphate , basaltic rock), together with manures/ organic residues. Include nitrogen fixing leguminous plants into cropping systems, establish improved fallow systems, use adequate crop rotations, encourage intercropping of plants with different growth habits in time (e.g. perennial and annual plants), and space (e.g. shallow and deep rooting crops) that would allow a more efficient use of soil water and nutrients.
Soil salinity	Reduce salinity to levels that are not limiting to agricultural productivity	Improving drainage, wash the salt with good quality water of low total salinity and sodium content. Use good quality irrigation water.
Soil erosion/low effective soil depth	Minimize soil erosion	Use of live barriers and/or dead barriers (e.g. stone lines) to limit soil erosion and promote natural terraces. Establish barriers following contour lines incorporating trees to stabilize these barriers.
Tradition of slash and burn	Promote a no-burning culture	Increase awareness among farmers about the negative effects of burning and the importance of organic residue management. Highlight no-burning systems like no-tillage and agroforestry.

Table 5.3 Soil constraints, management principles and management options in the long term.

5.5 Agricultural diversification

The diversification of small scale farming is a strategic management decision which generates multiple effects that are necessary for sustainable agriculture. The design of diversified production systems makes it possible to maintain productivity, to conserve biodiversity and the capacity of self-regulation. It also increases opportunities for complementarities and synergies between species that increase the water and nutrient use efficiency and reduce the economic risk for small scale farmers, especially in marginal areas, where the variability of environmental conditions is greater. Therefore, when crop yields are poor, it is possible to compensate for economic loss through other components of the agroecosystem.

There are several strategies for increasing agroecosystem diversity in time and space. Some of these include:

Crop rotation: The practice of crop rotation, on the same farm plot, increases the species diversity in time, may provide nutrients for subsequent crops and also disrupt the life cycles of pests and diseases. An example is the rotation of cereals and legumes.

Maize-bean rotation

Intercropping: This involves the practice of growing two or more crops simultaneously on the same farm plot, which increases the diversity of species in space, as well as the overall yield per unit area. For crops that can be intercropped, complementarity in the use of available light, water and nutrients is greater than the competition for them, and they can therefore coexist in close proximity with each other, cultivated in alternate ridges or in the same ridge.

Maize-bean Intercrop

Cover crops: The use of cover crops aims at improving soil fertility through nitrogen fixation (when using leguminous plants), recycling of nutrients, loosening of the soil (when using plants with deep and pivotal tap roots), promoting biological control of weeds through shading, considerable reduction in soil erosion, and in evaporative water loss on account of the lower average temperature of the soil. The use of cover crops is an important practice in no-till cropping systems, especially where the biomass of straw produced by crops is not enough for optimal functioning of the system.

Mucuna
(Mucuna pruriens)

Forage radish
(Raphanus sativus)

Agroforestry: This production system is strongly based on complementarity relationships that allow the growth of trees together with annual crops and/or animals, thereby achieving multiple use of the agroecosystem (Barrios et al., 2012). With the integration of trees in agricultural landscapes, agroforestry aims at reconstructing the ecological processes that occur in nature and contribute to the resilience of agroecosystems. These ecological processes have been disrupted during agricultural intensification, resulting in biodiversity loss, as in the case of monocroping.

Multi-strata Agroforestry Systems

Front: Gliricidia trees (Gliricidia sepium) used as poles for guiding lines in passion fruit cultivation, intercropped with beans

Background: Pigeonpea and black paper growing between Paricá (Schizolobium amazonicum) timber trees.

For more information on production systems that follow agroecology management principles, please refer to Monegat (1991), McNeely and Scherr (2002) and World Bank (2008).

5.6 Agriculture and the sustained provision of soil-mediated ecosystem services

Agricultural sustainability fundamentally depends on the sustainable management of the soil resource. Recognition of the role of agroecosystems in the provision of other ecosystem services besides agricultural production, and the fact that agriculture is the most widespread form of human-nature interaction, highlights the need to understand and manage the multifunctional nature of agroecosystems. Therefore, the main challenge in sustainable soil management is to maintain the capacity to produce food, fibre, and energy of plant origin for present and future generations, and at the same time to continue to generate other ecosystem services that make life on the planet possible (Barrios et al., 2012). This challenge is particularly complicated because of the need to address the issue in a holistic and comprehensive manner. It is not just a problem of the lack of nutrients and water in the soil, but also that of inadequate use of crops/varieties, poor planning of land use, interactions with pests and diseases, links between poverty and land degradation, national and global policies related to incentives that produce adverse consequences, and institutional failure. Thus, agricultural sustainability is not a simple problem. It requires a long-term vision that takes into account, in an integrated manner, social, economic and ecological aspects. That is, it should be socially just, economically viable and ecologically sound (Pretty, 1995).

The development of soil quality monitoring systems based on integrated indicators, which combine local with technical knowledge, is essential for informing farmers on the ecosystem service provision status of their farms, and for guiding soil management keeping in mind the importance of multifunctionality in agroecosystems (Barrios et al., 2012). In this way, rural communities and agricultural/environmental institutions with the capacity for local monitoring, together with new mechanisms of economic valuation, would facilitate participation in payment for ecosystem service systems which reward good management practices. It is expected that payment for ecosystem services will become an increasingly important source of income for rural communities and institutions, and an important incentive for sustainable agricultural management

5.7 Summary

In this chapter the indicators of soil quality associated with soil properties modifiable by management (in the short, medium and long term) are used as a starting point for identifying relevant agroecology management principles in order to take advantage of opportunities and to address soil constraints faced by small scale farmers. Different options for integrated management of soil fertility, which inherently follow these agroecological principles, are identified based on soil quality status and the farmer's capacity to use inputs. The importance of diversification in small scale farms is emphasized as a strategy that promotes multifunctional agriculture which is required for greater adaptability to both climatic and economic global changes. The main challenge in agriculture has to do with management of soils that sustain their ability to meet the needs of food security while generating other ecosystem services that make life on the planet possible.

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5.9 InPaC-S: Methodological Tools

PARTICIPATORY APPROACH METHODOLOGY - LEARNING BY DOING

DYNAMIC #11 IDENTIFYING SOIL MANAGEMENT OPTIONS USING THE MANAGEMENT OPTIONS MATRIX TOOL

Objective: Selection of soil management options taking into account the soil quality status and the farmer's capacity to use inputs.

Materials: note pads, pens, dark ink markers (Pillot type), Flipchart paper sheets, masking tape, transparent adhesive tape (cellotape).

a) Split the participants into five groups of about 5-6 people.
b) Identify the five most important indicators associated with modifiable soil properties from the results of the Integration Matrix. Each group will focus on one indicator.
c) Initiate a discussion in each group on which agricultural management options would be possible/practical in the location of the study depending on the relative status of the indicator of soil quality (low, medium, or high) and on the farmers' relative capacity to use inputs (zero, low e.g. < 50% recommended rate, medium/high e.g. >50% recommended rate).

d) Summarize the results of the discussion and consensus building by each working group for their respective indicator in a Management Options Matrix prepared on a flipchart paper.

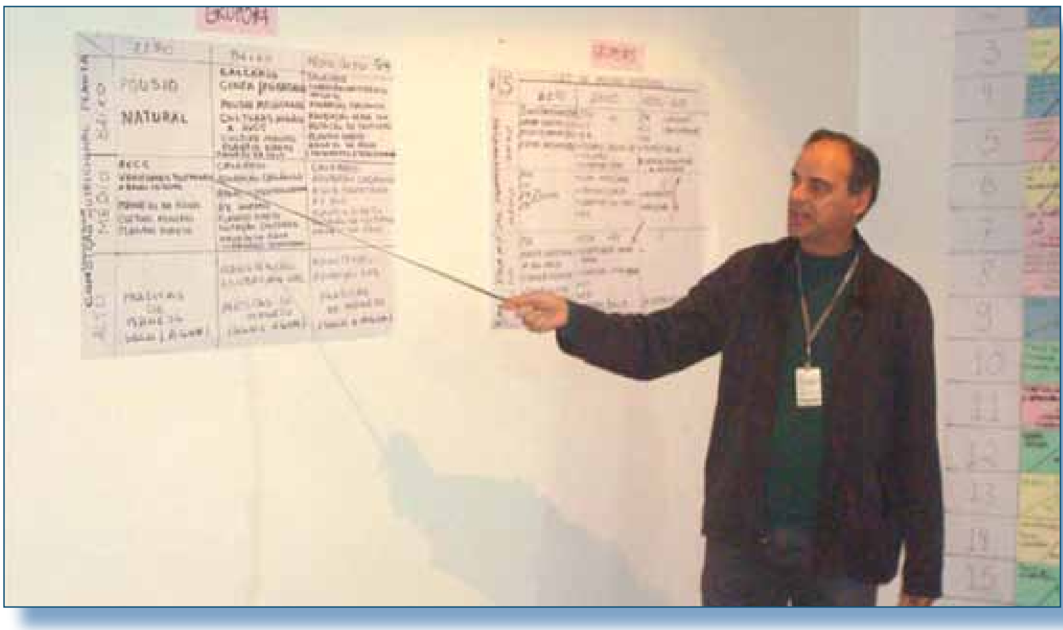
Farmer capacity to use inputs

Soil quality according to selected Indicator

	Zero input	Low input	Medium/High input
LOW			
MEDIUM			
HIGH			

Fig. 5.2 Structure of the Management Options Matrix.

e) Each group should display its flipchart paper on a common wall for discussion during plenary. One participant from each group will present the results from their discussion.



CHAPTER 6

THE SOILS FAIR: INTEGRATION IN PRACTICE

6.1 Introduction

The Soils Fair is a practical demonstration of the integration of local with technical knowledge on indicators of soil quality to farmers and technical professionals participating in the workshop. This promotes better understanding of the physical, chemical and biological properties of the soil through simplified demonstrative methods.

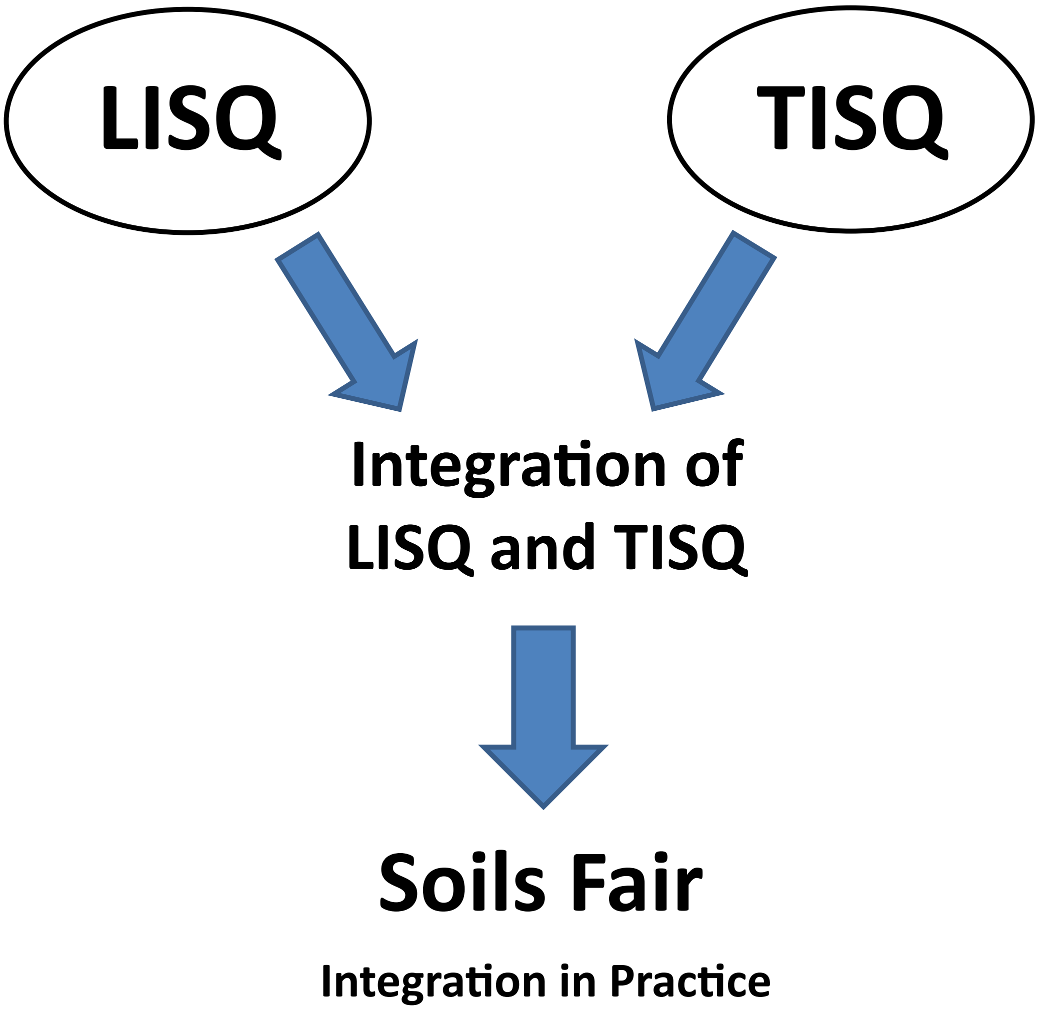


Figure 6.1 Process of local and technical knowledge integration.

These demonstrations are not intended to provide a detailed analysis of soil characteristics, but rather to introduce some concepts and ideas that are useful for linking indicators of soil quality with the modifiable or permanent soil properties they represent. The soil properties that will be discussed during the Soils Fair are described in Table 6.1.

Soil Properties	Thematic table	Methods
Texture **Structure**	**1**	**Hand evaluation** **Visual evaluation**
Organic matter **Colour**	**2**	**OM oxidation using hydrogen peroxide** **Munsell Colour Table**
pH **Soil fertility**	**3**	**pH paper** **Indicator plants**
Biological Activity Soil macrofauna and microorganisms	**4**	**Visual examination and PowerPoint presentation**

Table 6.1 Simple methodologies used to assess soil properties during the Soils Fair.

Oxidation of organic matter inside soil aggregate

Native plants as indicators of soil quality

6.1.1 Objectives

At the end of the Soils Fair, workshop participants will be able to:

- Use simple methods for assessing key physical, chemical and biological soil properties.
- Link local and technical indicators of soil quality.
- Explain to others the correspondence between local and technical indicators of soil quality.

6.2 Organization of the Soils Fair

The Soils Fair should preferably be held at the farmer community participating in the workshop on the morning of the fifth and last day of the workshop activities.

6.2.1 Preliminary and preparatory activities

In the planning phase of the Workshop (Annex 4) it is important to identify a local coordinator, who will be responsible for organizing the logistics of the Soils Fair.

The preliminary activities of the Soils Fair include to:

1) Identify the venue for the event within the participating farmer community (e.g. church hall, community association, school).
2) Acquire the necessary materials for the Soils Fair before the start of the workshop (Annex 5).
3) Inform the community leaders about the program and objectives of the workshop several times before the start of the workshop. On the first day (Monday), highlight the great importance of farmer participation to ensure success of this workshop activity. Plan to have a minimum of 20-30 farmers at the Soils Fair. This number should preferably include all participants in the Field Day Activity that was conducted on the third day of the workshop (Wednesday).
4) Identify two participating technical professionals, on the fourth day of the workshop (Thursday), to jointly lead each thematic table during the Soils Fair. This process should be conducted by the workshop coordinator/facilitator, taking into account the following criteria: area of expertise, experience in the topic covered by the thematic table, and willingness to develop planned activities for the thematic table. Thematic table leaders will receive guidance on key messages, demonstrations and practical exercises from workshop coordinator/facilitator.
5) Distribute the four thematic tables in the Soils Fair venue and fully cover each one with sheets of Kraft brown paper joined together with cellotape.
6) Write the name of each thematic table on three cards to be attached to three of its sides.

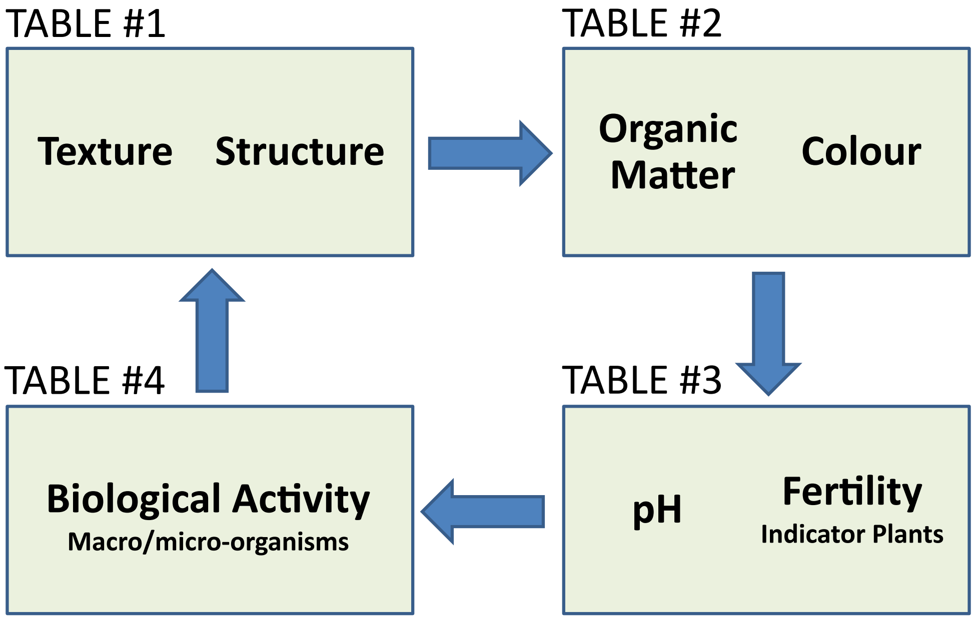


Figure 6.2 Thematic tables in the Soils Fair.

Note: The following activities are conducted on site just before the beginning of the Soils Fair.

7) Receive soil samples from five selected farmers (participants in the Field Day Activity) representing the best and the worst soil in their farms. It is important to ensure that the name of the farmer/community, and local soil quality classification (GOOD or POOR), is written for each sample on the Kraft brown paper used to wrap the thematic table. Mix each soil sample well before dividing it into three portions. Approximately half of the sample should be placed on thematic table #1 and a quarter of the sample on thematic tables #2 and #3 respectively.

8) Receive and classify local plant samples brought by farmers and used as local indicators of low (POOR) or high (GOOD) soil fertility, and display them on thematic table #3.

9) Receive samples of leguminous plant roots (beans, cowpea, soybean, pigeon pea, etc.) with nodules resulting from symbiosis with nitrogen fixing bacteria (rhizobia) as well as soil samples with small soil animals (earthworms, termites, beetles, etc.) that are common in the area and display them on thematic table #4.

6.2.2 During the Soils Fair

During the Soils Fair the order of activities is as follows:

1) Make a short presentation on the goals and basic dynamics of the workshop, featuring selected photos of the Field Day Activity conducted at the farmer community on the third day, as an introduction to practical activities of the Soils Fair.

2) Divide the technical professionals from the workshop into four groups (G1, G2, G3, G4). Each group will be assigned to each of the thematic tables (1, 2, 3, 4).

3) In the same way the participating farmers are distributed into four groups, each assigned to the four thematic tables.

4) Thematic table leaders start with key messages followed by demonstrations and practical exercises using samples brought by farmers.

5) After every 20-25 minutes of demonstration, the workshop coordinator/facilitator would signal to indicate that each group should move to the next thematic table following a clockwise rotation until all groups have gone through all four thematic tables.
6) After concluding the demonstrations present to the community the key results obtained during the workshop: i) the Synthesis Matrix, ii) the Integration Matrix and iii) the Management Options Matrix. After the presentation these results should be handed over to the farmer community leadership.

7) Discuss the results with farmers and explore other local options for soil quality management that were not considered.
8) Allow time for comments from farmers about the Soils Fair and the work done in their communities. Explore with them what they learnt from these activities and what possible use they foresee for the soil quality assessment methodologies that were presented. Ask them which activity they found most interesting and let them explain why.
9) Conclude the Soils Fair by thanking all local participants who played an important role in making the workshop, Field Day Activity and Soils Fair possible

Note: After the Soils Fair, all participating technical professionals should return to the workshop venue for final discussions and closing activities.

6.3 InPaC-S Methodological Tools

PARTICIPATORY APPROACH METHODOLOGY - COLLECTIVE REFLECTION

DYNAMIC #12 ASSESSING PERCEPTIONS ON USEFULNESS OF THE InPaC-S METHODOLOGY

Objective: To summarize perceptions by participants regarding the InPaC-S methodology and potential use in their regular activities and institutions.

Materials: note pads, pens, rectangular coloured cards (12.5 x 23 cm), dark ink markers (Pillot type), masking tape.

a) Divide the participants into groups based on their institutions, or activity sector (e.g. research, extension, education, etc.).

   Reflect on and respond briefly to the following questions, using a card to answer each question:

   1) Can the InPaC-S methodology be applied at your workplace? How?.

   2) Can this methodology facilitate collaborative processes, both within and among institutions? Please explain.

b) The responses should be presented by a representative from each group. Start by reading the card with the answer to the first question. Then, the card is affixed to the wall or any other flat surface. Repeat the same procedure for the card with the response to the second question. The same will be done for all the other groups.

c) Split into working groups (encourage self-organization) and initiate a discussion on potential action plans among institutions, using the following simplified action plan guide.

ACTION PLANS

SIMPLIFIED KEY QUESTIONS AND COMPONENTS

What to do?	→	Activities
Why doing it?	→	Purpose
How to do it?	→	Strategy
Where to do it?	→	Location
How many activities?	→	Goal
How long?	→	Duration
How much it costs?	→	Funding
Who coordinates?	→	Person responsible

Annexes

Annex 1

Workshop Description

Summary: The workshop entitled “InPaC-S: Participatory Knowledge Integration on Indicators of Soil Quality” involves 40 hours of activities spread over a period of five days (Monday to Friday). In brief, day #1 is dedicated to the introduction of the workshop program, to initiate the building of a knowledge sharing space among participants, and to establish a first contact with the farmer community participating in the workshop selected from the vicinity of the workshop venue. Day #2 begins with a session on basic soil science, technical indicators of soil quality (TISQ) and soil-mediated ecosystem services, followed by a detailed description of the InPaC-S participatory tools for the identification, classification and prioritization of local indicators of soil quality (LISQ). On day #3, the Field Day Activity takes place and the InPaC-S tools introduced the previous day are used jointly with the farmer community to generate a prioritized list of local indicators of soil quality using the Synthesis Matrix tool. On day #4 the prioritized list of local indicators of soil quality generated on Day #3 is integrated with corresponding technical indicators of soil quality, and associated with soil properties that can be modified through management or those of a permanent nature, using the Integration Matrix tool. The top five most important indicators associated with modifiable soil properties are selected for further analysis using the Management Options Matrix tool where agroecological management options are identified for different soil quality/farmer capacity to use inputs scenarios. Day #5 begins with the hosting of the Soils Fair at the farmer community. In this key event for the InPaC-S methodology, all the results obtained during the workshop are presented and handed over to the farmer community leadership. During the second half of the day, at the workshop venue, institutional or sectoral (e.g. research, extension and rural development, education) action plans are discussed and developed, with a final joint reflection, workshop evaluation, and delivery of Certificates of Participation at the Closing Dinner Event.

Workshop Schedule using the InPaC-S Methodological Guide

Day 1

- General introduction to the workshop program and brief historical review
- Workshop overview.
- Chapter 1 (Introduction)
- Dynamics #1, #2, #3, # 4

Day 2

- Chapter 2 (TISQ), Dynamics #5, #6, #7, #8,
- Chapter 3 (LISQ), Dynamic #9

Day 3

- Field Day Activity: the day is spent with the farmer community using participatory methodological tools to identify, classify and prioritize local indicators of soil quality

Day 4

- Chapter 4 (Integration, ILQS and ITQS), Dynamic #10
- Chapter 5 (Integrated Soil Fertility Management Principles and Options), Dynamic # 11
- Chapter 6 (The Soils Fair)

Day 5

- The Soils Fair is held at the farmer community.
- The technical-local knowledge on indicators of soil quality indicators and management options jointly developed during the workshop are handed over to the leadership of the farmer community
- Dynamic # 12
- Closing activities

Time	MON	TUE	WED	THU	FRI
08:00-09:40	Introduction Dynamics #1	CLORPT Dynamics #5	Departure 07:30 Field Day Activity	Integration of LISQ and TISQ Dynamics #10	THE SOILS FAIR
09:40-10:00	Coffee break	Coffee break	Coffee break (joint)	Coffee break	Coffee break (joint)
10:00-12:00	Dynamics #2 Historical review	ESERV Dynamics #6 TISQ Dynamics #7, #8	Field Day Activity	Dynamics #10	THE SOILS FAIR Information return to farmer community
12:00-13:30	Lunch	Lunch	Lunch (joint)	Lunch	Lunch
13:30-15:00	Workshop overview Dynamics #3	LISQ Dynamics #9	Return to Worshop venue Departure 14:00	Agroecological Mangement Principles & Options Dynamics #11	Action Plans Dynamics #12
15:00-15:20	Coffee break	Coffee break	Coffee break	Coffee break	Coffee break
15:20-17:30	Dynamics #4 Cross-country walk at farmer community	Dynamics #9	Synthesis of Information Field Day Activity Joint Reflection	Preparatory activities for The Soils Fair	Final collective Reflection Workshop Evaluations Certificates Closing

Graphic description of the workshop's program

Annex 2

Responses to Exercises 1, 2, 3, 4 and 5

EXERCISE #1

	Factors	Processes
Climate	X	
Soil loss		X
Temperature	X	
Rainfall	X	
Wind speed	X	
Cloudiness	X	
Soil gains		X
Humidity	X	
Relief	X	
Parent material	X	
Organisms	X	
Flora	X	
Fauna	X	
Translocations		X
Luminosity	X	

EXERCISE #1

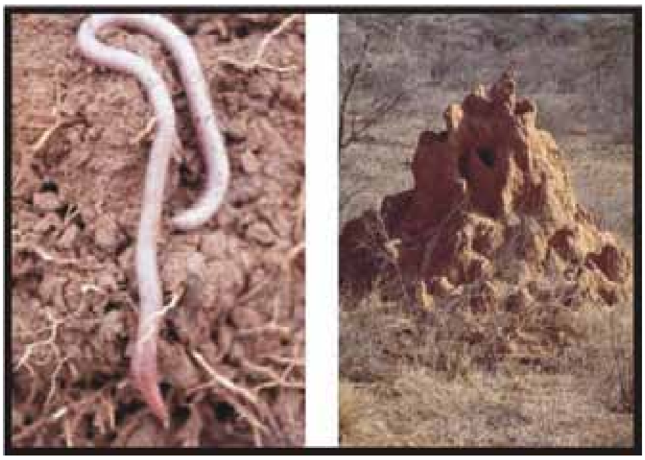
	Factors	Processes
Slope	X	
Valley	X	
Mountain	X	
Geology	X	
Erosion		X
Burning practice		X
Alluvial deposition		X
Incorporation of plant residues		X
Transformations		X
Clay movement		X
Clay mineralogy	X	
Microorganisms	X	
Soil evolution		X
Forest	X	
Pasture	X	

EXERCISE #2

FACTORS OF SOIL FORMATION

CLIMATE

1. Rainfall
2. Temperature
3. Wind
4. Solar radiation



ORGANISMS

1. Plants
2. Earthworms
3. Fungi
4. Ants

RELIEF

1. Valley
2. Floodplain
3. Mountain
4. Hill

EXERCISE #2

FACTORS OF SOIL FORMATION

PARENT MATERIAL

1. Sedimentary rocks
2. Calcareous rocks
3. Metamorphic rocks
4. Igneous rocks

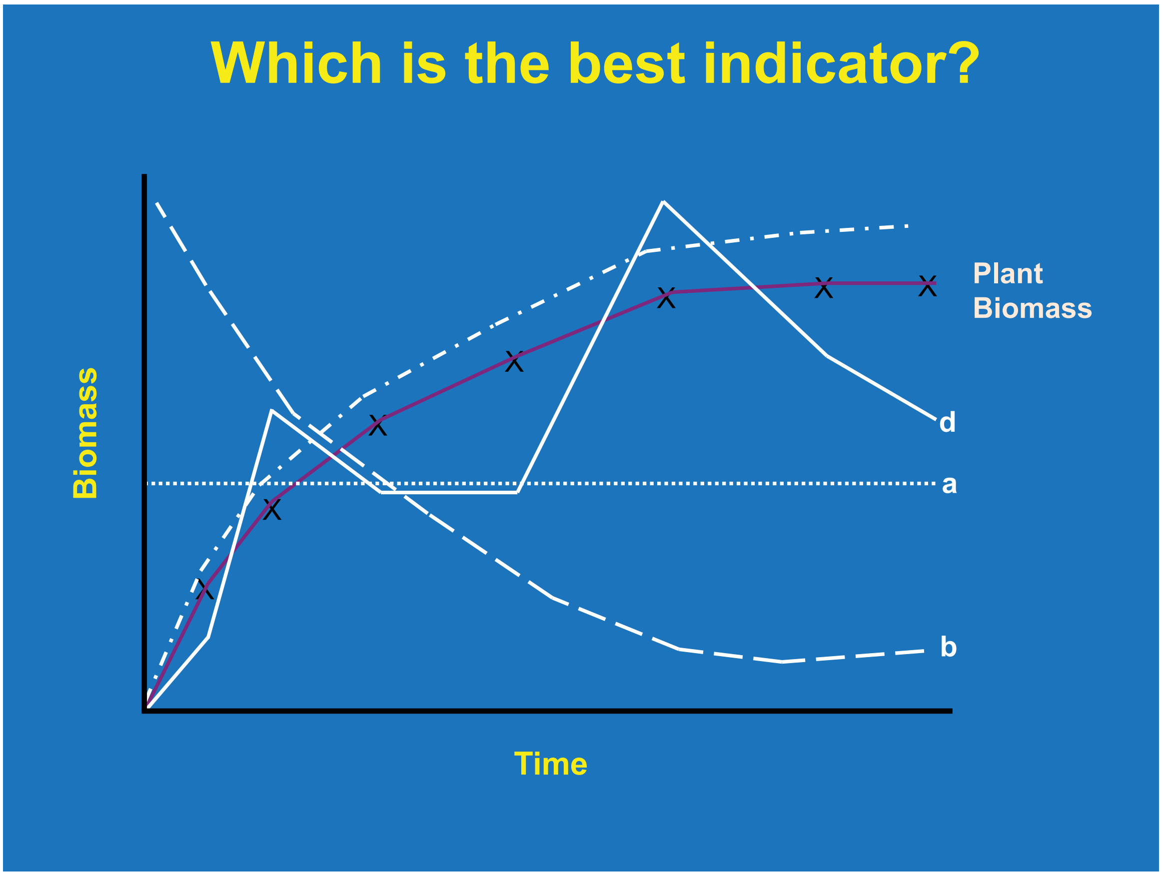
TIME

1. Landscape evolution
2. Geologic age
3. Weathering period
4. Seasonality

EXERCISE #3

	Type of Service
Pollination	SUPPORTING
Soil formation	SUPPORTING
Fibre production	PROVISIONING
Rainfall	Not a Service
Nutrient cycling	SUPPORTING
Production of building materials	PROVISIONING
Biological control of pests and diseases	REGULATING
Water purification	REGULATING
Scenic beauty	CULTURAL
Control of greenhouse gas emissions	REGULATING
Photosynthesis	SUPPORTING
Flood control	REGULATING
Recreation and educational area	CULTURAL
Food production	PROVISIONING
Climate regulation	REGULATING

EXERCISE #4



What response curve represents the best soil quality indicator as related to plant biomass?

a) Completely insensitive and thus the worst soil quality indicator.

b) Is the exact inverse reflection of the plant biomass curve and thus the best soil quality indicator.

c) It generally follows the behavior of the plant biomass curve and is thus a good soil quality indicator.

d) It is too variable and thus not a good soil quality indicator.

EXERCISE #5

Soil with earthworms	Soil with no earthworms
Deep soil	Shallow soil
Black, dark soil	Grey, white, yellow, light-coloured soil
Bacuri, Embaúba, Aroeira	Unha de boi, Lixeira,Taquara
Soil with gentle slope	Soil with steep slope
Fertile soil	Non-fertile soil
Moist soil	Dry soil
Soil with no erosion	Soil with erosion
Soil under thick forest vegetation	Soil under savanna vegetation
Soil with clay	Soil without clay
Soft soil	Compacted soil
Soil after fallow	Tired soil

NOTES TO EXERCISE #5

1) During the process of identifying indicators of good or poor soils, always try to elicit the opposite trait using terms commonly used by farmers.
2) In cases where opposite traits are not identified, complete the indicator synthesis card using a term opposite in meaning (e.g. dark soil/light coloured soil).
3) If you find a very general indicator (e.g. fertile/infertile) try to unbundle it as much as possible during the conversation with the farmer into the different factors considered when defining the term fertility.
4) When considering plants as indicators of soil quality it is very important to highlight trees on account of their longevity and therefore their adaptation to local conditions.
5) Some local definitions of soil quality can suggest contradiction (e.g. clay soil considered good for beans, and sandy soil considered good for cassava). It is important to keep in mind that our interest is to capture the generality of the indicator in the study area. Therefore, if clay soil is considered better for most local crops at a particular location then it is used as the general positive characteristic of the indicator for soil texture, and sandy soil considered the general negative characteristic of the same indicator.

Annex 3

Questionnaire for Cases Studies: Exploring local knowledge about soils and their management

Questionnaire for Cases Studies: Exploring local knowledge about soils and their management

Farmer's name:

Gender:

Name of Interviewer:

Date of Interview:

Participatory farm mapping

Prepare a map with the farmer showing the different soil types, topography and current land use, highlighting slope, location of crop fields and uncultivated areas, presence of pests, the presence of soil organisms (earthworms, ants, termites, etc.). Use this map during the farm walk to confirm different farm features and soil types described by the farmer.

Knowledge on soil

a) Are there different types of soil in your farm or surrounding area?
b) How can you distinguish one soil type from another: (Repeat all possible one-on-one comparisons and also contrast their soil classification criteria).
c) Descriptive properties of each soil type identified;
    - What is the color of the soil when it is wet and when it is dry?
    - Does it need much or little fertilizer?
    - What is the thickness of the litter layer on the soil?
    - During the dry season, is the soil dusty, hard or stony?
    - When it rains, is water accumulated on the soil surface, does it flows over the surface, or readily penetrates the soil?
    - Is the soil sandy or sticky?
    - Does the soil dry slowly after raining?
    - Is it easy to plough?
    - What is the slope of the soil (less than 10% = flat, 10-30% = moderate, more than 30% = steep)?

- When it rains, is the colour of water that flows towards rivers, lakes or lower parts of the farm brown, yellow, or transparent (related to erosion)?
- What are the common or dominant native plants growing on different soil types? (Try establishing a relationship between specific plants as possible indicators of a particular soil type).
- Are there earthworms, ants and termites?
- What is the mean crop yield? (low, medium, high)
- Over time, do you see a decline in crop yield, animal weight, milk production per animal?

d) What is your best soil for cultivation?
   - Has it always been good?
   - Was it better before?
   - To what extent was it better before?
   - And how about your worst soil?
   - Was it like this before?

e) Is this the best soil for a given crop (repeat the question for each soil mentioned)?

f) Can this soil be cultivated for a longer period than this other one (repeat for each pair of soils)?

Soil management practices

Spatial distribution of crops

When you are making a decision on the distribution of your planting area for the next planting season, how do you decide what area to dedicate to which crop?

Land preparation

Do you prepare the soil for cultivation? Do you prepare the different soil types in the same way?

If the soil is not prepared, do you use a hoe to plant? What is the sowing depth?

If the soil is prepared, in what direction do you prepare it? Is it in the direction of the slope? Is it perpendicular to the slope?

Do you slash and burn?
When do you slash and burn? What method do you use? Give examples.
How often do you burn?

Manure

Do you use manure?

What kind of manure do you use?

- Chicken
- Sheep
- Goat
- Pig
- Other

Where do you graze your animals?

Do you transport animal manure to other parts of your farm?

Do you use other organic fertilizers?

For which crops or plots do you use different types of manure? Why?

How do you apply manure (per plant, with irrigation, depending on crop)?

How much manure do you apply per crop or plot?

How do you calculate the appropriate amount of manure to be applied?

What is the effect of manure on the soil?

Chemical fertilizers

Do you use chemical fertilizers?

If so why and if not, why not?

What do you know about fertilizers?

- Cost
- Availability
- Results obtained after fertilizer application

In which crops or plots do you use chemical fertilizers? Why?
What kind of fertilizers do you use?
Do you know the meaning of NPK 10-20-10?

How do you select the type of fertilizer to use?

Do you use different types and amounts of fertilizers for different crops or plots?

How do you apply fertilizer (broadcast, to each plant individually, depends on the type of crop or type of fertilizer)?

How much fertilizer do you apply (kg/ha)?

How do you calculate the amount of fertilizer required?

What is the effect of fertilizer on the soil?

Who gives you information about fertilizers (the agricultural supplies vendor, extension and rural development staff, another farmer, etc.)?.

Green manure

Do you use green manure?

Which plants help to enrich the soil?

For which crops do you use green manuring and why?

How many days of work are spent on green manuring per crop?

Who does the work (family member, employee, casual labourer, etc.)?

How long do you keep the soil with green manure?

Crop residue management

Do you apply crop residues to the soil?

Do you leave the residue on the soil? If yes, for how long?

Do you allow cattle and other animals to eat the crop residues?

Do you incorporate crop residues into the soil?

When is this done (before the rains, after the first rains)?

Compost

Do you use compost?

How do you prepare compost and what ingredients do you use?

Do you apply compost to your whole area or only on some crops?

If so, to which ones?

Soil erosion control

Do you experience problems of soil erosion in your farm? Where?

Do you control soil erosion?

Do you use erosion control barriers?

What kind of erosion control barriers do you use (live, residues, terraces)?

For which crops do you use erosion control barriers? For what types of slopes and at what distance do you place them from each other?

What plants do you use as erosion control barriers?

Are these live barriers used as food supplement for animals?

How important is the quality of this supplement?

Do you construct terraces? What kind?

What crops are cultivated between the terraces?

How many labourers are required to carry out these activities?

Control of pests, diseases and weeds

What are the pests, diseases and weeds most commonly found on each crop?

Do you control pests, diseases and weeds? How do you do it (pesticides, manual control, biological control)?

What type of pesticide (insecticide, fungicide, herbicide, etc.) do you use?

How much pesticide do you apply?

How often do you apply pesticides and who does it?

At what time of the day is it applied?

Who tells you when to apply pesticides?

What are the effects of pesticides on the soil?

Soil organisms

What kinds of small organisms/animals have you seen that live in the soil in your farm?

Are they beneficial or detrimental to your crops, and why?

Where do you find different kinds of soil organisms/animals in your farm? Why do they occur there?

Are there certain types of soil organisms/animals that indicate if land will be good or bad for growing crops?

Are you aware of soil animals that help to enrich it?

Can you increase the number of beneficial soil animals in the soil? How?

Factors related to soil management decision making

- When do you decide to initiate crop rotation in a plot? What crops are planted in the rotation? In what sequence are they rotated? What changes do you observe in the soil? What is the duration of each rotation?
- When do you decide to leave a plot fallow? What indicators do you use to decide to leave a plot fallow (weeds, pests and diseases, soil structure, soil colour)? How long is the plot allowed to lay fallow? What indicators are used to return a fallow plot to cultivation?
- What types of plants can be intercropped in a plot? Why? Which plants would benefit each other when grown together? Try to identify examples of competitive effects or mutual benefit.
- Are there indigenous forests on your farm? What part of your farm is under forest cover? How useful is the forest? If it is a planted forest, why was it planted?
- Are there periods of the year when lack of water affects your crops? When does this occur? Can something be done to reduce the effects of drought?
- Which crops are most sensitive to drought? Which crops have deep roots and which ones have shallow roots? Which local plants have deep roots and which ones have shallow roots? To what extent do animals depend on food supplements during the dry season? How important are drought-tolerant crops?
- How does one know when the rainy season is about to start? Or rather, how does one know when it is time to prepare the land, sow, etc? Are there plants or animals that act as climate indicators?

General

- In a year without any rain or temperature problems, of every hundred seeds planted in the soil, how many germinate (may want to distinguish between those that failed to germinate, that show irregular germination or full germination)? Do crops grow quickly or slowly? Are they healthy and vigorous? Do you observe any yellow lines or spots in crops or on the leaves of trees? How well do crops tolerate drought, pests, diseases and weeds? How are your crop yields?
- Which are the poorest soils in your farm and in the region where you live? Do they need fertilizer? Do they respond to fertilizer applications?

- Which are the most fertile soils on your farm and in your region? Where are they found? Indicate which soils can be cultivated without the use of fertilizers.
- Can you identify two people in your community and possibly in the neighbouring communites, who do not use or use little fertilizer and still get high crop yields?
- Can you identify two people in your community and possibly in the neighbouring communites, who use fertilizer efficiently and get high crop yields?

Soil sampling is recommended as part of each Case Study

Preparation of a composite soil sample: identify a central area for each soil type described by the farmer. Draw a 5m line on the ground, and another one of equal length, perpendicular to it, so that they form an X. Collect soil samples at the end of each line and at their intersection (total of five samples) for each the following depths, 0-20 and 20-50 cm. Finally mix the five samples for each depth, to obtain a composite sample for each soil depth, by soil type/landscape position described by the farmer. If it is possible, geo-reference the soil samples by getting a GPS reading at the intersection of both lines. Collect samples of soils identified by the farmer as representative of their farm or region, identifying those cited as the poorest and those as most fertile. Once the samples are collected, contact the soil analysis laboratory nearest to you for guidance on the appropriate procedures for the dispatch of samples, soil analyses and interpretation of results.

Information about the farm

Take a GPS point of the location at the farm (include reference landmarks for the location of the farm, such as address, neighboring geographical features etc.)

Lat:

Long:

Elevation:

Name of city/state:

Farm name:

Farm size:

What is your main source of income?

a) How long has this farm been cultivated?

- Is it fully cultivated?
- Cultivated area (%)
- Uncultivated area (%)
- Provide a brief description of the cultivation history of different farm plots.
- Is it continuously cultivated?
- Is it only occasionally cultivated?
- What is the average annual farm income?

b) Land tenure

- Are you the owner?
- Are you leasing the farm?
- Have you inherited the farm?
- Did you buy it?
- Do you have a farm title deed? If not, why?

c) Name and age of the farmer

d) Can you read?

e) Do you know how to write?

f) Number of sons and daughters

g) Names and ages of other family members

h) Is there sufficient manpower within the family or do you need to hire manual labourers?

i) Which family members work in the farm?

- Father
- Mother
- Son
- Spouse
- Daughter
- Another family member

j) Do you use charcoal for cooking?

- What quantity is used per week?
- What is the source of the charcoal?

k) Do you experience risks of any kind? How would you list them in order of importance?

Interviewer's report:

1) The respondent's attitude was:

a) Cooperative
b) Indifferent
c) Nervous/shaky
d) Difficult to define
e) Other (comment) ______________________________

2) The respondent understood the questions:

a) Very well
b) Well
c) Poorly
d) Difficult to define
e) Other (comment) ______________________________

Annex 4

Planning The Workshop

RECOMMENDATIONS FOR PLANNING A WORKSHOP

Selection of location: The success of the workshop will be highly dependent on the selection of the right venue for the event. There are several criteria that could help in this selection:

- Local institution, with farmer mobilization capacity, interested to collaborate with local coordination of the workshop.
- Distance/access from the workshop venue to the selected small-scale farmer community. It is recommended that you plan for a venue which is a maximum of about 30 km away from the farmer community.
- Infrastructure and logistics (access to the workshop venue, availability of transport, accommodation, meals).
- Availability of farmers' community organizations.
- Farmer community has been in the area for more than ten years.
- Existing community involvement with extension and rural development government institutions and/or NGOs.
- Wealth of local information (history, maps, etc.)
- Diversity of soils in local agricultural landscapes.

NECESSARY MATERIALS

1) Rectangular coloured cards: A total of 600 cards (size: 12.5 x 23 cm) are prepared using white, light yellow, light red, light green and light blue sheets of cardboard paper.
2) Kraft brown paper (61x91cm) = 50 sheets.
3) Flipchart paper = 50 sheets
4) Masking tape = 3 rolls
5) Transparent adhesive tape (cellotape) = 2 rolls
6) Dark ink markers (Pillot type) = 25 units (10 black color, 5 red color, 5 blue color, 5 green color)
7) Air-filled balloons (rubber balloons) = about 50 pieces of medium size
8) Strips of white paper (2.5 x 21 cm) = 35
9) Note pads and pens = 35 of each

Annex 5

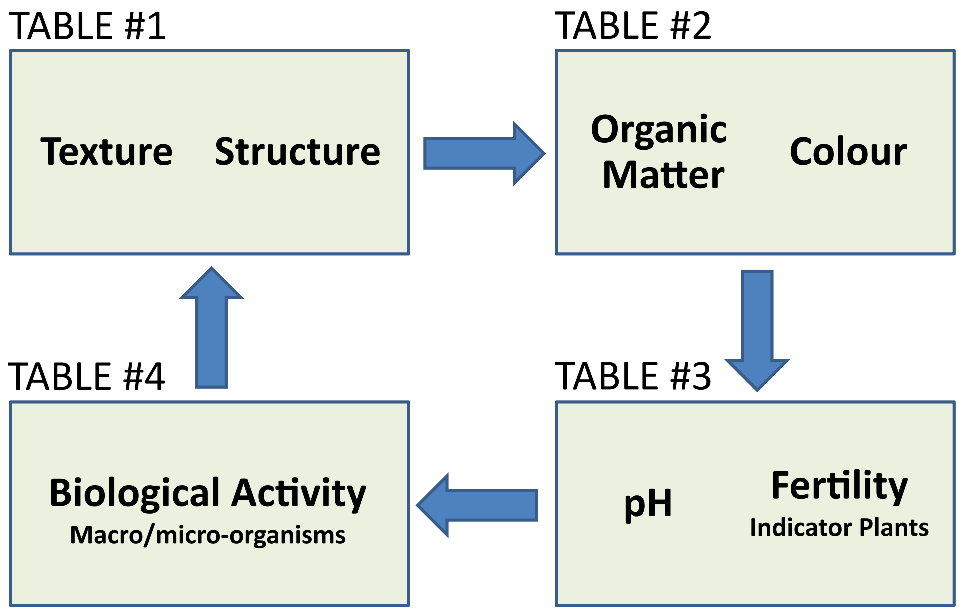
Planning The Soils Fair

RECOMMENDATIONS FOR PLANNING THE SOILS FAIR

Selection of location: The Soils Fair must be held in the farmer community, preferably in a place normally used for gatherings such as a church, school, meeting room, etc., with access to toilets, drinking water and electricity.

Logistics: You will need four large tables (approx. 2 m x 1 m) and chairs for at least 60 people. It is important to have an extension cable for connecting a laptop, data show projector, etc. It is suggested that community members are hired to provide refreshments (water, coffee/ tea and biscuits).

Preparation of thematic tables: Thematic tables should be covered using Kraft paper sheets, and labelled using cards taped on three sides of each table. The leaders of each thematic table will be standing facing the fourth side, behind the tables. This would allow for easy identification of thematic tables by participants and also for any photographic records of the workshop.



During the Field Day Activity, on the third day of the workshop, farmers should be requested to bring samples of good and poor soils from their farms, and indicator plants of good and poor soil. If possible, they should also bring nodulated roots from leguminous plants, and organisms found in the soil, such as earthworms, termites, millipedes, ants, etc. Once delivered, the workshop coordinator/facilitator will direct local samples towards the corresponding thematic tables, following the guidelines presented during the Soils Fair planning session on the fourth day of the workshop. The leaders of each thematic table will organize demonstrations using the local samples brought by farmers. All Soils Fair participants will be divided into four groups, each one going to a different thematic table. The leaders of each thematic table alternate while presenting the theme of each table for a total period of 20-25 minutes. At the end of the prescribed time an indication is given by the workshop coordination for rotation to be made and each group moves clockwise to the next thematic table.

NECESSARY MATERIALS

Thematic table #1 (Soil Texture and Structure): water bottle, plastic cups, metal spoon, roll of kitchen paper, 2 mm and 0.25 mm mesh sieves.

Thematic table #2 (Soil Organic Matter and Colour): hydrogen peroxide bottle, dropper, magnifying glass, Munsell colour table.

Thematic table #3 (pH and Indicator Plants): pH paper, pH 4 buffer solution (or lemon juice), pH 7 buffer solution, pH 10 buffer solution (or baking soda in water)

Thematic table #4 (Soil Biological Activity, Macro- and Micro-organisms): knife, magnifying glass, laptop, PowerPoint presentation about the living soil.

Annex#6

Workshop Evaluation

InPaC-S: Participatory Knowledge Integration on Indicators of Soil Quality

Workshop Evaluation

Date....../....../..........

Indicate with an X the score that better expresses your opinion about the statements presented below. Please help us improve. Your evaluation is very important. Thanks!

1. FACILITATOR/MODERATOR:

01	Ability to create interest on the workshop theme	**1**	**2**	**3**	**4**	**5**
02	Clarity and objectivity during the conduction of the workshop	**1**	**2**	**3**	**4**	**5**
03	Knowledge of subject	**1**	**2**	**3**	**4**	**5**
04	Ability to explain the content	**1**	**2**	**3**	**4**	**5**
05	Capacity to integrate theory and practice	**1**	**2**	**3**	**4**	**5**
06	Time management	**1**	**2**	**3**	**4**	**5**
07	Confidence and credibility	**1**	**2**	**3**	**4**	**5**
08	Availability to clear doubts	**1**	**2**	**3**	**4**	**5**

2. WORKSHOP PROGRAM AND DEVELOPMENT:

09	New information provided in the workshop	**1**	**2**	**3**	**4**	**5**
10	Organization of group activities	**1**	**2**	**3**	**4**	**5**
11	Issues addressed are consistent with the objectives of the workshop	**1**	**2**	**3**	**4**	**5**
12	Knowledge gained during the workshop will be useful in your workplace	**1**	**2**	**3**	**4**	**5**
13	The workshop duration	**1**	**2**	**3**	**4**	**5**
14	The quantity of didactic materials used	**1**	**2**	**3**	**4**	**5**
15	The quality of the audiovisual resources used	**1**	**2**	**3**	**4**	**5**

3. PARTICIPANT (SELF-EVALUATION):

16	In general, the workshop helped me to better understand the topics discussed	**1**	**2**	**3**	**4**	**5**
17	My participation contributed to the group dynamics	**1**	**2**	**3**	**4**	**5**

3. LOGISTICAL STRUCTURE:

18	Quality of accommodation	**1**	**2**	**3**	**4**	**5**
19	Quality of food provided	**1**	**2**	**3**	**4**	**5**
20	Suitability of the workshop venue	**1**	**2**	**3**	**4**	**5**
21	Quality of service provided by coordinator/facilitator	**1**	**2**	**3**	**4**	**5**
22	Reception of arriving participants	**1**	**2**	**3**	**4**	**5**
23	Punctuality	**1**	**2**	**3**	**4**	**5**

25) How did you find out about the workshop (just mark one answer)?
( ) e-mail, ( ) radio, ( ) through friends,
( ) regular mail, ( ) invitation, ( ) other events
( ) journals, ( ) websites, ( ) other ( ).

26) Is the duration of the workshop adequate?
Yes ( ), No, too long ( ), No, too short ( )

Please justify your answer

27) Did the workshop address your expectations? Yes ( ) No ( )

28) Enumerate positive aspects of the workshop:

29) Enumerate negative aspects of the workshop:

30) Overall, do you consider yourself Satisfied ( ) or Unsatisfied ( ) with the workshop?

31) Make suggestions on how this workshop could be improved: