Sustainable Land Management

Guidelines for
Impact Monitoring

TOOLKIT MODULE

A selection of practical tools
and cost-effective methods

Pathfinder Module Guidance for users
Sustainable Land Management Module The importance of SLM
SLM Impact Monitoring Module A seven-step procedure for SLM-IM
Toolkit Module A selection of practical tools and cost-effective methods

TOOLKIT MODULE

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Contributing Institutions (in alphabetical order)

AB-DLO, The Netherlands
CDE, Switzerland
CIDA, Canada
COSECHA, Honduras
DIFID, United Kingdom
GTZ, Germany
Helvetas, Switzerland
IBSRAM, Thailand
IDRC, Canada
IFPRI, USA
Intercooperation, Switzerland
IRG, USA
KIT, The Netherlands
NLH, Norway
OSS, France
PASOLAC, Nicaragua
SANREM-CRSP, USA
SDC, Switzerland
The World Bank
USAID, USA
USDA, USA

Authors: Karl Herweg (CDE), Kurt Steiner (GTZ), Joep Slaats (KIT)

Editorial Board: Julian Dumanski (The World Bank), Andreas Kläy (CDE), Cordula Ott (CDE), Christian Pieri (The World Bank)

Contributors: Barbara Altmann (GTZ), Gilles Bergeron (IFPRI), Ingo Binnewerg (free lance consultant), Roland Bunch (COSECHA), Anor Fiorini de Cavalho (Univ. of Vicosa, Brasil), Philip DeCosse (IRG), Toon Defoer (KIT), Malcolm Douglas (free lance consultant), Hari Eswaran (USDA), Eckehard Fleischhauer (German Federal Ministry of Environment), Lukas Frey (CDE), Urs Geiser (University of Zürich), Willi Graf (SDC), Anna Häring (University of Hohenheim), Bob Hart (University of Georgia, Athens, Georgia/SANREM-CRSP), Olivier Heiniger (free lance consultant), Thea Hilhorst (KIT), Stein Holden (NLH), Hans-Joachim Krüger (free lance consultant), Rod Lefroy (IBSRAM), Iain MacGillivray (CIDA), Adrian Maitre (PASOLAC), Zbigniew Mikolajuk (IDRC), Constance Neely (FAO), Gian Nicolay (Helvetas), Eric Smaling (AB-DLO), Charles Sloger (USAID), Thomas Stadtmüller (Intercooperation), Alistair Sutherland (DIFID), Anneke Trux (OSS), Floris van der Pol (KIT)

User interface and graphic design: GeoneX, Martin Moll
Layout and graphics: Lukas Frey
Cartoons: Karl Herweg
Photos: Learning for Sustainability, Madagascar / PROMIC, Bolivia
Language editing: Ted Wachs
Printed by: Paul Haupt AG, Bern

Please address comments, suggestions and orders to:

Karl Herweg
Centre for Development and Environment
Hallerstr. 12
CH 3012 Bern
Tel.: +41 31 631 88 22
Fax: +41 31 631 85 44
E-mail: cde@giub.unibe.ch

Kurt Steiner
GTZ
Dag Hammarskjöld Weg
D 65726 Eschborn
Tel. & Fax: +49 6196 79 32 87
E-mail: kurt.steiner@gtz.de

Toolkit

The Toolkit Module - Introductory Remarks

A selection of SLM-IM tools

Corresponding to selected steps of the SLM-IM procedure, the Toolkit Module contains a selection of practical and cost-effective methods, criteria, models, frameworks and examples. These were developed - and partly published - by various authors and institutions. For each tool, the Guidelines gives a brief introduction and - whenever possible depending on the source of the tool - specifies potentials, limitations, advantages, disadvantages, and required inputs and investments. In addition, users are provided with a reference source and/or address in case they need more detailed information to apply a tool.

see also
SLM-IM
Module

Participatory SLM-IM

Participatory SLM-IM promotes a sharing of the views of all stakeholders. Internal views (of local land users, communities, etc.) provide sound knowledge of locally adapted land management, while external views (of project personnel, researchers, decision- and policy-makers, etc.) help to broaden local horizons. Participation means eventually developing a common strategy of intervention and action. As long as all stakeholders involved are committed to eventual agreement upon a common strategy, initially contrasting views will enrich the debate on SLM and serve as a counter-check. Dealing with different views means being more flexible in reacting to the unexpected and helps to avoid missing the targets. Consequently, the methodological approach must consider (1) methods that allow stakeholders to formulate their individual opinions, and (2) participatory methods for learning about different perceptions and generating a common knowledge base.

Gender-oriented SLM-IM

Women are often recognised only as the wives of land users. Therefore, their SLM knowledge base is largely disregarded, for instance, by male land users or agricultural extension services. But with the development of participatory approaches, gender aspects gain importance. The Guidelines do not emphasise gender-specific tools, however. Rather, the entire SLM-IM procedure needs to be gender-sensitive, no matter which method is applied. For example, a method like the informal interview is not gender-specific as such, but its application must assure that both women's and men's knowledge bases will be considered, for example by assigning female interviewers to talk to women and male interviewers to talk to men.

How to use the Toolkit Module

The Toolkit is designed for selective use. It is the user's choice which tool to apply in a given situation. It is also the user's responsibility not to use the tools beyond their range of applicability! The Toolkit is printed like a notepad so that pages can be separated. It thus encourages the user to assemble a selection tailored to his or her working situation. Some of the given tools may be removed while others may be added from the project's own pool of methodological experience. A ring binder, for example, would be a suitable device for keeping the Toolkit together.

Section A: Core Issues and Impact Hypotheses - Introductory Remarks

Tools used for identification of core issues and formulation of SLM impact hypotheses

Core issues - what should be monitored?

Limited time and budgets do not allow monitoring of everything that seems possible or desirable. Identifying the core issues of SLM-IM means clarifying what is important for which stakeholders, and coming to an agreement.

see also
SLM-IM
Module ,
Step 2

Impact hypotheses - what happens if …?

Any intervention or project activity may cause more than the desired impact, which is usually assumed to be a positive one. Formulating impact hypotheses is a way of forecasting all possible impacts of a project activity, including the unintended and detrimental ones. If this is done with all stakeholders, a variety of scenarios can be developed and debated.

see also
SLM-IM
Module ,
Step 3

This section contains alternative tools

You can either select a tool for direct application or use the methods as an inspiration to design your own method tailored to a given situation. An overview of participatory methods for identifying core issues is presented first. A selection of tools is described in a more detailed manner. Most tools contain proposals for dealing with and harmonising different stakeholders' perceptions.

see also
Section B2
of this
Module

Overview: Participatory Methods for Identifying Core Issues

Bellows, B. (Ed.) 1995. Proceedings of the indicators of sustainability conference and workshop. August 1-5, 1994, Arlington VA. SANREM CRSP Research Report 1-95, 312 p.

Participatory method	Issues identified by the method
Participatory rural appraisals (preliminary)	• agricultural and natural resource use practices • changes in resource use and resource quality over time • changes in demographics, social interactions, economic processes, and interventions within the locality
Oral histories of community members (detailed)	• values and attitudes associated with resources • perceived impacts of the identified processes of change • perceived resource-use options
Resource inventories	• changes in resource use and resource quality over time
Resource use flow charts	• natural resource types, flows, and availability to social groups
Time use calendars	• agricultural practices, food supply, health conditions, rainfall, and labour variations during the year • critical times for resource use
Estimates of time and motion	• time spent in reproductive and productive activities and distances travelled to accomplish these activities
Mapping by community members	• resource locations in relation to access by social groups • natural resource types and resource flows
Drawings by community members	• attitudes towards resources
Community-based discussions	• current and prior resource use practices and socio-economic interactions • justifications or perceived reasons for changes
Farmer-conducted research	• adaptation of technical information to accommodate the economic conditions of the household and the environmental conditions of the farm • indigenous farming and natural resource use practices
Farm visits	• differences in resource quality, resource use practices and socio-economic interactions on different farms and across the landscape
Ground truthing of technical and policy indicators	• comparisons of community perceptions with technical information • relationship of exogenous indicators to the felt needs and perceptions of community sectors

Sustainable Development Appraisal (SDA)

CDE. 1998 (forthcoming). Sustainable Development Appraisal (SDA). A methodological tool for the participatory assessment of sustainability from local to regional planning levels. CDE, Berne.

Hurni, H. Ludi, E. 1998, with the assistance of an interdisciplinary group of contributors (forthcoming). Reconciling conservation with sustainable development. A participatory study in villages inside and around the Simen Mountains National Park, Ethiopia. CDE, Berne.

Contact: CDE, Centre for Development and Environment, Institute of Geography, University of Berne, Hallerstrasse 12, 3012 Berne, Switzerland. e-mail: cde@giub.unibe.ch

Objective and brief description

SDA generates baseline information and provides entry points for the development of activities to promote sustainable development. SDA monitors (a) internal development as well as (b) the impact induced by external development activities. It integrates the "internal" (indigenous) knowledge base with an "external" (scientific) view through participatory learning. The term "external" refers to the view of an interdisciplinary team. This allows replication, an indispensable condition for baseline data generation and impact monitoring at a later stage. Both local actors and external experts formulate hypotheses expressing their ideas of development opportunities. Comparison of these two assessments shows both disagreement as well as agreement. The latter is an excellent basis for defining entry points for development activities.

Looking at the characteristics of and the interactions between the land and the actors is the first component of the SDA, followed by analysis of temporal changes that affect the land units and the actors. Changes may create pressure or opportunities to which the ecosystems of the area react, and to which actors respond by adapting their land use systems. There is also an external impact on the system, induced by external actors, as well as economic influences such as regulations, markets, and taxes and finally, ecological impacts such as climate change, flooding, drought, or pollution. According to the set of problems formulated as hypotheses for different locations in the area, suitable methods for assessing each type of impact and its importance must be sought and applied in the study.

Procedure/steps

Part I Background and initial steps

- compilation of the problem context and initial development goals
- definition of core areas and supplementary areas for SDA
- situation-specific selection of SDA material and methods

Part II Participatory assessment of the current situation and trends

- elaboration of an actor typology
- elaboration of a spatial typology
- identification of relations between actor categories and spatial units
- assessment of bio-physical interactions of spatial units
- assessment of socio-economic and socio-cultural interactions of actor categories
- assessment of major changes and trends

Part III Participatory evaluation of development

- evaluation of change by different actors and stakeholders
- needs, options and constraints as seen by different actors and stakeholders
- development visions as seen by different actors and stakeholders

Part IV Synthesis of development profiles

- compilation of local development profiles (LDPs)
- compilation of a regional development profile (RDP)
- synthesis and recommendations on sustainability issues

Part V Initiation of multi-stakeholder negotiations

- negotiations on situation-specific goals of sustainable development
- negotiations on actions needed on the different actor levels
- participatory planning of implementation and follow-up

Indicators used depend on the research topics

- natural resources (e.g. soil, vegetation, water, etc.)
- land use (e.g. ratio of cultivated land to fallow land, forest cover, etc.)
- ha of cultivated land per household
- farming system (e.g. significance of crop cultivation and livestock production, technologies, etc.)
- socio-economic infrastructure (e.g. clinics, road network, schools, number of pupils enrolled, etc.)
- population (e.g. age distribution, level of empowerment of marginalised groups, etc.)
- visions (the way visions are formulated gives an indication of what people are lacking but regard as necessary or desirable for their livelihood)
- needs (the concrete terms of visions that give an indication of what different stakeholders perceive as necessary)
- options (indications of what different stakeholders perceive as feasible given their asset endowment)
- constraints (formulated by different stakeholders, giving an indication of how different stakeholders perceive their asset endowment in relation to planned activities)

Potentials and limitations

Potentials

SDA allows a broad assessment of a wide variety of topics in a given area. Combining indigenous knowledge and scientific assessment, the method avoids a bias in either direction and allows a problem- and development-oriented assessment, with the following advantages:

- comprehensive method
- collection of baseline information allows impact monitoring of project activities or internally induced changes at later stages
- good capacity-building effect, if the team is multi-disciplinary and multi-national
- combination of indigenous and scientific knowledge
- allows quantitative and qualitative assessments

Limitations

- medium to high requirements for support staff, depending on size of the area and aim of the study
- medium to high level of sophistication
- high educational level required of study team members
- institutionalisation requires considerable effort

Investments and prerequisites

Essential equipment

The necessary equipment depends on the remoteness of the location, on the topics to be investigated (e.g. soil mapping, soil classification, etc.) and on the number of team members. In remote areas, a considerable amount of equipment is necessary for a longer period of field study (camping material, etc.).

Labour requirements

SDA requires staff with scientific background, socio-economic and biophysical, with the ability to work in a multi-disciplinary and multi-national team.

Time expenditure

SDA requires time to build up confidence between different stakeholder groups (e.g. researchers, land users, government officials, etc.). Time input depends on the size of the study area, the degree of detail, and team composition. As a rule of thumb, one week of intensive field work per village (approx. 100 households) should be sufficient for a team of three members with different educational backgrounds and research topics (e.g. status and dynamics of natural resources, farming systems, infrastructure, socio-economic and political aspects). Time input increases if greater detail is required (detailed mapping, large number of interviews, etc.). Preparation time in advance of the field study should not be neglected (e.g. contacts with resource persons, analysis of existing material, etc.). The time for analysis is at least twice the time needed for fieldwork (e.g. preparing necessary maps on a GIS, analysis of different information layers, preparation of Community Development Profiles, writing of final report).

Participatory Action Research (PAR)

Defoer, T., De Groote, H., Hilhorst, T., Kanté, S., Budelman, A. forthcoming. Farmer participatory research and quantitative analysis - a fruitful marriage? Journal of Agriculture, Ecosystems and Environment.

A farmer participatory action research process was developed by the Malian Farming Systems Research team to assist farmers in improving the practices of soil fertility management. The process is based on a relatively simple and quick analysis of farm diversity focusing on soil fertility management, followed by resource flow models made by test farmers. These models are the farmers' major tool for diagnosing the way they manage soil fertility, and for planning and evaluating improvements over time.

To evaluate the process, an analytical framework has been developed, using the data from the resource flow models (cf. cross reference below). Management performance indicators based on farmers' perceptions of good soil fertility management and farm level nutrient flows and partial balances are monitored to assess differences between farm classes and changes over time, and to compare farmers' performance with standard references.

The resource flow models are an operationally useful tool. They assist farmers in analysing their soil fertility strategies, and in planning step-wise improvements. The visualisation of flows also allows for reliable and complete data collection, since omissions and mistakes are directly visible. Moreover, farmers not only provide information, but actively participate in the analysis itself.

Information obtained through quantitative analysis based on data gained from resource flow models can improve the knowledge and perception of the major actors involved in the process: researchers and farmers. Merging participatory action research and quantitative analysis leads to planning, experimenting and adapting ways to improve use of scarce local resources.

Phase	**Elements**
diagnosis/analysis	• diversity within a village territory (local indicators of "proper" soil fertility management; socio-economic characteristics of the household) • farmers' soil fertility strategies (resource flow model RFM)
planning	• farmer workshops, exchange visits, and planning maps
implementation	• implementation through test farmers
evaluation	• individual and group evaluation of test farmers: the activities realised are indicated on the planning map

(planning-implementation-evaluation continuum is repeated on an annual basis.)

The key purpose of the analytical framework is to turn information, which was gathered in a participatory way, into quantitative data, using the farm-based resource flow models.

see also
Section C1
of this
Module

The Pencil and Paper Computer

after **Vester, F. 1986^2.** Ballungsgebiete in der Krise. DTV, 151 S.

Understanding of how a land management system functions is gained by putting several elements of the system into a model, for example, a flow chart. The chart shows the elements together with their interrelationships. This description gives an overview but does not provide conclusions about the quality or quantity of the interrelationships.

Remaining questions:

- Which elements have the strongest influence on other elements but are only weakly influenced themselves? (active elements)
- Which elements have the weakest influence on others but are strongly influenced themselves? (reactive elements)
- Which elements influence the active and the passive elements, and to what degree?

We can find possible answers to the above questions with a so-called pencil and paper computer (P&PC), an extended but simple matrix:

	A	B	C	D	E	F	G	H		AS	Q
A	X								A		
B		X							B		
C			X						C		
D				X					D		
E					X				E		
F						X			F		
G							X		G		
H								X	H		
										AS	Q
PS									PS		

The elements are arranged from top to bottom (effect from) and from left to right (effect on). The order of the elements is of no importance. As only the relationship between elements is being investigated, the boxes where elements encounter themselves are excluded.

Evaluation of the interrelationship starts by placing numbers in all the boxes, e.g. between 0 and 3. A more detailed gradation would make sense if enough precise data are available instead of rough estimations.

0 = no effect
1 = low effect
2 = moderate effect
3 = strong effect

As soon as all boxes are filled out, the following simple calculations are made: The numbers are first added up for each line from left to right, resulting in the so-called active sum (AS) of the element. They are then added up for each column from top to bottom, resulting in the so-called passive sum (PS). Elements that strongly influence others (no matter how strongly they are influenced by others) have the highest active sum. Elements that are strongly influenced have the highest passive sum.

Next, the active sum of each element is divided by its passive sum (AS : PS = Q). The element with the highest Q-quotient is the active element, the one with the lowest is the reactive element.

It is also possible to determine how relations between the elements should be - for example, how to strengthen or weaken certain relations, or which interrelationships to change in order to convert a reactive element into an active element. Or you can determine which element is still needed in your model to make desirable changes possible. We are never in a position to consider all elements involved in reality, and the relationships among them can always be evaluated in a more detailed manner to get a sound analysis of the system. Nonetheless, the P&PC sheds important light on sensitivity to relationships of different quality and quantity, as well as their dynamism, which makes the system more than the mere sum of its elements.

For example, the most relevant elements of a rural land use-system are:
- farm household (including production factors)
- bio-physical environment (including natural resources)
- socio-cultural environment
- political and economic environment
- external factors (e.g. development co-operation)

This example is limited to five elements, but further elements or greater differentiation can be added as needed.

The P&PC matrix might look like this:

	A	B	C	D	E		AS	Q
A: farm household (including production factors)	X	*3*	*1*	*1*	*0*	A	*5*	*0.5*
B: bio-physical environment (natural resources)	*2*	X	*1*	*1*	*1*	B	*5*	*1*
C: socio-cultural environment	*3*	*1*	X	*2*	*1*	C	*7*	*1.2*
D: political and economic environment	*3*	*1*	*2*	X	*2*	D	*8*	*1.6*
E: external factors (e.g. development co-operation)	*3*	*0*	*2*	*1*	X	E	*6*	*1.5*
							AS	Q
PS	*11*	*5*	*6*	*5*	*4*	PS		

The results of our P&PC show that:
- the active element (highest Q-quotient) is the political and economic environment, moderately influenced only by the socio-cultural environment
- the reactive element (lowest Q-quotient) is the farm household, strongly influenced by almost all other elements

As only a few elements were taken into consideration, the result is not very astonishing. New conclusions can be expected as soon as further elements like population density, farming practices, etc., are added. As mentioned above, we could also ask how the relations between the elements should change so that e.g. the reactive element (farm household) of the system becomes a more active element. Or we can try to find out which element should be added to the model to induce a change.

Let us assume that we have identified the farm household as the reactive element and now want to know more about this element as a (sub-)system. Therefore, in an optional step, the procedure of the P&PC can be repeated in a second matrix made up of elements considered crucial to the understanding of the farm household as a system.

Impact Hypotheses - Development and Its Environmental Impacts

Swiss Development Co-operation/Centre for Development and Environment. 1994. Impact Hypotheses: Development and its Environmental Impacts. Berne, Switzerland, 101 p.

Contact: CDE, Centre for Development and Environment, Institute of Geography, University of Berne, Hallerstrasse 12, 3012 Berne, Switzerland.

Impact hypotheses (IH) are a tool for incorporating social and ecological interactions, as well as risks, in the planning, implementation, monitoring and evaluation of development activities. They offer a comprehensive approach to understanding, reducing or preventing adverse impacts of project activities. Such an approach reveals the limitations involved in predicting developments. It frees the user from thinking in terms of specific sectors (i.e. forestry, health, soil, energy, etc.), or mechanistic approaches, and creates awareness of the interconnectedness that characterises the ecological and social impacts of development actions.

IH promote the user's capacities for decision-making and individual action in development activities. IH are a working instrument for dealing with complex topics. At the same time, they are concise and easy to use.

The tool has three main parts with further subdivisions:

The local setting

• social order • modes of production • cultural values and norms	The local setting embedded in a wider context is the basic frame of reference for development activities.

Sectors

• (partly) renewable resources	soil; water; flora and fauna; cultivated plants; livestock	With regard to sectoral interventions, the hypotheses deal with areas that correspond to sectoral designations used by most development organisations. The sectors are further divided into subsectors.
• industrial production	energy conversion; material flows; waste management	
• the service sector	tourism; savings and credit; trade	
• infrastructure	water supply; energy supply; transport systems	
• health	preventive measures; medical care	
• education	primary education; vocational training	

Trans-sectoral areas

• energy • training and advisory services • research • technology transfer • political dialogue and structural adjustment • institutional and legal development • financial assistance • humanitarian aid	Discussion of trans-sectoral interventions acknowledges that many development activities significant at this level have impacts in several sectors.

Any subdivision, sector or subject can serve as the entry point. The user will find a brief introduction and a series of hypotheses regarding environmental interactions in complex systems. Cross-references and personal reflections verify the user's connections with other sectors of the book. Eventually, hypotheses relevant to a local setting are formulated, resulting in a list of possible impacts, as well as indicators that may serve for impact monitoring. This procedure is designed to guide staff with different professional backgrounds, and permits an individual approach to environmental issues by:

- demonstrating that every development project - no matter how much it may concentrate on a specific sector - has an environmental dimension;
- heightening awareness of systemic linkages and the secondary effects of interventions;
- illustrating possible and often incompatible effects of sectoral intervention on other sectors;
- clearly perceiving the influence of the local environment on development activities;
- elucidating the relative nature of self-proclaimed aims and project goals;
- emphasising process-oriented thinking and iterative procedures with all stakeholders.

IH stand in contrast to mechanistic methods such as matrices or checklists in classical Environmental Impact Assessments. They constitute a more flexible, subjective method that can be used any time and in any situation, alone or in a group. The result is an expert's approach that should be supplemented by local stakeholders' perceptions of impacts and their choice of indicators.

Potentials

Easily applicable: everyone can use IH based on his/her knowledge, scope of work, or local circumstances and find an individual approach to environmental issues. Existing impact hypotheses - project goals or reflections and consulting from other sources - can easily be cross-checked and supplemented according to a given local work situation.

Expanding the range of ecological competence: hypotheses on interactions in a man-environment system may seem simplistic, banal or even erroneous. But as opposed to detailed checklists or matrices, IH are meant primarily to stimulate thinking that transcends the confines of the regular working environment and conventional modes of thought. At the same time, these hypotheses, as well as the contradictions they imply, illustrate that the impacts of an intervention can be predicted only to a very limited extent and that there are no blueprint solutions to problems in complex systems.

Changing behaviour by reducing fear of complexity: complexity fosters anxiety and leads people to narrow the scope of problems in order to preserve a sense of their own competence. This, however, diminishes the capacity to act appropriately in a given situation. Planning in complex systems requires a perception that predicting environmental impacts is a highly relative exercise. IH make it possible to deal with complexity, anxiety and overblown ambitions, thereby preserving flexibility of action.

Limitations

Hypotheses are necessarily limited in scope and are presented in general. Although they invite and facilitate examination of the environmental aspects of development, they are not a substitute for thorough impact studies. Interactions and potential risks resulting from an application of IH need to be examined, concretised and expanded with regard to specific situations, activities and actors.

Network Analysis

Bellows, B. 1996. Indicators of sustainability. Workbook for the SANREM CRSP. Washington State University/University of Wisconsin, USA.

Network analyses and flow charts highlight major components of a "system" and how they are inter-linked. Developing a flow chart to identify core issues, to formulate impact hypotheses, or to identify indicator sets, needs to be done together with stakeholders in a sequential order as proposed below:

1 Identify elements and issues (some of which may become indicators later on) related to the land problems perceived in the project area.

2 Discuss and agree upon their causal relationships. Identify as many interrelated issues as possible. Keep in mind that relationships can be of different types, for example flows of energy, nutrients, or information.

3 Write all factors (elements and interrelationships) on individual slips of paper or adhesive paper.

4 Identify a central or critical factor and place its card in the centre of a large paper or poster.

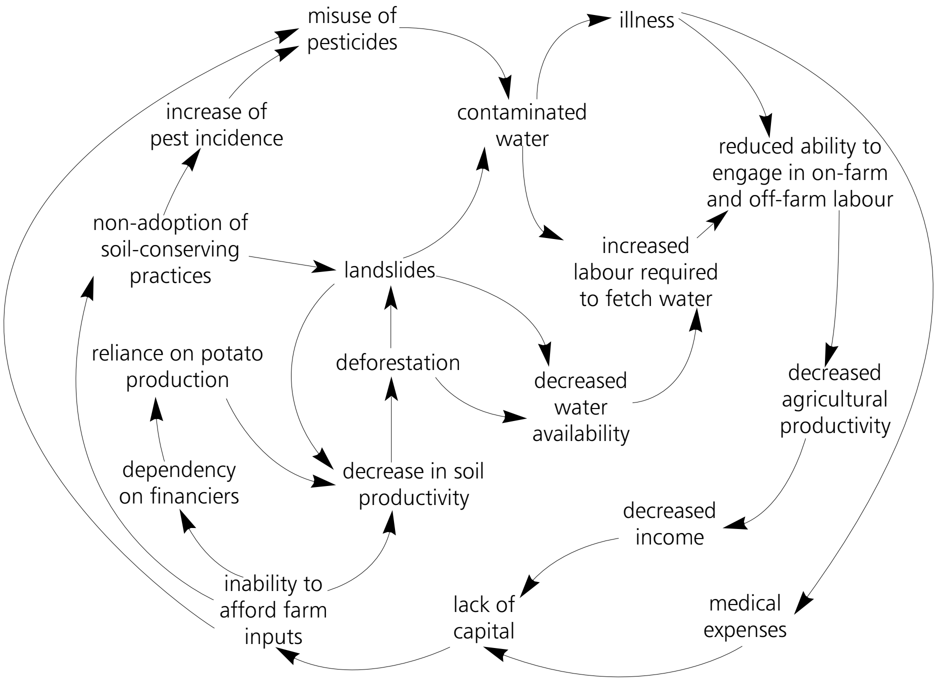
5 Place all factors directly related to the central factor (primary factors) around it and draw arrows linking these factors in the direction of the influence, energy, or information flow (from ➤ to). Closely related pairs or groups of factors should be placed beside each other.

6 Identify secondary factors that are related to the primary factors, place them on the poster, and draw their relationships with all possible factors already on the board.

7 Identify factors of tertiary and lower significance and proceed as described above.

8 During all steps, discuss and rearrange the factors to minimise flows and overlapping arrows.

9 Identify factors or interrelationships that can be used as indicators.

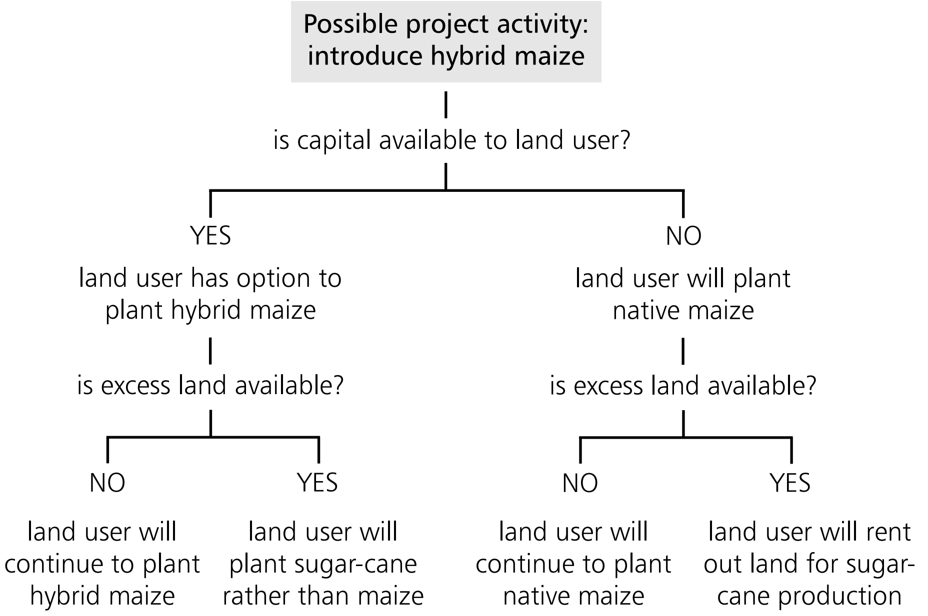


Decision Tree

Bellows, B. 1996. Indicators of sustainability. Workbook for the SANREM CRSP. Washington State University/University of Wisconsin, USA.

A decision tree illustrates how land users - and other stakeholders - may respond in different ways to a project activity, depending on their resource base and management capacity or on the biophysical environment they are living in. Decision trees are used to identify project activities enhancing SLM, to judge the appropriateness of indicators, to identify the importance of factors that bring about responses, to prioritise indicators or, as in this example, to formulate impact hypotheses.

After a possible project activity has been identified, and based on either hypothetical assumptions or analysed interview responses, an important question will be asked and possible answers listed. Subsequent questions and answers are then added. The decision tree indicates whether or not the project activity is likely to be perceived as useful or successful, and whether it can contribute to SLM.



Section B: Selection of Indicator Sets - Introductory Remarks

Tools used for identification of meaningful indicator sets

How to find relevant indicators

Indicators are simplified representations of a complex reality, and a simplification always carries the risk of over-simplifying and thus identifying irrelevant or even wrong indicators. Identifying relevant indicators that produce the expected quality of results is therefore a most crucial step in SLM-IM. To assist in your selection, the following tools are available in the Toolkit Module:

see also SLM-IM Module, Step 4

- Section B1 provides a set of **selection criteria** to bring important aspects of the selection process to your attention, to cover things you may not have thought of. Developing your own selection criteria is necessary to find indicators of a quality and accuracy that are in line with your SLM-IM targets.

see also SLM-IM Module, Step 4

- Section B2 offers an alternative **framework** and a guide to how to develop your own **structural model** to assure that the indicators are inter-linked in a largely qualitative way, describing an entire land management system. Thus you avoid selecting a group of separate variables that do not permit an appropriate assessment of SLM later on.

see also SLM-IM Module, Step 4 and Section A of this Module

- Section B3 presents additional **examples of indicator sets**. Since it is neither possible nor would it be useful to present a complete list of indicators, these examples show how sets can be assembled and categorised in different ways and so be adapted to specific project situations. The examples also contain land quality indicators which allow a comparison of results with other projects or agro-ecological zones.

see also SLM-IM Module, Step 4

Developing Criteria for Indicator Selection

adapted from **Becker, B. 1997.** Sustainability assessment. A review of values, concepts and methodological approaches. Issues in Agriculture, No. 10, CGIAR, Washington, USA, 63 pp.

How can you select indicators that produce relevant results of the expected quality and accuracy? Choose selection criteria from the following list, modify the list, or add criteria that are important in your situation. While identifying SLM indicators later on, use the modified list to check whether the indicators will meet these criteria.

Scientific quality	**Ecosystem relevance**	**Data management**	**Sustainability paradigm**
each indicator:	each indicator:	indicators are:	indicators consider:
• really measures what it is supposed to detect • measures the significant aspect • is problem-specific • distinguishes between causes and effects • can be reproduced and repeated over time • is uncorrelated, independent • is unambiguous • ...	• changes as the system moves away from equilibrium • distinguishes agro-ecosystems moving toward sustainability • identifies key factors leading to unsustainability • gives warning of irreversible degradation processes • is proactive in forecasting future trends • covers the full cycle of the system through time • corresponds to the aggregation level • highlights links to other system levels • permits trade-off detection and assessment between system components and levels • can be related to other indicators • ...	• easy to measure • easy to document • easy to interpret • cost-effective • comparable across borders and over time • quantifiable • representative • transparent • geographically relevant • relevant to users • user friendly • widely accepted • ...	• what is to be sustained • resource efficiency • carrying capacity • health protection • target values • time horizon • social welfare • equity • participatory definition • adequate rating of single aspects • ...

Matrix for Selecting Indicators of Sustainability

Müller, S. 1996. How to measure sustainability: A proposal for the agricultural and natural resources sector. Discussion Paper Series on Sustainable Agriculture and Natural Resources No. 1. Inter-American Institute for Co-operation in Agriculture (IICA) and German Agency for Technical Co-operation (GTZ), GTZ, Eschborn, Germany, pp. 36-55.

The matrix is a framework for a systematic selection of an indicator set, which covers the essential dimensions (aspects) and properties (pillars) of sustainability.

- Productivity tells how production factors or inputs are combined to produce outputs.
- Stability refers to the constancy of productivity in the face of normal fluctuations and cycles in the surrounding environment. Stability implies the security aspect (risk aversion).
- Resilience describes the ability to maintain productivity in the face of stress or shock.
- Equity indicates the manner in which the benefits and costs of production are shared.

Indicators at watershed level

Property	*Ecological dimension*	*Economic dimension*	*Social dimension*
Productivity	• *crop yield per hectare* • *water quality* • *fertiliser application* • …	• *land price* • *price for using irrigation water* • *wages for daily labour* • …	• *farm household income* • *wages for daily labour* • …
Stability	• *annual variability of crop yield* • …	• *variability in crop income* • …	• *variability in farm household income* • …
Resilience	• *sediment yield in the river* • *% area under natural vegetation* • …	• *external inputs (fertiliser, pesticides) as % of total input costs* • *saving and investment capacity* • …	• *% of farmers with land title* • *% farmers with secondary education* • *expenditure for health* • …
Equity	• *% farms with access to irrigation water* • *Gini coefficient of land tenure* • …	• *% farms with access to credit* • *% of farmers receiving technical assistance* • …	• *% farms covered by social insurance* • *% farmers living in their own houses*

Environmental Assessment in Development Co-operation - Principles of Ecological Planning

Kläy, A., Perich, I.; Hurni, H.; Huguenin, A.; Schläfli, K. 1992. Environmental Assessment in Development Co-operation: Principles of ecological planning. Development and Environment Reports, Vol. 4, Berne, Switzerland, 46 p.

Contact: CDE, Centre for Development and Environment, Institute of Geography, University of Berne, Hallerstrasse 12, 3012 Berne, Switzerland. e-mail: cde@giub.unibe.ch

By contrast with the "PSR framework" and the "Matrix for selecting indicators of sustainability", Environmental Assessment (EA) encourages users to develop a structure according to their own needs. EA describes how to evaluate changes in the environment of development projects and how to assess the contribution of project activities to these changes. This tool provides a conceptual framework that can be used for planning development activities. At the same time it is the base for another tool: Impact Hypotheses - Development and its Environmental Impacts. EA promotes understanding of the complexity of ecological issues, and helps ensure that environmental concerns are included in all decisions - from planning to implementation, from policy level to project level. It makes users aware of the dynamics and sensitivities of ecosystems, of the dangers of environmental fallacies in development projects, and it emphasises the importance of participatory processes in impact assessment.

In ecological planning, a systemic evaluation instrument is needed in order to reconcile different perceptions and establish a common basis of understanding. This provides the basic starting point for participatory discussion. The instrument can be developed using the following procedure:

1) Characterisation of the system, its dynamics and trends as a frame of reference

In a first step, characteristic features, interactions, and interdependencies in a project setting will be evaluated by different stakeholders. This will produce an overview of the socio-economic and environmental system, its dynamics and trends. Different perceptions and aspects need to be structured in a scheme. Diagram 1 below shows an environmental system divided into (six) different subsystems, which could be further subdivided if needed. The subsystems are closely related and inter-linked, and not considered in hierarchical order.

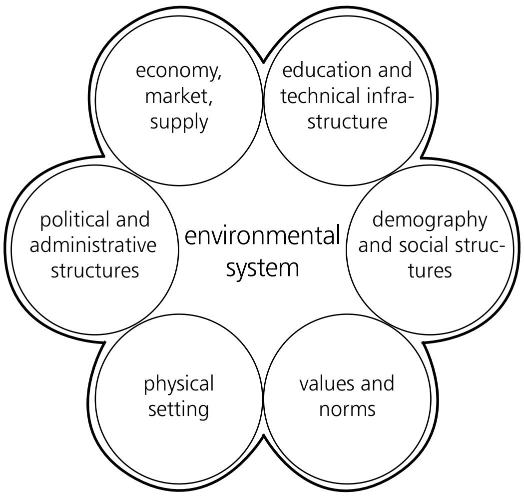


Diagram 1: Subsystems in an environmental system

2) Assessment and qualitative evaluation of observed and expected changes

Changes (dynamics and trends) observed in the local biophysical and socio-economic setting are qualitatively assessed and compared with (1) the broader goals of development co-operation and (2) the specific target areas of the project. The respective emphasis given to different target areas will depend on the dynamics of a region, its key processes, and stakeholders involved in the debate. Diagram 2 shows an example of (seven) target areas. For all target areas, indicators of change are identified in order to assess the regional development in relation to the target areas.

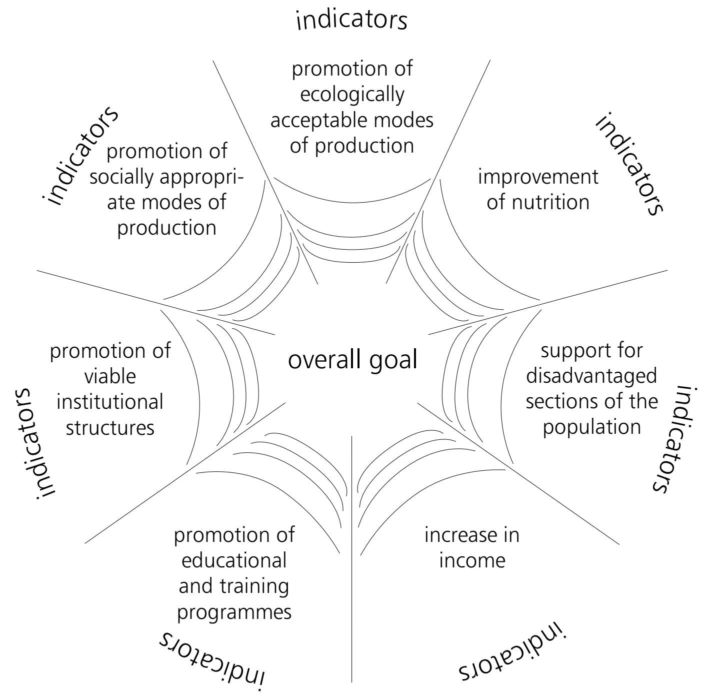


Diagram 2: Target areas for which indicators are formulated

3) Using indicators in an assessment framework

Two matrices will be developed while assessing the situation. From the discussion, indicators are chosen and evaluated for monitoring development trends in the region (Matrix 1: Assessment of indicators in the project region). Target areas are arranged in columns, each of which is subdivided into two or three indicators (I 1.1, I1.2, I1.3). The indicators are assessed along the horizontal lines using rankings from +++ to - - - . The stakeholders decide the ranking (very high - very low; positive - negative, etc.).

Then Matrix 2 (Effects of project activities) is developed to estimate the impact of the project. Prospective and actual impacts are qualitatively symbolised by arrows, in order to compare and assess different project activities. Possible guiding questions are:

- What impact on the dynamics of development can be expected from a particular activity?
- In the light of these dynamics, what influence could the activity have on preserving the ecological potential?
- How will degradation processes be influenced by project activity on a regional scale?

	target areas															
	1			2			3			4		5		6		7	
indicator rankings	I 1.1	I 1.2	I 1.3	I 2.1	I 2.2	I 2.3	I 3.1	I 3.2	I 3.3	I 4.1	I 4.2	I 5.1	I 5.2	I 6.1	I 6.2	I 7.1	I 7.2
+++													▨				
++	▨			▨		▨											
+		▨	▨				▨							▨	▨		▨
+/-					▨				▨	▨							
-																▨	
--											▨						
---								▨									

Matrix 1: Assessment of indicators in the project region

	target areas																
	1			2			3			4		5		6		7	
project activities	I 1.1	I 1.2	I 1.3	I 2.1	I 2.2	I 2.3	I 3.1	I 3.2	I 3.3	I 4.1	I 4.2	I 5.1	I 5.2	I 6.1	I 6.2	I 7.1	I 7.2
PA 1	↗		↗↗	↗	↗	↗		↗↙	↗			↗	↗	↗	↙		
PA 2	↗	↗	↗↗	↗↗	↗	↗↗	↗						↗	↗	↙↙		
PA 3	↗↙	↙↙	↗↗	↗		↗↗↗		↙				↗↙	↗	↗	↙↙	↗	↗↗
PA 4			↗			↗↗	↙	↙				↗↙	↗		↗↙↙		↗
PA 5	↗↙	↗	↗↙	↙	↗↙	↗↗		↙	↗	↗	↗	↗↗			↗↙	↗	↗

effect			
	positive	negative	none
strong	↗↗↗	↙↙↙	☐
moderate	↗↗	↙↙	
weak	↗	↙	

Matrix 2: Effects of project activities

Toolkit

Result: The environmental system as a frame of reference

EA provides a frame of reference that expands a project's log frame and M&E procedure, and widens a project's horizon. It allows classification and assessment of potential impacts of project activities on the socio-economic and biophysical surrounding, which serves as a starting point for reorienting the project and optimising its strategy.

In using and interpreting the matrices, the following points must be kept in mind:

- *Matrices are helpful as analytical tools and guidelines, but provide no absolute scale of evaluation. The information is only as valid as the quality of the debate on which it is based.*
- *The negotiation process for evaluation should be transparent and monitored to ensure that it can be reproduced and understood by outsiders. Each step in the process of systemic evaluation should be listed and explained, from the point where indicators were formulated to the point where they were examined and assessed.*

Indicators Categorised According to **Agro-ecological Zones** and **Land Issues**

Pieri, C., Dumanski, J., Hamblin, A. & Young, A. 1995. Land quality indicators. World Bank discussion papers, No. 315. Washington D. C., 51 pp.

Land issues and proposed land quality indicators for agro-environments in Latin America

Steep land

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

Acid savannas

Issues	Land Quality Indicators
intensity and diversity of land use	• percentage of different land use and terrain types • stability of net farm profits
land quality	• water-table level changes • water contamination • sediment load • percentage of soil cover/bare soil • crop nutrient uptake vs. fertiliser use • lime consumption/km^2
agricultural productivity	• actual/potential productivity (climate x terrain) • trends in crop yields • net farm profits
agricultural impacts on biodiversity	• proportion of gallery forests, wetlands, natural savannas
farm practices	• percentage of arable land with conservation practices
land tenure	• percentage of farmed area with recognised title

Land issues and proposed land quality indicators for agro-environments in Sub-Saharan Africa

Sub-humid zone

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

Semi-arid zone (dry farming only)

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

Arid zone (pastoral system only)

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

Indicators Categorised According to the **Pressure-State-Response Framework**

Bellows, B. 1996. Indicators of sustainability. Workbook for the SANREM CRSP. Washington State University/University of Wisconsin, USA.

The matrix is developed by initially identifying current conditions (states). A series of pressures that produced these biophysical conditions can then be identified. These changes in biophysical states stimulate biophysical and socio-economic responses. These responses may occur concurrently, as shown in the table below, or sequentially, with each response acting as a pressure producing the next response.

Pressures	**States**	**Responses**
1. drought in the Sahel	• soils with low native fertility and nutrient holding capacity	1. decreased fallow periods
2. in-migration of herders into Donsin	• limited land area available for grazing	2. declining soil fertility
3. increased cattle population in Donsin	• limited use of/access to external inputs	3. declining cattle productivity
		4. declining crop productivity due to decreased supply of manure
		5. declining quality of life for the people in Donsin
		6. out-migration of people from Donsin seeking employment

Indicators Categorised According to **Land Problems** and the **Pressure-State-Response Framework**

Pieri, C., Dumanski, J., Hamblin, A. & Young, A. 1995. Land quality indicators. World Bank discussion papers, No. 315. Washington D. C., 51 pp.

Land problem	**Indicators of ...**		
	... Pressure	**... State**	**... Response**
1. Soil erosion: water erosion on arable land, particularly steep land in all agro-climatic zones	• extent of cultivation of sloping land without adequate conservation measures	• rates of erosion (t/ha and year), obtained by field measurement or modelling • loss of topsoil, soil organic matter and nutrients; truncated soil profiles • extent and severity of visible signs of erosion, e.g. thin or rocky soils, soil slips, gullies, areas of abandoned land	• extent of adoption of soil conservation practices, by area or farm • number of farmer associations active in conservation • abandonment of land formerly cultivated
2. Decline in soil fertility, humid, sub-humid, semi-arid zones	• cultivation/fallow ratio • ratio of cultivated to cultivable land • ratio between monoculture and multiple cropping or crop rotation • extent of cultivation of marginal (fragile) land	• ratio between actual and estimated potential crop yields • balance between soil nutrient in- and outputs, obtained by measurement and modelling • changes in soil properties over time • occurrence of specific soil deficiencies, e.g. of micronutrients • occurrence of indicator plants for soil degradation or soil health	• extent of use of biological methods of soil improvement • adoption of crop rotation or multiple cropping • use of fertilisers • number of farmer groups or associations • abandonment of farmland
3. Forest clearance for agriculture	• observed clearance of forest areas for cultivation • ratio of cultivated to cultivable land	• percentage decrease of forest cover	• government legislation to protect forest and effectiveness of its implementation; • public awareness campaigns for forest protection and their effectiveness; • increased afforestation (communal, private or governmental)

Land problem	Indicators of ...		
	... Pressure	... State	... Response
4. Forest degradation	• ratio between harvest of wood (for all purposes) and estimated re-growth • shortages of fuelwood, charcoal or domestic timber, as indicated by high prices • illegal cutting within forests	• presence of degraded forests (communal or government), as determined by forest inventory of qualitative observation	• improved community participation in forest protection and management • increased adoption of agroforestry
5. Degradation of rangelands, particularly in semi-arid areas (desertification)	• fodder shortages, particularly in the dry season • ratio of vegetation biomass to feed demand; • proportions of land, livestock and population, assessed with respect to agro-climatic zone	• reduction in plant cover on rangelands • adverse changes in plant species composition of pastures, e.g. ratio of annual to perennial grasses, frequency of unpalatable species, presence of indicator plants for degraded pastures • appearance of areas of trampled, crusted or gullied land	• adoption of measures for improved range management (control over livestock numbers, rotational grazing, etc.) • number and effectiveness of community institutions for purposes of range management • conflict between pastoral peoples and neighbours
6. Lowering of the groundwater table	• farm water requirements estimated to be in excess of groundwater recharge	• falling water tables, as monitored at specific sites • reports of tube wells drying up • reports of crop failure/shortfall through insufficient irrigation water	• reports of deepening of tube wells • adoption of management practices that increase water use efficiency
7. Salinisation	• application of irrigation water (through dam and canal systems) without adequate measures for drainage • inappropriate water pricing	• rising water tables, as monitored at specific sites • increasing salinity levels of groundwater • increasing salt content of soil • appearance of patches of saline soil • appearance of areas of waterlogging • reports of crop failure or shortfall through soil salinisation or waterlogging	• implementation of improved measures for irrigation water management • initiation of soil reclamation schemes • increased cultivation of salt-tolerant crops • abandonment of fields or farms due to salinisation or waterlogging • trends in expenditure on maintenance of distribution canals, etc.

Indicators Categorised According to the **5 Pillars of Sustainability** and **Scale Dependency**

Compilation from different sources

Scale	**5 Pillars of sustainablity**
	Productivity
field/plot	soil fertility status, colour change of plant leaves
farm	crop yield, frequency of diseases, access to credit, number of crops per year
community/ district	training and education facilities, quality of extension
	Security (risk aversion)
field/plot	availability of water and nutrients, variability of yield
farm	livestock population density, family size, food reserves, diversity of products, length of fallow period, number of draught animals (oxen)
community	food security, health status, state of education,
district	out-migration, access to resources, climatic variability, land tenure, property rights, political stability
	Protection
field/plot	plant biodiversity, soil loss, number of erosion rills
farm	soil degradation status, ground cover, indigenous technologies, on-site water quality, length of fallow period
community	effectiveness of protective measures, cultivation of marginal land, planted tree density, local collective action, labour sharing
district	flood risk, colour of water, other symptoms of resource degradation, off-site water quality, deforestation
	Viability
field/plot	-
farm	land management practices, labour availability, household income, income stability, rate of time preference
community	crop choice, crop rotation, costs of agricultural inputs, crop prices, existence of co-operatives
district	non-farm labour demand, access to markets, percentage of subsistence farms, equity of income distribution
	Acceptability
field/plot	-
farm/ community	adoption rate of protective measures, decision-making process
district	norms and values, diffusion of innovations, legal and regulatory framework, co-ordination of international support, information dissemination system

Indicators Categorised According to **Scale Dependency**

Bellows, B. (Ed.) 1995. Proceedings of the indicators of sustainability conference and workshop. August 1-5, 1994, Arlington VA. SANREM CRSP Research Report 1-95, 312 p.

Level	Soil quality indicator	Economic sufficiency
field/plot	topsoil depth	cost of input/crop yields
farm/household	% of land with severe erosion	farm profitability
watershed/ municipality	sediment flows within and out of watershed	availability of crop at local market
bio-region/district	% of vegetation cover during critical times	regional sufficiency in locally produced crops

Indicators Categorised According to **Generic and Local Types**

Bellows, B. 1996. Indicators of sustainability. Workbook for the SANREM CRSP. Washington State University/University of Wisconsin, USA.

Three examples of indicators and their association with indicators from the major SANREM CRSP research sites.

Indicators	Philippines	Ecuador	Burkina Faso
soil quality	• landslides • red soil colour indicates eroded soil • low soil productivity associated with deforestation by small-scale farmers	• steep slopes scarred by erosion and landslides • land management practices are not adapted to the ecosystem • low dairy production levels due to nutritional imbalances from pastures	• increasing areas of bare and highly crusted abandoned lands • change from maize to sorghum to millet as soil fertility decreases
human health and nutrition	• lack of operational health care facilities in municipality • wells are reported to be contaminated	• lack of health care services in rural areas forces people to move to town	• increased dependency on western medicine due to loss of traditional herbal remedies • dependency on open wells for drinking water
access to resources	• dependency on off-farm incomes • dependency on financiers	• percentage of lands managed or held by absentee land-owners • need to utilise land fully to insure that land is not titled to another person	• abandonment of manure contract agreements between Mossi and Fulani • sale of forages to markets in Ouagadougo

Indicators Categorised According to **Generic and Local Types**

CIAT 1997 a. Indicadores locales de la calidad del suelo. By Burpee C. G. and Willmer R. Turcios. Tegucigalpa.

CIAT 1997 b. Cuadro de indicadores de la calidad de suelo. Tegucigalpa.

The CIAT Hillside Project for Central America recently developed a guide for soil health indicators, according to the Wisconsin Soil Health Scorecard (University of Wisconsin) and CIAT's own studies on local soil indicators used by Honduran hillside farmers (CIAT 1997 a). The guide includes a set of 38 indicators, presented as questions about soil colour, texture, erosion, soil use, etc., instructions on how to analyse the answers to the questions, and a brief comment on the circumstances under which the guide might be used. The guide is available in the form of a booklet and ready for field testing (CIAT 1997 b).

For each question, 3 specific answers are supplied, according to the logic:

0	(soil) not healthy
1	(soil) damaged
2	(soil) healthy

Excerpts taken from the guide, p. 2, in the original Spanish and translated into English:

"1. Color del suelo mojado (¿Cuál es el color del suelo cuando está mojado?)
Which colour is the soil when wet/ humid ....?

- 0 La tierra es café claro, amarillo claro, anaranjado, gris claro, o casi blanco. The colour is: light-brown, light-yellow, orange, light-grey or whitish (close to white)
- 1 La tierra es color café, gris o rojizo.
  The colour is: brown, grey or reddish
- 2 La tierra es negra, café oscuro o gris oscuro."
  The colour is: black, dark brown or dark grey

"3. Profundidad de la capa fértil (¿Qué tan profunda es la capa fértil del suelo?)
How deep is the fertile layer of the soil?

- 0 No hay capa fértil, o la capa fértil es muy delgada, menos de 2 pulgadas. La tierra mala está muy cerca a la superficie.
  There is no fertile layer or it is very shallow, less than 2 inches. The bad (=unproductive) soil is very close to the surface.
- 1 La capa fértil tiene poca profundidad, entre 2 y 5 pulgadas.
  The fertile layer is rather shallow (or: not very deep), measuring between 2 and 5 inches.
- 2 La capa fértil es profunda, más de 5 pulgadas."
  The fertile layer is deep, measuring more than 5 inches.

Once the user has answered the 38 questions (or the ones that can be answered in the case of a specific site), he is invited to calculate the percentage of healthy, damaged and unhealthy aspects (indicators) of that particular soil. The set of indicators can be used by farmer communities, preferably once a year on the same spot, in order to monitor changes.

Section C: Selected Methods for SLM Impact Monitoring - Introductory Remarks

Tools used for cost-effective monitoring of SLM indicators

This section contains cost-effective and practical monitoring methods that are relatively easy to handle. Neither modelling (e.g. the Universal Soil Loss Equation, USLE) nor methods requiring extensive laboratory analysis and sophisticated field experiments are included. In these cases, the reader is referred to the standard literature or consultation with subject matter specialists.

Section C contains:

C 1: Trans-sectoral monitoring methods to monitor a variety of indicators using the same tool.

- participatory methods focusing on the **indigenous** (internal) knowledge base
- monitoring methods focusing on the **experts'** (external) knowledge base

C 2: Sector-specific monitoring methods, which usually allow monitoring of single indicators, mostly of a biophysical nature.

To allow a better comparison of apparently similar methods, or methods focusing on the same indicator, some participatory methods are presented in synoptic tables. Most methods are described using a standard format, the criteria of which were established on the basis of need assessment as expressed by Swiss and German development agencies. If the original source or reference was specific about a method's accuracy, potentials and limitations, prerequisites, and investments, this information is included. Beyond that, it is difficult to estimate the precision, the time needed to conduct a specific method, the precise costs, etc.

Assemble your own selection of methods

The user is encouraged to use this Toolkit Module as a basis for assembling his or her own selection of methods. This project- or situation-specific assembly will consist of methods presented in the Guidelines - including their adaptation to a specific situation- and possibly newly developed monitoring methods. The authors of the Guidelines would be grateful for feedback regarding additional methods and users' adaptation of methods so that this Toolkit Module can be gradually updated.

see also
SLM-IM
Module,
Step 5

Suggested standard format for the protocol of monitoring methods

1) Title of the method
2) Reference/source or address for further information
3) Objective and brief description
4) Procedure/steps
5) Indicators addressed
6) Quality of the method
7) Potentials and limitations
8) Investments and prerequisites

Toolkit

Overview: Participatory Observation and Interview Methods

preferably used in combination (triangulation)

	Direct observation	**Participant observation**	**Local knowledge & local classification**
Objective	• capturing observable phenomena and environmental processes	• understanding the perception of a local community	• capturing local knowledge, facilitating extension, comparison with experts' knowledge
Procedure	• observation of biophysical parameters • verification of (quantitative) results • classification of results	• observation of social interactions • documenting field notes as soon after the observation as possible	• reading existing case studies and study reports to increase the observers' sensibility • informal discussions
Indicators	*biophysical parameters* • variability of crop yield • livestock density • ground cover • biodiversity	*social interactions* • access to credit • access to resources • quality of extension • labour sharing	*local technologies* • LM practices • diffusion of innovation • soil fertility/biodiversity • decision-making-processes • norms and values
Quality of the method	• rather subjective • has to be verified by other methods	• rather subjective • needs reflection	• quite precise
Potentials	• wide range of indicators • easy to handle • no preparation • always applicable	• appropriate as first phase of monitoring (identification of core issues)	• based on detailed observations to a great extent • depends on access to and acquaintance with local/indigenous knowledge systems
Limitations	• observers' sensitivity	• influence of the observer's presence • endurance, reflection of the observer's own perspective • observers' sensitivity	• longer period of professional adjustment
Equipment	• memo-book • basic instruments (meter, inclinometer, etc.)	• memo-book	• secondary literature for preliminary studies • previously completed investigations
Labour requirements	• individual or • team-work	• social scientists and social anthropologist if possible	• co-operation with social anthropologists if possible • experienced staff
Time expenditure	• depending on the subject	• depending on the subject	• may take considerable time to harmonise different knowledge bases

	Visualisation [1]	**Semi-structured interview** [2]	**Structured interview & questionnaire**
Objective	• used for planning, joint discussion and analysis of information by community members and/or experts	• topics pursued as they arise, discovery of important local issues	• investigation of a predefined topic; aspects of interest are already known
Procedure	• depends on the tool • can be done with paper and pencil, with seeds, stones, sticks on the ground, etc. • documentation of results	• introduction of interviewer and explanation of aims • guided interview with10-15 key questions: what, where, when, who, what would you do if...?	• well-prepared questionnaire • pre-test for adjustment • introducing interviewers
Indicators	*complex context* • soil degradation status • decision-making process • crop yield and variability • norms and values	*qualitative indicators* • access to resources • access to credit • decision-making process • norms and values	*socio-economic indicators* • not directly measurable/ observable indicators (household income, food reserves, property rights, labour availability, length of fallow period)
Quality of the method	• depends on acceptance by local stakeholders	• depends on the flexibility of the interviewer	• comparable data, statistical assessment
Potentials	• offers most variable instruments within the scope of RRA/PRA	• allows more detailed information • interesting issues may arise	• depends on the quality of the questionnaire
Limitations	• not all cultures necessarily learn and communicate best in a visual way	• interviewers must be known and trusted • considerable preparation needed	• little flexibility • difficult to go into circumstances in depth
Equipment	• using material that can be found at the site	• tape, if the interviewees accept	• questionnaires
Labour requirements	• well-trained personnel • more than one observer recommendable (complementary views on complex context)	• two interviewers: one asks questions, the other takes notes • well-trained personnel	• several interviewers are necessary for a representative sample size
Time expenditure	• group work needs more time than individual procedures	• more time than a structured interview	• needs less time than a semi-structured interview • depends on the sample size

[1] including: mapping, modelling, scoring matrices, diagramming (transect walks, historical transects, seasonal calendars, timelines, Venn diagrams, decision trees, 3-d-models

[2] including: community interview, household/group interview, key informant interview, individual interviews

Participatory Rural Appraisal / Participatory Learning and Action

includes

- participant observation
- direct observation
- semi-structured interview
- local knowledge & local classification
- visualisation (mapping, modelling, scoring matrices, causal diagramming)

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Contact: Helmut Eger, GTZ, division 45; Reiner Forster, GTZ, unit 04; Klaus Hornberger, GTZ , division 4405 , GATE-ISAT (German Appropriate Technology Exchange); Peter Keller, GTZ, division 45, rural development; Sigfrid Schroeder-Breitschuh, GTZ, division 45, rural development
P.O. Box 5180, 65726 Eschborn, Germany. E-mail: surname.name@gtz.de

Thomas Zeller, Swiss Agency for Development and Co-operation (SDC), Section East Africa, Postfach, 3003 Bern, Switzerland. E-mail Thomas.Zeller@deza.admin.ch

Objective and brief description

Tools for participatory approaches often exist as compilations, such as RRA (Rapid Rural Appraisal), PRA (Participatory Rapid/Rural/Relaxed Appraisal), or PLA (Participatory Learning and Action). Independent of nomenclature, they are characterised as a qualitative approach of "optimal ignorance" and "appropriate imprecision". Participatory methods propagate mutual learning. They are a combination of assistance for local people in gaining confidence to conduct their own appraisal and analysis, and assistance for external experts in understanding local perceptions. The PRA/PLA methodology covers a set of approaches, methods and behaviours for rural and urban planning, programme implementation, and monitoring and evaluation.

Participatory tools cover quite a wide range of indicators. They usually produce qualitative results and also serve as a cross-check on quantitative results, for example from structured interviews or other methods. Participatory tools are used best in combination with similar or complementary approaches and methods (triangulation) to ensure quality of information appropriate for decision-making. PRA/PLA involves a shift of orientation in development co-operation, giving much more emphasis to indigenous knowledge systems. This is a shift from:

- dominance of Northern countries to facilitation, promoting assumption of responsibilities by local stakeholders (actors) for designing and evaluating their own development projects
- ready-made solutions to strategic diversity
- individual perception to group interests
- verbalisation to visualisation, for better access to information for everybody
- measurement to comparison
- the frustration of data analysis to the fun of social interaction
- one-way data abstraction to mutual communication and learning

Procedure/steps

1. Local stakeholders have to be informed about the intentions of outsiders; procedures and the objectives of activities have to be explained (even if the objectives are to be determined by local stakeholders).
2. Before starting the SLM-IM process, about a day is needed for familiarisation. Remember that participatory methods are two-sided processes: you want to get information from/about local people (for their own benefit!) but they also want to get to know about you. This forms the basis for a process of "mutual learning". It is not only the results and contents that count; reflection on processes is also important.
3. Familiarisation helps you to identify key persons who might advise you, assist in applying some methods, and give valuable background information. It might also provoke a continuation of SLM-IM by local stakeholders after projects have been phased out.
4. Don't start applying methods without a concept or an analytical framework (model) into which the information can fit.
5. Start by getting an overview of local circumstances first (e.g. transect-walk) before concentrating on specific issues.

6. Avoid standardised procedures, use your own best judgement at all times. Only the specific situation can give you hints about follow-up; stakeholders should decide how to go ahead.
7. 'Participatory' means involvement of all relevant social groups. Make sure that particularly underprivileged strata are not neglected.
8. Repeat methods with different groups if they seem suitable.
9. You are more likely to be on the right track and your results are more likely to be reliable if you apply an appropriate mix of tools in an analytical framework. Cross checking is inevitable: as participatory methods are rather subjective, results have to be verified by different approaches (triangulation).

Indicators

- numerous socio-economic and biophysical indicators

Quality of the methods

- rather subjective (behaviour, attitudes, values and beliefs)
- statistical evaluation is not necessarily ensured
- need for verification by other methods

Potentials and limitations

Potentials

- nearly no preparation
- can be used in all project phases
- rapid, qualitative appraisals, comparatively cost-effective
- basically integrates local/indigenous knowledge
- allows in-depth investigation
- hidden aspects can be discovered that are not obvious at first glance

Limitations

- greatly depends on the ability of the researcher or observer; quality control is necessary to avoid abuse and maintain certain professional ethics
- conflicts can arise and conflict management may be necessary
- the key to participatory approaches is not so much the methods, but the behaviour, attitudes, values and beliefs of those who conduct the survey
- detailed manuals may fix and "fossilise" practices and understanding which become outdated
- methods have to be accepted and must be applicable by local stakeholders
- exaggerated, standardised and routine use of participatory methods will "saturate" people
- even if the tools/methods are allegedly participatory, there must be reflection about what ends are really served by the results: solution of locally perceived problems or project staff reports

Investments and prerequisites

Essential equipment

- memo-block
- material can be used that is found at the site (visualisation)

Desirable equipment

- measuring instruments
- tapes, cameras

Labour requirements

survey team composition, depending on the situation:

- well-trained, experienced and sensitised staff
- several observers/interviewers would give a more objective picture
- assistants are useful for some methods (e.g. semi-structured interviewing: someone who takes notes)
- local stakeholders in the team facilitate access to and acceptance by a local community
- it is essential that both women and men are on the team, especially for participatory methods

Time expenditure

- little preparation time for the development of an analytical framework
- the methods need to follow local time schedules

Participatory Transect Walk - Visualisation

Pretty, J.N. 1990. Rapid catchment analysis for extension agents. Notes on the 1990 Kericho workshop for the Ministry of Agriculture, Kenya. IIED, London.

Objective and brief description

The walk is conducted by a team to observe and talk about issues of local importance. The area under study is systematically traversed by experts and (local) informants. The walk follows a specific route, e.g. from the highest to the lowest point, from north to south, etc. Everything mentioned by the informants is discussed and noticed. The walk supplements "official" information (reports, secondary literature, etc.) with subjective and lateral observations and experiences. The method can be used for a qualitative approach as well as for a rapid quantitative assessment.

Procedure/steps

- Local key informants are asked to form an observation team together with experts.
- A route is identified by the local participants depending on what is to be observed.
- If possible, the team develops its own norms for group behaviour (team contracts).
- The transect walk is planned (definition of the subject, methods used).
- During the transect walk, new findings are considered and pursued if they seem to be important to the overall subject.
- Different units (slope, level terrain, forest, field, village, natural sites, cropland, etc.) and problem areas (accessibility, erosion hazard, malaria, etc.) are distinguished.
- Information is shown in a generalising transect map.

Indicators

- variability of crop yield
- availability of water
- access to resources
- land tenure, property rights
- biodiversity
- cultivation of marginal land
- resource degradation
- livestock density
- land management practices

Quality of the method

The transect walk is a method that provides an overview at the beginning of SLM-IM. The information is not very detailed, though, and the transect maps are generalised.

Potentials and limitations

Potentials

- closely considers the local knowledge base
- applicable by all local land users
- new important issues arise which may have been overlooked

Limitations

- subjective information

Investments and prerequisites

Essential equipment

- notebooks, pens

Desirable equipment

- large sheets of paper

Labour requirements

- depends on the subject

Time expenditure

- 1-3 hours; up to one day

Participatory Mapping and Modelling - Visualisation

Pretty, J.N. 1990. Rapid catchment analysis for extension agents. Notes on the 1990 Kericho workshop for the Ministry of Agriculture, Kenya. IIED, London

Objective and brief description

Mapping or modelling allows a simple monitoring of visible changes in indicators for local beneficiaries. Complex contexts can be revealed by visualising them. 'Resource mapping' and 'social mapping' can be distinguished in relation to the subject. Both are essential in land use planning activities. Maps or map-models are a 'snapshot of the present', and monitoring means drawing maps both from the present and from the past, and comparing them. Thus, resource degradation and resource preservation can be monitored.

Procedure/steps

Mapping can be done in a group with several participants or separately by several individuals. Maps can be drawn on paper if people are used to it, but it is also possible to draw them with a stick on the ground. Small branches, stones, seeds and any other material can facilitate the mapping. 3-dimensional terrain or map models might allow a better overview. Clear symbols and an agreement about a homogeneous utilisation of symbols have to be developed. The scale of the map depends on the observed area and the importance of specific details. Discussion after the mapping and explanation are as important as the mapping itself.

Indicators

- soil degradation status
- land tenure, property rights
- variability of yield
- access to resources
- cultivation of marginal land
- effectiveness of protective measures

Quality of the method

- semi-quantitative and qualitative statements are possible
- development of the method and acceptance of it by the local people is an important criterion for the value of the results
- quality depends on the ability to explain and interpret the maps

Potentials and limitations

Potentials

- complex contexts can be visualised
- the different 'mental maps' of group members demonstrate their perceptions and the information they have
- the construction of 3-dimensional map models may allow the participation of more group members
- the method uncovers issues which are not yet on the agenda

Limitations

- the mix of the team and the personal background of its members may reveal incompatible interests
- the person who draws the map, like the rapporteur, may easily misuse this dominant position

Investments and prerequisites

Essential equipment

- pens and large sheets of paper, sticks, stones, etc.

Labour requirements

- an experienced facilitator

Time expenditure

- 45 - 75 minutes

Survey - Questionnaire - Structured Interview

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Contact: Peter Ay (freelance consultant): Lilienthalstr. 18, 10965 Berlin. Tel.: +49-(0)30-693 55 13, Fax: +49-(0)30-694 01 788, e-mail: ay_zdunnek@t-online.de

Objective and brief description

Quantitative surveys (mostly questionnaires and formal interviews) are a supplement to ecological methods and qualitative participatory approaches. Surveys cover a wide range of techniques which can be used in any stage of a monitoring process, as an initial baseline survey or as a follow-up survey. A survey in a community is commonly conducted using a questionnaire. Information obtained from several individuals is recorded uniformly in a short period of time. For an initial baseline survey, informal key questions might already satisfy the demand, but temporal comparability requires a more structured procedure.

A questionnaire is usually applied within a structured or formal interview (interviewer-administrated). It is also possible to distribute questionnaires so that the respondents fill them in by themselves (self- administrated). The procedure depends on local circumstances (literacy, practice in handling questionnaires). In a monitoring process it might be advantageous to personally introduce the questionnaire in a first round. Repeated monitoring may allow the use of self-administrated questionnaires when people are used to it. But saving time in data collection can cost extra time in data analysis.

Procedure/steps

1. A structured interview and a questionnaire have to be well prepared.
   - They require a predefined structure. As no adjustments are made during the interview, the type of data desired and data analysis requirements should be known in advance.
   - This kind of **analytical framework** dominates the selection of **qualitative** ('Are you content with the last crop yield?) and **quantitative questions** ('How much did you harvest last year?'). Quantitative data can be subject to simple statistical analysis and be displayed as graphs or tables. Qualitative information provides a better understanding by giving the background of the quantitative results. Moreover, it helps to bring out unforeseen facts and opinions.

  - **Closed-ended questions** such as, "Has crop yield increased within the last two years?" which allow only 'yes' or 'no' answers facilitate the analysis. Whereas **open-ended questions** such as, "Why do you think crop yields decreased in the last decade?" may bring up other important project issues.
2. A **pretest** of the questionnaire (length of the questionnaire, the way the questions are posed, their order, etc.) permits adjustment before starting the definite interview phase.
3. The interviews can be guided by experts to build a relationship with the community. But depending on the extent of the survey and other restrictions such as language problems, it may be necessary to select external interviewers, professionals as well as voluntary assistants, from the local community. **Training** of the interviewers is necessary, for professional investigators and community volunteers. Local investigators may have better access to people, and answers are more likely to be understood and passed on in the right sense. But local interviewers might need more guidance, as they may have less interview experience.
4. Just as the interviewer wants to get information, the interviewee also wants to get to know about the project and about the interviewer: Who is she/he? What is she/he doing? What is the background of the organisation she/he is working for? What is the purpose of the interview? So before asking the first question, an **introduction** is indispensable to build up a confidential and constructive relationship.
5. Questions should be asked in a **comprehensible order**. Beginning with simple questions may serve as a kind of warm up so that complex questions are easier to be answered later.
6. The selected persons should be interviewed **individually** and their answers should not be influenced by the interviewer. Confidentiality has to be assured and guaranteed.

Quality Control Checklist - Construction and Structure of Questionnaires

- Does the questionnaire provide a clear order in which questions must be asked/answered by respondents?
- Has the questionnaire been reviewed to ease coding of responses to questions?
- Are written responses required? If so, how will they be coded later?
- Are the responses coded when the data are entered into the computer? If so, how?
- Are written data entered in and coded by the computer? If so, has this been programmed and verified?
- Do the data have to be coded for qualitative analysis? If so, how?

Quality Control Checklist - Field Testing Questionnaires

(reliability of the data collection)

- Are all questions interpreted consistently by the respondents?
- Do all questions have a common scale of interpretation? (e.g. can everybody answer in kg, or km, or days?)
- Is there a logical flow among questions in the questionnaire or interview guide?
- Are the data obtained consistent with the data requested?
- Is the sequence of and are the connections between the questions clear and easily understood?

- Are the questions easy to read on the data collection form?
- If applicable, are colour and contrast used effectively in the questions?
- Can respondents or interviewers record their answers on the data collection form with sufficient clarity?
- Is there sufficient space next to each question to accommodate unexpected responses?
- Are response categories properly laid out and consistent throughout the questionnaire or interview?

Indicators

The following indicators are relevant for SLM, particularly the socio-economic indicators, but also perceptions of biophysical indicators:

- labour assignment/availability
- length of fallow
- utilisation of inputs
- crop yield
- self-sufficiency
- use of crop residues
- household income (farm income and off-farm income)
- food reserves
- access to credit
- access to resources/property rights

Quality of the method

- results depend largely on experts' assessments of main issues
- statistical analysis is possible
- the quality of the method depends on the quality of the questionnaire and the quality of training, experience and trust in the interviewers

Potentials and limitations

Potentials

- a large number of comparable data/information can be gathered in a short period of time

Limitations

- questions are usually prepared for expected issues; unforeseen issues do not normally arise
- questionnaires and structured interviews are methods typical of Northern cultures but are not necessarily known everywhere else
- a structured interview usually creates an artificial situation which may not deliver valid results
- answers may be distorted by the expectations of the respondents
- the accuracy of the data is difficult to assess
- structured interviews have little flexibility

Investments and prerequisites

Essential equipment
- questionnaires, storage
- transport for interviewers

Desirable equipment
- computer for analysis

Labour requirements
- trained interviewers, both women and men
- involvement of local volunteers if possible

Time expenditure
- questionnaire preparation may take a couple of days
- one interview should not require more than ½ - ¾ hour of the interviewee's time
- if the subject requires more detailed treatment, the interview should be divided into several sessions

Local Land and Soil Classification
Example: PATECORE, NRM Project in Burkina Faso

Brokensha, D., Warren D.M., Werner, O. (Ed.). 1980. Indigenous Knowledge Systems and Development, University Press of America, New York, USA.

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Schutjes, A.H.M. and van Driel, W.F. 1994. La classification locale des terres par les Mossi: Paysans et pédologues parelent-ils le même langage? Publication de l'Antenne sahelienne No. 13, Université de Ouagadougou/UAW, Ouagadougou, Wageningen.

Contact: K.-P. Kirsch-Jung, Division 45, GTZ, P.O. Box 5180, D-65726 Eschborn

Objective and brief description

Local taxonomies and classifications are often more precise and based to a greater extent on detailed observation. PATECORE (Projet Aménagement des Terroirs et Conservation des Ressources dans le Plateau Central) in Burkina Faso created a method based on local classifications for analysing the relation between vegetation and soil and determining indicators for land conditions. Elements of local/indigenous knowledge are merged with ecological and economical aspects of SLM-IM. The main objective of the method is to make users aware of plants as indicators of unsustainable land use.

Procedure/steps

1. **Soil classification:** Farmers' nomenclature of soil properties, terrain properties and land use is described and classified. The local nomenclature and classification are used for extension purposes.
2. **Land classification with vegetation:** Utilisation of trees and shrubs by farmers was revealed through interviews. The appearance of vegetation as the overall indicator for land users is defined by vegetative composition and structural properties:
   - From a pre-determined point within a representative site the ground is squared from east to west and from south to north (20 m x 20 m, 28.2 m diagonal length). Distance is measured by steps. The plant cover is classified as follows:

class	cover (%)
0	< 1
1	1 - 10
2	10 - 50
3	> 50

   - Dominant and frequently occurring plant species are documented. Indicator plants (bio-indicators) are identified and measured (indicator species, species groups, forms of life) according to the local nomenclature.
3. Different areas (groups) are distinguished in terms of their land use potential or potential risk, according to the appearance of vegetation.
4. For each group, proposals for land use practices are elaborated in order to diminish potential risk.
5. The appearance of specific indicator plants serves as a signal for early intervention by land users. Training is conducted on the use of indicator plants for land use management.

Indicators

Visible changes in:

- coverage (crusts, gravel, stones, tree-strata (> 3 m), shrub-strata (< 3 m), herbal strata)
- plant biodiversity
- soil degradation
- land management practices
- crop choice, crop rotation

Quality of the method

- qualitative approach
- depends on the access to local/indigenous knowledge systems by project staff
- serves especially for extension purposes

Potentials and limitations

Potentials

- permits work with land users from their own knowledge base, which is often more astute
- facilitates dialogue with local stakeholders and joint elaboration of viable, more appropriate solutions for land management problems

Limitations

- needs a longer period of professional adjustment to minimise dominance of academic perception
- correlation of local/indigenous observation and technical/scientific aspects is not always easy

Investments and prerequisites

Desirable equipment

- literature on case studies, study reports

Labour requirements

- experience and basic knowledge in different fields: ecological and sociological approach
- co-operation with social anthropologists
- raising self-awareness by reading study reports is the best preparation

Time expenditure

- becoming familiar with local nomenclature may take several weeks or months
- awareness of local/indigenous knowledge is essential throughout a project's lifetime

Bio-Resource / Nutrient Flow Determination

Budelman, A. 1997. The nutrient flow analysis in local learning and adaptive research. Potential and pitfalls. Paper Seminar at Department of Environment, University of East Anglia, Norwich, UK.

Defoer, T., Kanté, S. , Hilhorst, T and De Groote, H. 1996. Towards more sustainable soil fertility management. Agricultural Research and Extension Network (AgREN) Network Paper No. 63, Overseas Development Institute (ODI), London, UK.

Defoer, T, De Groote, H. , Hilhorst, T, Kanté, S. and Budelman, A. 1998. Farmer participatory action research and quantitative analysis: A fruitful marriage? Journal of Agriculture, Ecosystems and Environment (Special issue; Forthcoming).

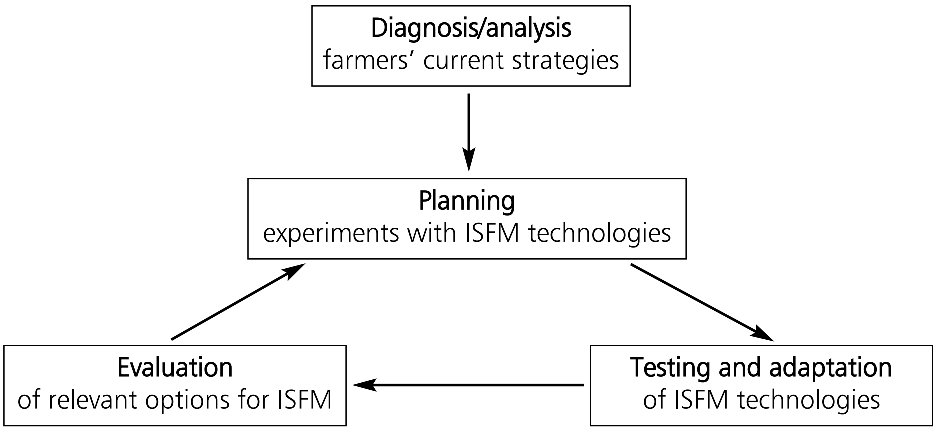
Objective and brief description

This is a method for assessing the flows of resources and nutrients within a farm, among farms, and between farms and communally managed resources. The objective is to establish a nutrient balance at farm level, implying more sustainable land management.

The method describes and quantifies flows of resources and nutrients between elements of a farm as a system, and among and between farms in a community setting, as a consequence of farming practices. This method is used to enable land users to analyse their management of natural resources and to identify and plan alternative sustainable technologies that meet their needs. In applying this method land users discover and learn about new technologies by experimenting with them and evaluating and adapting them. Farmers are motivated to change their practices when they are able to relate their subjective appraisal of land management practices (which are sustainable and which are not) to differences in resource flows.

Procedure / steps

The approach of integrated soil fertility management (ISFM) in which this method is used consists of four phases, each having a certain number of steps:



Phase 1: Analysis/diagnosis of current soil fertility management strategies

- Diversity analysis at community (village) level
  - analysing the use and management of natural resources at community level, using historical profiles, natural resource maps, transect walks, etc.;
  - analysing villagers' communication and information networks with organograms, for example;
  - analysing the diversity of soil fertility management strategies among farmers that exists within the village setting, and the distribution of agricultural resources and farm management practices: e.g. priority ranking of farmer indicators for performance/sustainability, farm classifications according to management performance/ economic performance, resource endowment, representative selection of experimenting farmers, etc.
- Selecting test farmers on the basis of different analyses.
- Analysing strategies of test farmers/diagnosing farmers' current soil fertility management strategies (for each of the distinct farm classes), using farmer-made resource flow maps; visualising the level of resource recycling, resource losses and depletion, and dependence on external resources, with the farm as the unit of analysis; comparing differences among farm classes.
- Linking test farmers with other farmers at village level; discussing maps and findings in community meetings to identify possibilities for improvements within the package of integrated soil fertility management (ISFM) practices, specifically for the distinct farm classes.

Phase 2: Planning experiments for integrated soil fertility management (ISFM) technologies

- Exchanging views through the development of farmer communication networks/ farmer workshops/ exchange visits:
  - prioritising alternative ISFM practices for the coming growing season for the different farm classes;
  - visualising planned activities/experiments, showing improved resource recycling, using planning maps (farmer-made resource flow maps).

Phase 3: Testing, monitoring and adapting ISFM technologies

- Selecting performance indicators to monitor the effect of the ISFM technologies:
  - observing, recording/registering phenomena/processes;
  - making interpretations on the basis of farmer perceptions and by linking scientific insights with farmers' knowledge (see monitoring framework);
  - adapting technologies according to local requirements;
  - feedback of information.

Phase 4: Evaluation of the relevant IFSM options

- Recording and analysing changes at different levels: field/livestock, farm, community by different classes/gender, individually and community based:
  - interpreting changes that will allow planning of new activities/tests.

Indicators

- input-output flows of nutrients related to management practices of farmers (basic applications of mineral and organic manure, livestock and household inputs and use of crop product, crop residues and livestock and household products) resulting in partial nutrient balances at the farm level and at the farm sub-systems levels (cropping systems, livestock system, household system)
- management performance indicators related to farmers' indicators for proper soil fertility management (application rate of crop residues, organic manure and inorganic fertilisers per unit of land or per unit of livestock or unit of labour): These indicators can be compared to standards for application rates prescribed by research and by extension services

Quality of the method

- rapid appraisal
- participatory: strong farmer involvement from diagnosis through planning, experimenting and evaluation
- discovering, learning and action are key elements
- the method of calculating nutrient flows and balances derived from resource flow maps made by farmers basically takes into account the visible and tangible flows that can be managed by the farmer and uses farmers' estimates of quantities of resources, often expressed in local units, such as cart loads, bags, etc. The nutrient contents of the resources may come from 3 different sources: (i) literature, preferentially from the study area, (ii) research data from a local research station or (iii) laboratory analysis. The method strives for satisfactory accuracy, which is directly related to the purpose of the analysis and which means that quantification should be useful in the process of farmers' learning and action: Partial nutrient balances and management performance indicators are used in discussion with farmers during planning and evaluation sessions (see phases 2 and 4). It is meaningless to evaluate the outcomes of a farmer-based flow analysis with a yardstick appropriate for evaluating scientific research. Thus, the method does not aim at high-level scientific precision; this would be too expensive and time consuming, with little chance of significantly improving the learning and action process.
- partial balances and management performance indicators calculated are directly related to changes in management practices and the related results of these practices (in terms of yields, crop residue recycling, etc.). So we can say that the method has a certain degree of sensitivity in the sense that it indicates whether a change occurs in the direction a system moves.

Investments and prerequisites

Villagers and researchers/extensionists willing to commit themselves to a long period of working together

Labour requirements

People involved in this method should have:

- basic knowledge of soil fertility and farming practices
- multi-disciplinary insight: a team of 2 to 5 researcher/extensionists is required to facilitate the process
- full commitment to work for several years together with the farming community
- experience in collaborating with farmers and in PRA techniques

Time expenditure

- the process requires the full commitment of the farmer community and a team of researchers for several years
- the diagnostic phase: 4 to 10 days (depending on the number of resource flow maps drawn)
- the planning phase: 2 to 6 days (depending on the number of planning maps drawn)
- the experimentation phase: 3 to 6 days (depending on assistance requested by the farmers)
- the evaluation phase: 2 to 5 days (depending on the number of planning maps to be evaluated)

Prerequisites

- expert advice; no facilities

Potentials and limitations

Potentials

- creates common ground for discussion and exchange of views and learning among land users and between land users and researchers/extensionists
- demonstrates direct links to causes of unsustainability and links between action and indicators
- in described procedure sustainability is linked to socio-/economic/cultural factors (labour, equipment etc)
- relatively easy to handle
- short preparation time
- rapid qualitative and quantitative overview
- the land user is actively involved through visualisation and omissions in information are rapidly identified

Limitations

- only quantifies visible changes in nutrient flows (erosion; deposition is not considered)
- inaccuracy in assessing sustainability
- quality of information depends on land users' recall, planning, and own evaluation
- nutrient content data mainly from literature source

Mapping Symptoms of Unsustainable Land Management

Contact: Karl Herweg, Centre for Development and Environment, Department of Geography, University of Bern, Hallerstr. 12, 3012 Bern, Switzerland (herweg@giub.unibe.ch)

Objective and brief description

Mapping symptoms of unsustainable land management provides an overview of visible resource degradation problems, which degradation processes prevail, and where. On the basis of mapping, core issues can be identified, or decisions can be made about which symptoms need further investigation and more accurate monitoring methods. Visible signs of resource degradation can also be a starting point for informal discussions with local and other stakeholders on the spot, and consequently for understanding different perceptions of the same issue. Mapping can be used by external stakeholders who are not familiar with the locality to form their own opinion for a vivid debate with local stakeholders.

Procedure/steps

1. If the project area is too large to be covered, representative localities, catchments or communities need to be selected. Topographic and thematic maps, tours through the area on foot or by car, and discussions with people familiar to the area facilitate the selection.
2. The attached list will give initial hints about what to look at. Informal discussions may give further clues about which additional symptoms and indicators to look for.
3. A walk with a team through the area under observation can loosely follow transects, for example. But persons conducting the mapping should remain open to interesting excursions to "hidden" spots beyond any predetermined route, and seek discussions with local land users.
4. While walking, relevant observations should be marked on the map and accompanied by extended remarks and descriptions in the field book. Sketching of the area enhances detailed observation more than taking photos. Like photographs, sketching can be used to visualise impressions or changes after a certain period of time.
5. Symptoms of degradation will be observed within their landscape context, with a continual search for possible inter-relations or causes of degradation up- and downslope, up- and downstream, or along paths and roads to settlements.
6. Sketches, photos and notes will be used to reflect on the mapping and for discussions with others who did not see the location. Sketches can be used on the same day, while photos may take longer to be developed. Field maps need to be redrawn on clean paper while the field impressions are still vivid, preferably on the evening of the field day.

Indicators

- visible symptoms of land use changes and resource degradation (see table below)

Quality of the method

In general, mapping yields qualitative results, but some indicators can be quantified or suffice as requirements for semi-quantitative analysis. Within the framework of SLM, mapping is an important component, particularly if it is used in combination with other methods: on the one hand, with the analysis of the causes and effects of degradation, and on the other hand with more detailed investigation of single processes if necessary.

Potentials and limitations

Potentials
- gives a rapid overview
- walking and mapping provides a rather intensive impression of a new location
- mapping a degradation problem within a "landscape" context reveals interrelations of biophysical and socio-economic processes

Limitations
- mapping reveals only what is visible to the person who applies the method
- quantitative statements, in particular, should be supported by additional investigations

Investments and prerequisites

Essential equipment
- clip board
- topographic maps, sketch maps
- compass, altimeter
- field book, pens

Desirable equipment
- camera, binoculars
- metre, measuring tape
- spade, soil auger
- field pH meter

Labour requirements
- 1 - 3 persons, with backgrounds in both social and natural sciences

Time expenditure
- Depending on the terrain and detail of mapping: on average 3 - 4 km^2 per day and person or team

Symptom of unsustainable land management	**Preliminary indicators (what to observe)**
Soil erosion by water	• exposed plant roots (cm) • rills, gullies and accumulations (no., density, volume) • reduced topsoil depth (spade or drill) • change in soil colour indicates subsoil exposure
Wind erosion	• dust storms, mobile dunes, pegs as reference points indicate movement of dunes
Nutrient depletion (incl. acidity), Toxicity	• pH (field pH metre)
Salinisation/Alkalinity	• pH (field pH metre) • salt on soil surface
Compaction/Crust formation	• soil crust, thickness and strength; break the crust by hand and classify the force you use
Lowering groundwater table	• drying of wells • dying trees • more impalatable weeds - less fodder species
Increasing runoff	• flash floods
Declining water quality	• water shows colour brown (soil erosion) • algae • bad smell
Sedimentation of water reservoirs	• water shows colour brown • deposition visible during low water table
Degradation of plant resources (possibly as a consequence of soil and water degradation)	• leaf colour (confirm with farmers) • pests and diseases • ground cover (estimation in %) • varieties of plants/varieties of weeds
Degradation of animal resources (possibly as a consequence of degradation of the plant resources)	• No. of livestock/household/village • malnutrition • animal diseases
Land use changes	• land use mapping, % crop-, pasture-, woodland

Integrated Transect Method (ITM)

Graef, F., N. van Duivenbooden & K. Stahr, 1998. Remote sensing and transect-based characterisation of soil and terrain (SOTER) units in Niger, a multi-scale approach. Journal of Arid Environments (in press).

van Duivenbooden, N. & P.N. Windmeijer, 1995. Manual for semi-detailed characterisation of inland valley agro-ecosystems. WARDA/IITA/SC-DLO/WAU Report 4, SC-DLO, Wageningen, 86 p.

van Duivenbooden, N., P.N. Windmeijer, L.O. Fresco & W. Andriesse, 1996. The Integrated Transect Method as a tool for land use characterisation, with special reference to inland valley agro-ecosystems in West Africa. Landscape and Urban Planning 34: 143-160.

Windmeijer, P.N., T.J. Stomph, A. Adam, R. Coppus, N. de Ridder, M. Kandeh, M. Mahaman, & M. van Loon 1998. Transect sampling strategies for semi-detailed characterisation of inland valley systems. Neth. J. Agric. Science 43 (in press).

Contact: N. van Duivenbooden, Senior Scientist Land Use Systems, ICRISAT, BP 12404, Niamey, Niger. Tel: 227-722725; fax: 227-734329 Email: N.van-Duivenbooden@cgnet.com

P.N. Windmeijer, Scientific Co-ordinator Consortium for Sustainable Use of Inland Valleys, c/o WARDA, 01 BP 2551, Bouaké, Côte d'Ivoire, Tel: 225-634514; fax: 225-634714 Email: P.N.Windmeijer@cgnet.com

Objective and brief description

ITM has been developed as a scientific approach to characterise land use systems. Therefore it should be possible to use it to compare land use systems and agro-ecosystems on a larger - regional, national and international - level. But the method's inherent independence of scale allows its application at the project or local level as well.

ITM describes a methodology for characterising land use based on transect surveys. ITM generates data on a semi-detailed level, using a multidisciplinary approach: ecological and socio-economical impacts of a project can be revealed/monitored along a cross-section in the project region. Land use in this context is understood as interaction among different aspects:

- biophysical land use (concrete human interference in the functioning of a given agro-ecosystem),
- land use purposes (socio-economic use of land, e.g. for self-sufficiency), and
- land use circumstances (socio-economic aspects, e.g. market system and biophysical, e.g. soil type).

Monitoring the whole region might be too costly, but a representative transect can save time and project resources. Concentrating on one (or several) transect(s) can also provide an analytical framework for the specific methods of the "mapping of symptoms of land degradation".

Procedure/steps

- identifying subjects and issues to be monitored by ITM
- level of detail is fixed in advance (scale-dependency of the type and number of collected data)

- project staff, specialists (geographers, agricultural engineers) select the transect route:
  - transect selection is based on scientific interpretation of the agro-ecological unit (satellite images and aerial photographs if available)
  - a transect should cut across different land sub-elements (valley bottom, fringes, slopes and crests), from one top of the crests to the other at the opposite valley side
- width of the sample area on both sides of the central transect line has to be selected (tens of metres in general, to one kilometre for mountain surveys)
- applied methods are chosen and prepared
- local key informants are asked to accompany the investigation crews
- transect surveys of different disciplines can be carried out in independent rounds, but it would be better to take joint action for initiating dialogue between different disciplines
- interviews are held with farmers cultivating their fields in the transects under study to obtain more qualitative information about land use (changes), to validate transect observation, and to gain background information about the farm and farmer's family

Indicators

- soil fertility
- soil erosion
- land use, crop choice and crop rotation
- access to resources
- income of land users
- land tenure, property rights
- cultivation of marginal land
- land management practices

Quality of the method

- quantitative and qualitative data on a semi-detailed level
- depending on focus: detailed and quantified

Potentials and limitations

Potentials

- concentrating on the same catchment area for ecological and economic aspects may simplify the analysis of interdependencies later on
- concentration in space makes concentration in topics possible, providing more detailed information about specific issues
- low costs (if no chemical analyses are needed)
- concentration on certain issues
- clear diagrams as output, showing lateral views and bird's eye views

Limitations

- experts' assessments
- ITM requires at least a soil scientist, an agronomist, and a socio-economist
- as the transect route is chosen by project staff/experts, it may not be representative of major land problems in the view of local people
- relevant impacts beyond the transect catchment area might be overlooked
- drawing of final maps can be time consuming (depending on details requested)

Investments and prerequisites

Essential equipment

- aerial photos, topographic maps
- inclinometer, compass
- 50 m of rope, soil augers (Edelman and stony soil auger)
- soil colour chart, field pH kit or pH paper, water bottle, pickets
- A3 and A4 note pads, mm-paper, clipboard, pencils
- labels for sample bags, coloured plastic bags (for marking the transect), sample bags
- soil and land use description forms and codes list, questionnaires, interview forms

Labour requirements

- project staff/experts concerned with ecological and socio-economic aspects
- participation of locals

Time expenditure

- a few hours to several days (depending on number of transects and details requested)

Photo-Monitoring

Bosshart, U. 1997. Photo-Monitoring. Centre for Development and Environment, University of Berne, Berne, Switzerland, 44p.

Swiss Agency for Development and Co-operation (SDC). 1992. Photography in project work. Uses and limits in photo-observation. 50 pp. Bern.

Objective and brief description

Photo-monitoring is a comprehensive, fast and objective method for detecting visual changes in objects and possibly for identifying their causes. Photographs are taken from permanent viewpoints, in conformity with a script prepared in advance. When processes or events have an expected development, photographs are taken regularly at fixed time intervals (systematic monitoring), otherwise they are taken whenever remarkable change occurs (occasional monitoring). To enable a three-dimensional interpretation, pairs of photographs of the same object are taken from two adjacent viewpoints.

Procedure/steps

- define the terms of reference of photo-monitoring (what, when, who, when, how)
- plan the photo-monitoring (prepare the script, describe the terms of reference)
- implement monitoring: locate and mark the photo viewpoints, take the photographs, fill out accompanying field form
- sort results and evaluate photo-monitoring (check whether terms of reference or script should be modified, or whether photo-monitoring is still appropriate)
- classify, file and interpret the results

Indicators

Visible changes in:

- landscape, land use
- constructions

Quality of the method

- quality of method depends on experience of photographer and preparation for monitoring
- quick appraisal
- moderately accurate to accurate (land use types and borders can be determined with an accuracy of ± 5%)
- sensitivity of the method depends whether changes in the indicator are visible on the photograph

Photo-monitoring is appropriate for assessing changes in land use in small selected areas, the impact of physical soil and water conservation measures and the stability of their construction, the behaviour of implemented physical soil and water conservation measures, the temporal stability of gauging stations, and the development of the environment surrounding hydraulic constructions.

Potentials and limitations

Potentials

- comprehensive, fast and objective method
- information available later (checks can be made)
- professional manpower or sophisticated equipment are not necessary (=low initial and operational costs)
- few investments for preparation

Limitations

- method is merely a complement to other monitoring methods; better if not used in isolation
- single point photo-monitoring is only qualitative; baseline approach allows a qualitative and a partially quantitative interpretation. However, quantitative analysis and interpretation are time consuming.
- adequate preparation of the terms of reference of photo-monitoring before its implementation is necessary
- institutionalisation (who does what) and transfer of methods require considerable efforts

Investments and prerequisites

Essential equipment

Simple pocket camera or slightly more sophisticated equipment (35-mm camera, changeable lenses, filters, tripod and cable release), field forms, 100-200 ASA films, pocket stereoscope for baseline photo monitoring. (Costs: sophisticated equipment estimated at US$ 1,230-2,100)

Desirable equipment

Cabinet for filing, light box for examination of negatives or slides, stereoscope table version, large-scale topographic maps or altimeter and compass

Labour requirements

People with experience in taking photographs

Time expenditure

Time input depends on the number of scripts, the number of sites, and distance to sites, and can therefore not be quantified generally. In comparison to in situ land use surveys, using photo-monitoring for land use assessment requires less time in the field but far more time in the office to translate the information into a land use map.

Overview: Methods for Monitoring Soil Fertility

	Extended spade diagnosis	**Various soil kits**	**Soil fertility assessment**
Objective	• assessing the effects of management practices on soil structure and its stability (physical soil properties)	• monitoring the status of soil fertility with the help of a field laboratory (chemical soil properties)	• participatory soil survey for general soil fertility assessment, specific tools and methods to support extensionists on the farms
Procedure	• taking a spade profile • examination of root length • shear strength measurement • taking soil samples to test the aggregate stability	• consulting an expert • soil sampling • assessment of general field and soil conditions • chemical analysis • data collection in standard sheets	co-ordination of different phases: • participatory soil survey • dissemination of results • training on diagnosis and recommendation • participatory technology development
Indicators	regarding soil fertility: • root density in subsoil • structure • aggregate stability • soil moisture • shear strength	sample indicators: • pH • salt content • nutrients • electric conductivity • nitrate of water extracts	• soil fertility management practice • crop choice • land management practice • quality changes in extension
Quality of the method	• quick appraisal • combination with quantitative data possible • accuracy 15-30 % • sensitive to indicator changes	• rapid assessment of soil fertility and more sophisticated tests	• qualitative and quantitative assessment • focuses on understanding and applying principles of soil fertility management
Potentials	• no preparation time • any time applicable • considers local knowledge • participation of land users • can be used as demonstration model • cost-effective	• allows more sophisticated analysis of soil chemical indicators	• extensionists, farmers and scientists share their experience • demonstration effect of profile characterisation • raising awareness and creating understanding
Limitations	• decreasing accuracy when observers are inexperienced	• considerable knowledge of chemistry required • based on experts' knowledge, costly	• expensive and time consuming for implementation and co-ordination
Equipment	• flat spade (or local tools)	• portable field laboratory • maps	• equipment for soil samples • handbook with basic information • maps, pH-meter, inclinometer, etc.
Labour requirements	• 1 person • initial training course • basic knowledge of soils • experience with farmers	• 1 person with at least basic chemical knowledge	• soil scientist (initially) • expertise in training and extension
Time expenditure	• ½ - 1 hour per profile	• several hours per site	• mapping 1 day • digging soil pits (1-2 days) • soil sampling (5-6 days) • entire process: 1 year

Toolkit

Soil Fertility Assessment - An Example from Indonesia

Dierolf, T., Kramer, E., Fairhurst, T. 1997. When there is no soil test ... Helping extension workers assess soil fertility in the tropical uplands. In: Better Crops International, Vol. 11, No.

Contact: Thomas Dierolf, Director of Operations, Jasa KATOM, JI. Kehakiman 283, Bukittinggi 26136, West Sumatra, Indonesia. [Email: Katom@padang.wasantara.net.id]

Ellen Kramer, Agriculture and Resource Management Advisor, ProRLK, P.O. Box 146, Padang 25001, West Sumatra. [Email:Prlkgtz@indosat.net.id]

Thomas Fairhurst, Deputy Director, PPI/PPIC East & Southeast Asia Program, 126 Watten Estate Road, Singapore 287599. [Email: thf.ppising@pacific.net.sg]

Objective and brief description

An approach and a collection of methods to provide extension workers with the information and skills required to carry out a simple soil fertility assessment for advising farmers on proper soil fertility management.

- A general soil fertility assessment is done using a participatory soil survey.
- Tools and methods are developed to help extension workers make specific farm-level diagnoses and recommendations, which are then tested in farmers' fields.

The following elements of an environmental education learning process are applied:

Element	Method
Awareness	Participatory soil survey
Knowledge/attitudes	Dissemination of results
Skills	Training in diagnosis and recommendation
Participation	Participatory technology development
	'Working relationship put into practice'

Procedure/steps

Major steps for each method:

1. Participatory soil survey (PSS)
   - scientists review secondary soil data
   - farmers, assisted by extension workers and scientists, sketch simple land use and soil maps. Farmers identify soils by colour, texture and presence of indicator plants
   - farmers and scientists use information from the previous steps to select representative soil pit sites
   - scientists, in the presence of extension workers, farmers, and village officials, characterise the soil pit profiles and take soil samples for basic chemical and physical analyses.
   - scientists process the results
2. Dissemination of results
   - feedback to farmers is provided through discussion in the village and visits to soil pits
   - simple diagnostic tools for farmers and extension workers are identified
   - a soil fertility handbook, training guide, and fact sheets for extensionists are created
   - presentations and workshops are organised for policy makers

3. Training on diagnosis and recommendation
   - training of trainers
   - training of extension workers in:
     - a method of diagnosing soil fertility (e.g. interviewing farmers to understand land management history, looking for soil fertility indicator plants and nutrient deficiency symptoms)
     - how to recommend improved soil fertility management (method and timing of fertiliser application, balanced fertilisation, organic material management, absolute amount of fertiliser applied)
     - conducting participatory technology development
   - developing a Soil Fertility KIT for extension workers (includes a diagnosis and recommendation process, principles of acid upland soil fertility management, tools and methods)
4. Participatory Technology Development (PTD)
   - testing recommended technology against farmers' practices on farmers' fields
   - collecting data from monitoring sites (e.g., plant height, soil and/or plant samples for analyses depend on intensity of monitoring activity)
   - analysing data/samples and recording crop yields on monitoring sites
   - discussing the results with farmers

Indicators

Visible changes in farmers' practices in the project area compared to outside farmers' practices in:

- soil fertility management (e.g., management of organic material, use of rock phosphate on acid soils, improved fertilisation practices, application method, type, timing, balanced fertilisation)
- crop choice (increased planting of perennial crops) and crop yields
- land management practice (e.g., planting along contour lines, establishing soil erosion measurements)

Quality changes in:

- extension (increased awareness of soil fertility problems, improved skills and use of participatory approaches)

Potentials and limitations

Potentials

- very suitable tool for awareness creation and extension
- focuses on understanding and applying principles of soil fertility management
- creates a better understanding of local soil fertility problems among land users, land owners, extension workers, policy makers, and scientists
- makes soil survey results relevant, transparent, and useful
- makes changes in soil fertility management visible to farmers (PTD)
- improves applicability of recommendations
- extension workers, farmers and scientists share their expertise to identify the potentials and limitations of agriculturally important soils

- extension workers increase their awareness of the properties of local soils, which will help them to assist farmers in soil fertility management
- characterising a soil profile in the field stimulates discussion about the soil among the participants
- helps to overcome the lack of accurate field-specific soil test data and fertiliser recommendations

Limitations

- requires the involvement of several agencies, the co-ordination of which may be difficult
- time consuming for implementation and co-ordination among scientists, extension workers and farmers

Investments and prerequisites

Essential equipment

- equipment to take soil samples/access to soil laboratory for analysing samples
- handbook with basic soil fertility information, including relevant chemical data on the topsoil, maps with profile locations and photos of representative profiles and indicator plants
- geological and topographic maps/pH-meter, inclinometer, camera
- transport

Labour requirements

- soil scientists/laboratory staff
- experts on developing training and extension material (first time only)

Time expenditure

- for PSS, depends on the area covered: mapping (1 day), digging soil pits (1-2/day), soil sampling (5-6/day)
- the entire process (PSS until PTD) takes 1 year

Extended Spade Diagnosis - Complex Evaluation of Soil Conditions

Beste, A. 1996. Exposé of dissertation. The extended spade diagnosis by Hampl/Kussel. Additional development and experimentation of an applicable field method for the evaluation of ecological soil vitality under agricultural management. Mainz, Germany, Unpublished.

Hampl, U. 1995. Beratung zur Umstellung auf Ökologische Bodenbewirtschaftung. Dissertation and der Universität Hohenheim. Verlag Dr. Kovac. Hamburg, Germany

Preuschen, G. .1990. Die Kontrolle der Bodenfruchtbarkeit - Eine Anleitung zur Spatendiagnose. SÖL-Sonderausgabe Nr. 2, Stiftung Ökologie und Landbau, Bad Dürkheim, Germany.

Contact: Ulrich Hampl/Andrea Beste, Stiftung Ökologie und Landbau, Weinstraße Süd 51, D-67098 Bad Dürkheim, Tel.: +49-(0)6131-63 99 01/(0)6322-80 69,
Fax: +49-(0)6322-98 97 01; E-mail: stiftung.SOEL@t-online.de

Objective and brief description

The spade diagnosis was developed in the 1930s and extended in 1994. It is a field method for assessing the effects of management practices on soil structure and its stability. Soil structure stability is highly related to the biological activity of soil organisms. The dynamics of water flow, soil structure, and soil biological activity are complex. Therefore, assessment methods have to be able to

- provide a comprehensive qualitative impression of the actual state of soil "health"
- deliver reliable data on common soil parameters

Procedure/steps

- identifying a location with representative vegetation and surface
- digging out a 'brick-like' soil sample with a spade
- examining the root structure along the profile
- taking small core samples with a defined volume from each layer
- measuring shear strength
- taking soil samples to test aggregate stability
- testing aggregate stability by moistening aggregates in a bowl and categorising their degree of decomposition

Indicators

- root density (roots/cm^3)
- soil structure
- aggregate stability (improved test of crumb stability from SEKERA)
- soil moisture, pore volume and bulk density
- shear strength

Quality of the method

- quick appraisal, which can be combined with exact and quantitative data information gained in laboratory studies, both taken from the same location
- accuracy ±15-30 %
- quite sensitive to indicator changes

Potentials and limitations

Potentials

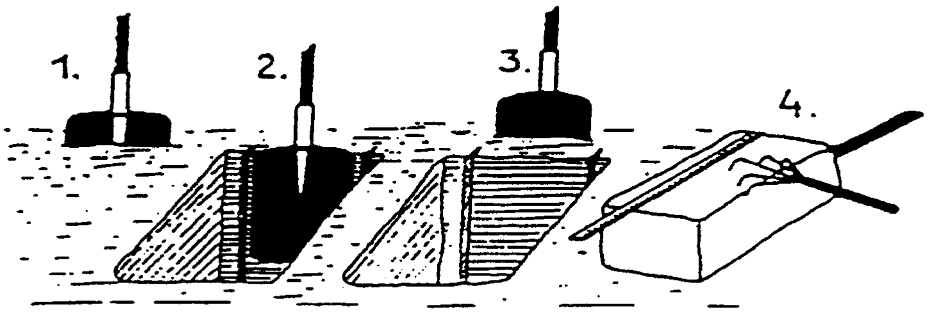
- cost-effective and easy to handle
- no preparation time
- rapid qualitative and quantitative overview
- participation of land users is useful at any stage of investigations
- farmers' experience is used in consulting other farmers

Limitations

- requires basic training because accuracy decreases when observers are inexperienced

Investments and prerequisites

- profile (U-shaped) and/or flat spade (can be produced locally)
- field forms, assessment schemes
- bowls for wetting aggregates
- initial training course by experts
- basic knowledge of soils
- experience in working with farmers



Soil Texture Estimation - The Finger Test

Herweg, K. 1996. Assessment of current erosion damage. Centre for Development and Environment, University of Berne, Switzerland, 69 p.

Hurni, H. 1986. Soil Conservation in Ethiopia. Centre for Development and Environment, University of Berne, Switzerland, 100 p.

Objective and brief description

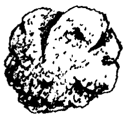
Soil texture contains a lot of information about the soil structure, soil pores, infiltration, and runoff. It can easily be determined using the following procedure.

Procedure/steps

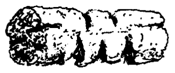
1. Take a small handful of fine earth from the soil as your sample.
2. Slowly add small amounts of water, mix it very well with the sample, and try to form a ball. Stop adding water as soon as the ball starts to stick to your hand.
3. Soil texture can roughly be estimated by using this moist sample. Try to form the sample into the different shapes shown below. If you do not have sand, start from the second picture and see how many of the following shapes you can form with your sample. The last shape that you are able to form will tell you the soil texture.

1. The soil remains loose and single-grained; it can only be heaped into a pyramid: **Sand**

2. The soil contains sufficient silt and clay to become somewhat cohesive; it can be shaped into a ball that easily falls apart: **Loamy Sand**

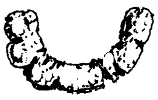


3. The sample can be rolled into a short, thick cylinder approximately the diameter of a pencil: **Silt Loam**

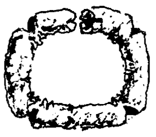


4. This cylinder can be rolled into a thinner cylinder about 15 cm long: **Loam**

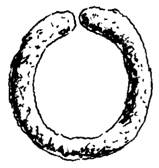
5. The thinner cylinder can be bent into a U-shape: **Clay Loam**



6. The U-shaped cylinder can be bent to form a circle that shows cracks: **Light Clay**



7. The U-shaped cylinder can be bent to form a circle without showing cracks: **Heavy Clay**



Indicator

- soil texture

Quality of the method

- qualitative texture assessment, sufficient for a first classification in the field

Potentials and limitations

Potentials
- easily applicable everywhere

Limitations
- needs some experience and feeling

Plant Leaf - Soil Fertility Calibration An Example of Combining Generic and Local Indicators

Gameda, S., Rais, M., Craswell, E., Dumanski, J. 1998. Integration of Local Knowledge and Scientific Research for an Expert System on Sustainable Land Management: a South-East Asian Case. Proceedings, Fourth World Congress on Expert Systems (in press).

Objective and brief description

Plant indicators allow conclusions about the status of soil fertility. It should be noted, however, that plant growth and leaf colour are highly specific to the plant variety and location. Therefore, the method described serves as an example. Adaptation to the conditions of your project area is inevitable!

Procedure/steps

- A range of plant indicators is identified by experienced farmers, who also do the ranking for each indicator. Guiding questions for the ranking are: Is the plant growth vigorous, normal, or stunted? Is the colour of the plant leaves dark green, yellowish throughout affected leaves, yellowish at the tips and along edges, or purple on older leaves?
- Soil and plant analysis and/or estimates of regional agronomists provide a quantitative ranking.
- The assessment, which encompasses both the indigenous and the scientific knowledge base, is done in an iterative process involving both contact farmers and regional agronomists.

Indicators	indicating
• Soil colour	soil organic matter
• yellowness of whole leaves and plant height	availability of nutrient N
• growth and colour	availability of nutrient P
• yellowness of leaf edges and plant height	availability of nutrient K

Quality of the method

With participation of appropriate personnel and knowledge development methodologies, the method is very reliable. The quality depends on:

- expertise of people developing the information base: Ideally, knowledgeable contact farmers, regional agronomists/extension officers, and research scientists.
- thoroughness of questionnaires/interviews for obtaining qualitative indicators

Qualitative ranking	*High*	*Moderate*	*Low*
soil organic matter	*dark soil*	*brown soil*	*yellowish soil*
availability of N	*dark green leaves, healthy, vigorous growth*	*colour, normal moderate growth*	*yellowish leaves, stunted growth*
availability of P	*normal growth, normal colour*	*normal growth*	*older leaves purple, stunted growth*
availability of K	*normal growth*	*normal growth*	*leaves yellowish from tip running along edge, older leaves show symptoms first*

Quantitative ranking	*High*	*Moderate*	*Low*
soil organic matter	*> 1.2%, yield reduction 0%*	*1 - 1.2%, yield reduction 0 - 20%*	*< 1%,yield reduction > 20%*
availability of N	*> 0.5%*	*0.2 - 0.5%*	*< 0.2%*
availability of P	*> 15 ppm*	*8 - 15 ppm*	*< 8 ppm*
availability of K	*> 90 ppm*	*60 - 90 ppm*	*< 60 ppm*

Assessment:

if...	*...then*
plant growth is vigorous …	*soil fertility is good*
plant growth is normal …	*soil fertility is sufficient*
plant growth is stunted …	*soil fertility is poor*
colour of plant leaves is dark green …	*soil nutrient availability is good*
colour of plant leaves is yellowish throughout affected leaves …	*soil nutrient N is the limiting factor*
colour of plant leaves is yellowish at the tips and along edges …	*soil nutrient K is the limiting factor*
colour of plant leaves is purple on older leaves …	*soil nutrient P is the limiting factor*

Potentials and limitations

Potentials

- very suitable for "information-rich" but "data-poor" regions
- methodology expandable to most regions of the developing world
- reliable method in regions where data is otherwise not available

Limitations

- knowledge/information base is highly location-specific
- dependent on the availability and expertise of personnel to develop a knowledge/information base
- an iterative process, initially tedious
- dependent on the level/depth of expertise of participating farmers, regional extension officers, and scientists

Investments and prerequisites

(Estimates for work related to plant and soil analysis and questionnaire)

Data-gathering stage (questionnaire preparation, data compilation, validation, secondary data review) = 1 person-year (includes compilation of correspondence between farmers and researchers = 3 person-months

Aggregate Stability Demonstration

Contact: Kurt G. Steiner, GTZ, Pilot project Sustainable Soil Management, Postfach 51 80, 65726 Eschborn, Germany. E-mail: kurt.steiner@gtz.de

Objective and brief description

This method allows a quick analysis and demonstration of the impact of different cultivation methods on the aggregate stability of soils. It is a qualitative method which helps to explain to local land users, for example, how soil structure has been affected by tillage and cropping methods. Soil samples are taken from fields under different cropping systems and adjacent sites under long-term fallow or forest. The samples are put into water. The differences in aggregate stability are indicated by a different fragmentation of the samples after a given period of time.

Procedure/steps

- two or three fields with quite different cultivation practices are selected with the support of local land users
- two or three samples are carefully taken from each site (e.g. with a spade or a similar tool)
- samples are put into a glass of water or just kept moist
- after a few minutes to one hour, stability can be analysed by the different breaking properties of the samples

Indicators

- aggregate stability
- organic matter (as most important component of aggregate stability)

Quality of the method

- quick appraisal
- qualitative assessment
- semi-quantitative (the time of fragmentation of the samples can be measured; the method can be repeated every year, documenting the comparisons)

Potentials and limitations

Potentials

- high demonstration effect
- simple method

Limitations

- purely quantitative interpretation is not possible

Investments and prerequisites

Essential equipment

- spade or similar tool

Time expenditure

- ½ - 1 hour

Soil Water and Erosion Demonstration Rainfall Simulation and Model ('Mr. Gumbo's Three Fields')

The methodology was developed in the framework of the AGRITEX/GTZ Conservation Tillage Project in Masvingo, Zimbabwe. Specifications on the tools can be obtained from the authors.

Elwell, H.A. 1986. Soil Conservation. The College Press, Harare.

Hagmann, J. 1996. Mechanical Soil Conservation With Contour Ridges: Cure for, or Cause of, Rill Erosion. Land Degradation & Development, Vol. 7, No. 2/1996, pp.145-160.

Hagmann, J., Chuma, E., Murwira, K. 1997. Kuturaya; Participatory Research, Innovation and Extension. In: van Veldhuizen, L., Waters Bayer, A., Ramirez, R., Johnson, D. & Thompson, J.: Farmers' Research in Practice: Lessons From the Field. IT publications, London, pp. 153-173.

Hagmann J., Chuma E., Gundani O. 1997. From Teaching to Learning; Tools for Learning about Soil and Water Conservation. ILEIA Newsletter, Vol. 13, No. 3, pp. 26-27

Contact: Jürgen Hagmann, Natural Resource Management Consultant, Talstr. 129, 79194 Gundelfingen, Germany, Tel: +49/761/54762, Fax: 54775, Email: JHagmann@aol.com

Edward Chuma, Inst. of Environm. Studies, Univ. of Zimbabwe, P.O. Box MP 164, Harare, Zimbabwe Email: ERUDO@esanet.zw

Objective and brief description

A sprinkling can ("rainfall simulator") and other tools are used to stimulate the process of group exploration, discovery, and learning, or as a basis for monitoring activities. With the help of simulation models, for example, by exploring the causes and effects of soil erosion and monitoring them in their own fields, farmers come to an understanding of bio-physical processes. Once they understand the process in their fields, they can define their indicators for observation, make use of a variety of management options suited to their needs, and experiment with them. Thus, a system is developed that corresponds best to their own needs, resources, skills, etc. In the long run, farmers become more independent of blueprints provided as solutions by a 'knowledgeable' outsider.

Procedure/steps

'Mr. Gumbo's three fields' consists of three boxes, not much larger than filing cabinets (0.3 m x 0.5 m x 0.1 m), filled with earth. There is an outlet at the bottom and a chute at the top. Under each outlet or chute, there is a glass beaker for measuring. Slope inclination is simulated by bricks underlying the boxes. One 'field' is mulched, one has tied ridges, and the third is like an ordinary untreated ploughed field. When rainfall is simulated by vigorously swinging a sprinkling can, the water shoots through a drain in the ordinary ploughed "field" over the chute into the glass beaker. With the other two 'fields', the mulch and ridges visibly retain the rain/water. It soaks in and appears after a while at the bottom of the box, flowing through a narrow tube into the other glass beaker. The 'rain' has quite clearly seeped into the groundwater, while the unprotected soil is washed down together with the water and ends up in the surface waters (container under the chute).

Questions for discussion are:

- What happened?
- Why did it happen?
- Have you seen this happen in your fields?
- What is the effect in your field and has this changed over the last few decades?
- What effect has this had on plants growing on these soils?

Indicators

- runoff
- soil loss
- groundwater flow
- soil erosion
- drought

Quality of the method

Demonstration method rather than monitoring method, which provides a qualitative impression of possible effects of land management rather than measuring real effects or indicators in the field.

Potentials and limitations

Potentials

- visualisation of land management effects
- can help land users to formulate indicators for soil erosion
- excellent visual demonstration which offers a good atmosphere for collective learning

Limitations

- simulations might imply the tendency to exaggerate results
- no (quantitative) measurement of real effects
- takes time and resources to construct the 'three fields'
- needs careful handling, otherwise effects might fail

Investments and prerequisites

Essential equipment

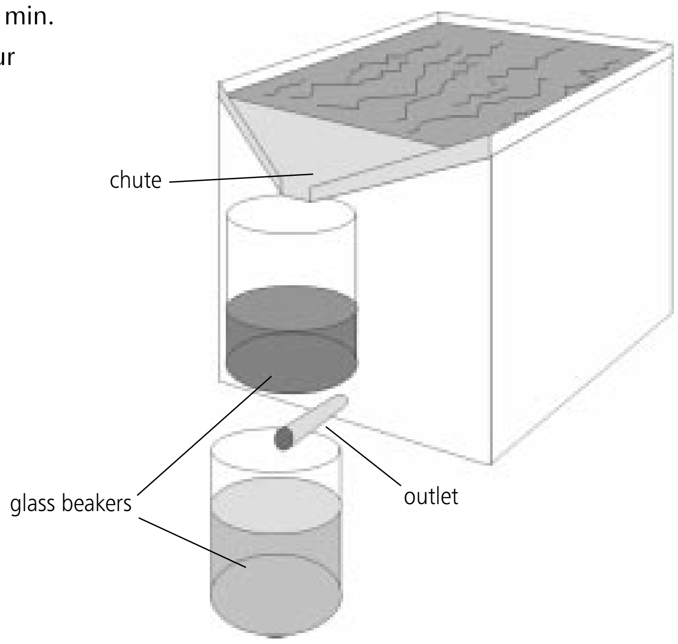
- 3 boxes (0.3 m x 0.5 m x 0.1 m), filled with earth
- watering can with sprinkler head
- bricks to adjust slope
- 3 large and 3 small glass beakers

Labour requirements

- experienced person with basic knowledge in soil erosion and conservation and with communication skills as a facilitator

Time requirements

- construction: 1 day
- demonstration: 15 min.
- discussion: >1 hour



Assessment of Current Erosion Damage (ACED)
Mapping Visible Erosion Features

Herweg, K. 1996. Assessment of current erosion damage. Centre for Development and Environment, University of Berne, Switzerland, 69 p.

Objective and brief description

ACED is a field method for assessing visible soil erosion damage of recent origin, for roughly estimating soil losses from current rill and gully erosion, and for identifying causes of erosion as starting points for corrective action. Soil losses are estimated by measuring the rill and gully volumes. Relating their occurrence to conditions in the field, to possible causes upslope, and to consequent damage downslope and downstream, results in the description of an erosion topo-sequence. This sequence - and the critical erosion points along the sequence - offer various opportunities for soil and water conservation. Besides these technology options, ACED invites further discussion of the "reasons behind the causes" of erosion.

Procedure/steps

- assessing soil loss magnitudes by measuring the volume of visible erosion features
- assessing conditions on the damaged field (surface roughness, drainage, depth of topsoil, texture, slope, vegetation cover, land management, etc.)
- observing upslope and downslope areas in regard to their link with the erosion damage
- identifying critical locations for erosion on the slope and debating possible technological solutions

Indicators

- absolute soil loss (t, m^3), soil loss per area of actual damage (t/ha, m^3/ha)
- area of actual damage as percent of field size (%)
- location of erosion features in field (sketch)

Quality of the method

- quick appraisal
- accuracy ± 15-30%
- focus on development of corrective measures

Potentials and limitations

Potentials

- easy to handle
- cheap measurement devices
- short preparation time
- rapid qualitative and quantitative overview
- provides erosion assessment between field and watershed level
- easy linkage to causes and to socio-economic/cultural/political context

Limitations

- only quantifies damage caused by single storms (no annual loss figures)
- no assessment of sheet erosion, no assessment of runoff
- inaccuracy (> 30%) when observer is inexperienced

Investments and prerequisites

Essential equipment

- manual and field forms
- meter and measuring tape
- slope inclinometer
- sketch maps

Desirable equipment

- topographic map 1:10,000 or larger
- camera, binoculars
- pocket calculator
- rain gauge (nearby)

Labour requirements

- Basic knowledge of soil erosion and SWC is needed; some experience in designing conservation strategies and practise in collaborating with farmers is desirable.

Time expenditure

- Approx. 1 day for 5 - 15 ha (depends on the amount of erosion features)

Prerequisites

- transport to cover large areas
- facilities: none
- expert advice: initial training

Sediment Traps (Troughs)

Hudson, N.W. 1993. Field Measurement of Soil Erosion and Runoff. FAO Soils Bulletin No. 68, Rome. ISBN 92-5-103406-0

Nill, D., Schwertmann, U., Sabel-Koschella, U., Bernhard, M., Breuer, J. 1996. Soil Erosion by Water in Africa, GTZ (Hrsg.), Roßdorf. ISBN 3-88085-514-5

Zöbisch, M.A. 1986. Erfassung und Bewertung von Bodenerosionsprozessen auf Weideflächen im Machakos-Distrikt von Kenia. Der Tropenlandwirt, Beiheft Nr. 27.

Contact: Kurt G. Steiner, GTZ, Pilot project Sustainable Soil Management, Postfach 51 80, 65726 Eschborn, Germany, e-mail: kurt.steiner@gtz.de

Objective and brief description

Soil movement is estimated by means of sediment traps or troughs. Eroded soil leaving a field is caught and collected by a simple tank construction to estimate soil losses from a defined area (per hectare, per region etc.). Traps are usually too small to accommodate both soil loss and runoff. The latter must be "filtered" and drained out of the trap.

Procedure/steps

1. Representative sites on a homogeneous slope are selected where the traps will be installed.
2. The catchment area for each trap should not be too large, e.g. 5 to 10 m^2.
3. Sediment boxes (metallic, e.g. 1.0 x 1.0 x 0.5 m, with removable covers) are dug in the soil at the lower end of the representative site.
4. Soil losses are estimated (e.g. per hectare) based on the amount of soil in the trap.
5. Instead of inserting a trap construction it may be sufficient to dig a hole and place a large piece of tissue in it. The soil which erodes from the field will flow into the hole and accumulate on the tissue, from where it can be removed for weighing.

Additional hints:

- Different impacts of soil and water conservation treatments can be tested simultaneously on at least two sites, after these sites have been calibrated. "Before and after" demonstrations on one site are problematic, though.
- Runoff measurement would be possible, connecting the trap to a larger container or tank. This, however, would come close to a rather costly set-up of test plots.

Indicators

- soil loss
- infiltration

Quality of the method

The method produces approximate results suitable for demonstration rather than precise data for a broader analytical approach. It allows:

- good measurement of soil loss without disturbance of test plot borders;
- more precise quantitative data than the soil loss estimation with pins, although data still display high variability and inaccuracy

Potentials and limitations

Potentials

- practicable on arable land, grassland, or forest land (with a larger catchment area)
- simple and cheap devices
- good visualisation for land users
- measurement in natural surroundings (no artificial test plot conditions)
- easy to handle, with little maintenance

Limitations

- prone to theft
- low accuracy of measurements
- simple and semi-qualitative measurement may render analysis difficult later on
- relatively high demand for supervision after each rain
- danger of obstruction (when runoff is measured)
- trap measurement is prone to high level of error if erosion rills occur on the site

Investments and prerequisites

Essential equipment

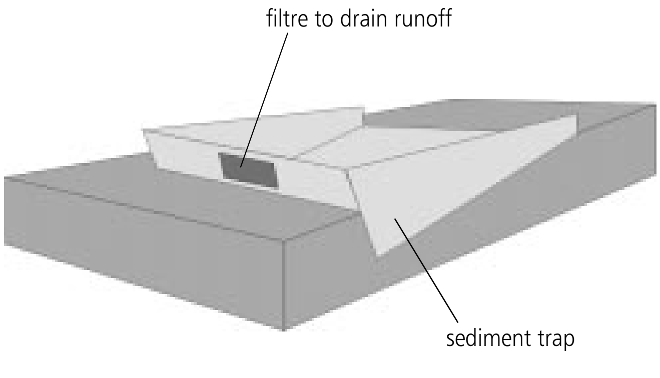
- metal sediment traps or tissue for a "sediment hole"
- rain gauges
- water balance
- inclinometer
- meter

Desirable equipment

- fence (surrounding the pits)
- connecting pipes (metal, plastic)
- collector tanks (plastic barrels)

Labour requirements

- installation: 2 persons,
- measurement: 1 person,



Time expenditure

- installation: ½ hour per trap
- measurement: ½ hour to empty each trap
- longer time for analysis, evaluation and interpretation of the data than with more precise methods

Erosion Nails (Pins)

Hudson, N.W. 1993. Field Measurement of Soil Erosion and Runoff. FAO Soils Bulletin No. 68, Rome. ISBN 92-5-103406-0

Nill, D., Schwertmann, U., Sabel-Koschella, U., Bernhard, M., Breuer, J. 1996. Soil Erosion by Water in Africa, GTZ (Hrsg.), Roßdorf. ISBN 3-88085-514-5

Moeyersons, J. 1989. La nature de l'érosion des versants au Rwanda. Institut National de Recherche Scientifique, Butare, Republique Rwandaise, Pub. 43.

Zöbisch, M.A. 1986. Erfassung und Bewertung von Bodenerosionsprozessen auf Weideflächen im Machakos-Distrikt von Kenia. Der Tropenlandwirt, Beiheft Nr. 27.

Objective and brief description

Erosion nails constitute one of the 'reconnaissance methods' which allow initial approximation of the amount of soil erosion in specific situations. If necessary, they might be followed by more precise (but also more expensive) measurements. The method is based on a visible movement of surface soil. Therefore, erosion nails are hammered into the soil up to a defined length. Topsoil removal changes the visible length of the nails that can be measured (in cm or mm).

Procedure/steps

1. Representative sites are selected.
2. A large number of nails is placed along the slope of a field, spaced several metres apart and with a lateral displacement of 10 to 20 cm, in order to avoid any interference with runoff from one nail to the nail downslope.
3. The visible length of the nails is measured after defined time periods (preferably months or longer intervals).
4. Topsoil loss (per hectare, per region etc.) is estimated.

Additional hints:

- The nails can be made of iron, sealed wood, or any other material which does not rot rapidly.
- The length of the nails should suffice to push them into the soil and give them a firm footing (nails 300 mm in length are often used). Nails in clay soil must be driven deeper into the ground, because they may be dislocated by swelling and shrinking.
- The diameter of the nails is preferably small (about 5 mm), as thicker ones could interfere with surface flow and create accumulations that distort the measurement.
- A metal washer around the nails at surface level provides a better base for measuring from the top of the nails to the washer.

There are similar procedures which are also based on verification of soil surface level:

- Rocks, boulders, tree roots, etc., serve as erosion "nails" when collars are painted just above surface level around them. The distance from the collar to the surface indicates the topsoil loss.

- Bottle caps are pressed slightly into the soil surface to protect the surface from rain splash. Sheet and splash erosion is calculated from the difference between the eroded area and the soil protected by the cap.
- Stones, tree roots, etc. protect the soil from splash erosion, conserving the "old" soil surface. The distance to the "new" surface indicates the topsoil loss.

Indicators

- soil loss
- sedimentation, accumulation

Quality of the method

- poor accuracy can partly be balanced by using a large number of nails
- the usefulness of nails is limited on clay soils with intensive swelling and shrinking

Potentials and limitations

Potentials

- as the method is cheap and simple, many measurements can be conducted simultaneously, which improves the reliability and representativeness of data
- good method on land with high soil loss rates
- good visualisation, especially for land users
- particularly suitable for measurement over a period of several years

Limitations

- a reading error of 1 mm causes an error of 10 - 15 t/ha!
- less suitable for arable land because management operations change the soil surface
- a great number of nails is necessary

Investments and prerequisites

Essential equipment

- erosion nails
- slide rule

Desirable equipment

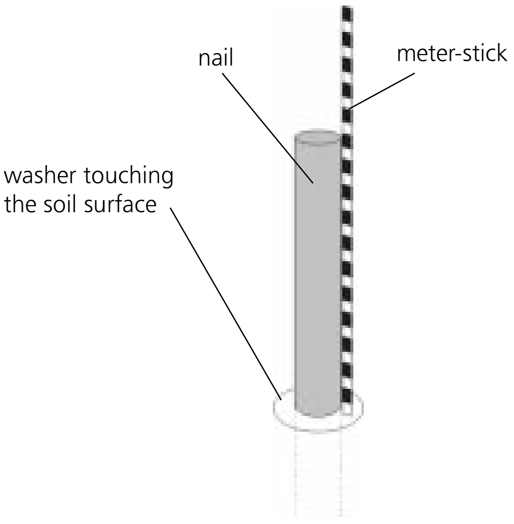
- soil maps

Labour requirements

- two persons to install and measure

Time expenditure

- measurement: a few minutes per nail



Ground Cover Estimation
Vegetation-, Mulch-, Stone-, Land-cover

Herweg, K. 1996. Assessment of current erosion damage. 69 p.; Bern.ISBN 3-906151-07-7

Nill, D., Schwertmann, U., Sabel-Koschella, U., Berhard, M., Breuer, J. 1996. Soil Erosion by Water in Africa. GTZ No. 257. Roßdorf. ISBN 3-88085-514-5

Objective and brief description

Ground cover plays an important role in reducing rain splash and sheet erosion. Plants - the major ground cover - are divided into four components: leaves, mulch, stems and roots. Leaves and mulch protect the soil from raindrop impact, the density of stems reduces runoff velocity and force accumulation of eroded particles, and the network of roots facilitates infiltration and therefore reduces runoff and soil loss. There are several simple procedures for the assessment of cover:

1. Meter-stick and knot method
2. Visual estimation using an estimation table.

Procedure/steps

1. A meter-stick or a simple cord (10 to 20 m) will serve this purpose. Depending on the desired degree of detail, 1 cm or 10 cm (dm) marks will serve as reference points on the stick. In case the cord is chosen, knots are made at intervals of cm (dm). The stick or cord is placed straight on a plot (throwing the stick on the plot may be simpler). All the cm (dm) marks or knots in contact with mulch or plants are counted on one side of the stick or cord. Cover (C) is calculated as follows:

C (%) = number of cm (dm) marks touching cover x 100 / length of meter-stick cm (dm)

2. Visual estimation of a plot requires a limited area of observation (e.g. a square of several m^2). Wooden sticks may serve to delimit this area. Small squares are assessed more easily, while larger ones might be difficult for the eye to perceive. Cover within the square is assessed using an estimation table:
   - Select the box in the table which seems to be most similar to the plant density in the field (black dots representing plants).
   - The field is then compared with the boxes showing 10% more and 10% less than the selected one, to confirm or revise the selection.
   - The procedure is repeated on at least two other plots on the same field. The average of these estimations represents the average plant cover.

With higher plants (maize, sorghum), lying on the ground and estimating the plant leaves against the sky, in addition to estimating the immediate ground cover, will give an approximation of the real cover. Land cover can be estimated using the visual estimation table and comparing it with a land use map. For all methods, the number of measurements on the same field depends on the homogeneity of the cover.

Indicators

- plant cover
- mulch cover
- stone cover
- land cover

Quality of the method

- quantitative assessment with accuracy of ±10 - 20%
- quality and variability of results depend on the homogeneity of the area, the ability to select representative plots, and the experience of the observer
- adequate method for small plots

Potentials and limitations

Potentials

- easy to handle
- indirect measurement of erodibility

Limitations

- greater inaccuracy in case of high plants
- needs some practice to calibrate the eye and the estimation table

Investments and prerequisites

Essential equipment

- meter-stick
- sticks, cord
- estimation table

Labour requirements

- 1 person; more observers may give a sounder estimation

Time expenditure

- about ½ hour/hectare

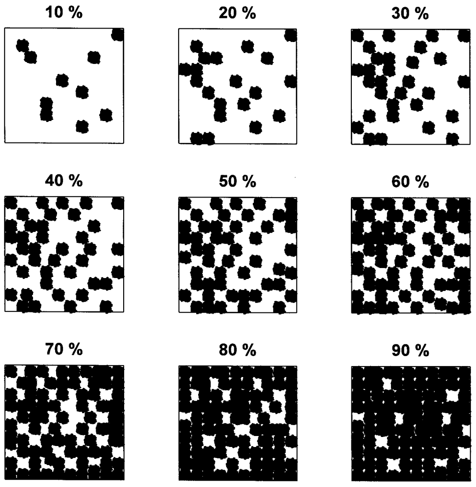


Table for visual estimation of ground cover

Crop Yield Assessment
Soil Fertility Indication

Contact: Stephan Krall, GTZ, OE 4230, P.O. Box 5180, 65726 Eschborn, Germany. E-mail: stephan.krall@gtz.de

Objective and brief description

Weighing of crop yield and biomass would be the most exact method to get realistic data about field productivity, but devices are often not available. Moreover, weighing total crop yields may be time consuming and costly. An assessment of the potential crop yield is easier to handle.

Procedure/steps

If yield variability is small, a simple assessment of potential yield per hectare can be made by the formula:

plants/ha x grains/ear of corn x weight per thousand seeds (g) x 1000.

For crops with a high number of small grains, such as millet or sorghum, weight per cm^2 of the cob's surface can be used instead of weight per thousand seeds. The cob's surface is calculated with the formula used to calculate the surface of a cylinder:

plants/ha x productive cobs or ears/plant x surface of cobs or ears (cm^2)
x weight (g/cm^2) x 1000

Potential crop yield can differ greatly from real crop yield. Therefore, variability of yield as well as yield losses have to be modified by an estimated correction factor.

Indicators

- crop yield
- field productivity

Quality of the method

- depends on variability of crop yield and reliability of correction factors

Potentials and limitations

Potentials

- easily applicable method, potential for widespread use
- easy to handle

Limitations

- probably great variation in non-homogeneous crops
- correction factors may be difficult to estimate

Investments and prerequisites

Essential equipment

- measuring tape

Labour requirements

- 1 person

Time expenditure

- 30 min/field

Cost Benefit Analysis
Example: Soil and Water Conservation

Gittinger, J.P. 1982. Economic Analysis of Agricultural Projects. 2nd Edition. Johns Hopkins, Baltimore.

Kappel, R. 1996. Economic Analysis of Soil Conservation in Ethiopia: Issues and Research Perspectives. Research Report No. 35. Soil Conservation Research Programme, Bern & Addis Abeba.

Objective and brief description

So far, the main focus of soil and water conservation (SWC) research has been on ecological and technical aspects. Monitoring activities based on social science began in order to make SWC technologies socially acceptable. The main questions are: Why do farmers do what they do? What strategies do they apply to cope with land and soil degradation? What indigenous technologies are used and might be improved? How could the acceptance of SWC techniques be enhanced? etc.

To assess whether a given technology is profitable or not, a comparison is made between a situation with and without SWC, including the costs and benefits accruing, according to the formula below. The profitability of a technology is given if the Net Present Value (NPV) is greater than zero.

$$NPV = \sum_{t=1}^{T} \frac{PC - NC}{(1+r)^t}$$

$$PC = \sum_{i=1}^{I} P_i x Q_i$$

$$NC = \sum_{j=1}^{J} P_j x R_j$$

NPV = Net Present Value
NC = Negative Cash Flow
PC = Positive Cash Flow
P = Price
Q = Quantity of Output
R = Quantity of Input
r = Discount Rate
t = Time
T = Time Horizon

Procedure/steps

- establishment of relationship between soil loss and yield decline
- assessment of current input and output prices
- assessment of costs and benefits of soil conservation (e.g. labour investments, material, loss of land, additional yield on conservation structures, etc.)
- assessment of costs and benefits of agricultural production (e.g. labour investments, crop yield, livestock production, expenses for fertiliser, etc.)
- assessment of discount rate of individual farmers
- assessment of planning horizon of individual farmers

Indicators

- profitability of a technology

Quality of the method

- quick assessment of whether a given technology can be regarded as profitable or not
- cost Benefit Analysis (CBA) is an appropriate method for assessing the profitability of a given technology. Different technologies can be assessed using the same (quantitative) method

Potentials and limitations

Potentials

- quick analysis
- comparison of different technologies

Limitations

Gives no conclusive answer to question of why farmers accept or reject a given technology because:

- the technology must fit into the current farming system or the farming system must be adaptable
- there might be other investments offering even greater profitability
- CBA is only a complement to other methods of analysis
- not all inputs and outputs in subsistence economies are valued in monetary terms

Investments and prerequisites

Essential equipment

- computer and spreadsheet programme

Desirable equipment

- none

Labour requirements

- people with basic experience in economy and computer software

Time expenditure

- depends on availability of data

Section D: Assessment of Sustainable Land Management - Introductory Remarks

Tools used for analysing data and assessing SLM

Assessment of monitoring results enables both project staff and land users to identify and prioritise problems and potential solutions and thus helps orient project programmes to the needs of the target group(s).

This section is concerned with assessment of SLM-IM results in terms of:

- **Selected methods for data analysis of on-farm trials:** Many of the methods and values used in statistical analysis assume a Gaussian normal distribution of the results. However, environmental data from on-farm trials are often highly variable and not normally distributed. Often, it is the extreme value rather than the mean which is important for an interpretation and assessment of the results. Irregularly distributed data require analysis by less sophisticated methods, which are described in this section.
- **Aggregating and ranking:** Data that differ in quality and quantity may be the most common and appropriate method for the assessment of complex systems such as a land management system. A more detailed example presented in this section explains how to aggregate values for different indicators and how to come to an overall assessment of sustainability.
- **Overall assessment of SLM:** The barometer of sustainability provides an alternative scheme for final assessment of progress in SLM. This scheme can be used if indicators for social and biophysical well-being, as well as assessment criteria for these indicators, have been determined beforehand.

see also
SLM-IM
Module,
Step 6

Selected Methods for Data Analysis of On-Farm Trials

Marks, M.K. 1996. Monitoring and evaluation toolkit. International resources group. Contract No.624-0265-C-00-3026; Project No. 683-0265. Washington D.C. 171 pp.

Mutsaers, H.J.W., Weber, G.K., Walker, P., Fischer, N.M. 1997. A field guide for on-farm experimentation. IIITA/CTA/ISNAR, IITA Publications Unit, Croydon, UK. ISBN 978-131-125-8

Steiner, K.G. 1987. On-farm experimentation handbook for rural development projects. Guidelines for the development of ecological and socio-economic sound extension messages for small farmer. GTZ, publication No. 203, Eschborn. ISBN 3-88085-342-8 (GTZ)

Werner, J. 1993. Participatory development of agricultural innovations. Procedures and methods of on-farm research. GTZ, publication No. 234, Eschborn. ISBN 3-88085-492-0

Contact: Kurt G. Steiner, GTZ, Pilot Project Sustainable Soil Management, Postfach 51 80, 65726 Eschborn, Germany. e-mail: kurt.steiner@gtz.de

The objective of this tool is to present a selection of statistical methods that are particularly appropriate for the evaluation of data derived from **on-farm trials** and **surveys**. Statistical references should be consulted for further details. The general procedure establishes the framework for data processing:

- determining an analytical framework before data collection
- data collection
- preparing raw data for analysis, which means checking
  - completeness
  - experimental errors
  - data consistency
- supplementing or adjusting data if necessary; otherwise disregarding data
- transferring data into appropriate format
- data processing (using appropriate statistical procedures)
- graphic and tabular representation
- interpretation and conclusion

Evaluation of On-Farm Trials

Objective and brief description

The purpose of on-farm experimentation is to reveal the impact of innovations brought by a project. In order to assess the potential for adoption or adaptation of a land management practice, on-farm measurement must involve economic viability, social acceptability and bio-technical feasibility.

Usually, development projects deal with on-farm conditions in a real-life context and less with highly controlled on-station research situations. Consequently, analysis and evaluation of data derived from on-farm trials require methods other than those used for analysing on-station trials. For example, in most cases the hypothesis that data are normally distributed is invalid. Soils and site conditions, as well as the management of the plots, become an experimental variable. In addition, there are numerous non-experimental variables such as yield loss to livestock or theft. The purpose of on-farm trials is to show differences between various sites or treatments (management practices or options) and explain the reasons for these differences. Therefore, statistical values related to the Gaussian normal distribution, such as arithmetic mean, standard deviation, etc., are often not useful, as they hide variability of reactions or results obtained under entirely different situations, and they give a misleading impression of comparability.

General rules for the evaluation of on-farm trials are:

- Outliers have to be examined carefully before excluding them from analysis. They might contain the most important information.
- Absolute values are often less important than ranking and proportions.
- Qualitative or semi-quantitative evaluation of results by land users should be used to complement quantitative assessments (dialogue on results using interviews, group discussions, ratings, rankings, etc.)

Below is a relatively simple description of statistic methods that are particularly appropriate for analysing on-farm data. Preference is given to non-parametric tests, as they are not based on the assumption of a normal distribution of results. Most of the methods can be used for soil, crop or economic data as well.

1) +/- Test

The +/- test is a chi^2-test (non-parametric test). It is appropriate for a large number of observations. The test can be applied either for paired or for unpaired observations. "Paired" observation means that control and test plots are always located together on one field or farm, while "unpaired" means that control and test plots are located on separate fields.

Procedures:

- "Paired" observations: Results are ranked above (+) or below (-) the value of the test plot. A chi^2-test is applied; the result of the test indicates whether the differences between land management practices or techniques (treatments) are significant or not. (Significance is the likelihood that an expected result will actually occur). If the differences are not significant, a more sensitive test may be applied.

- "Unpaired" or independent observations: In this case the median value of the control treatment is calculated and the number of control plots with values above (+) or below (-) this median is counted. If there is no significant difference between treated and untreated plots, the number of + and - must be equal. If the numbers differ, however, a chi^2-test indicates whether this difference is significant or not.

N.B.: a statistical difference between farmers' practices and an innovation, for example, does not mean that the innovation is attractive to a farmer, and that it is worthwhile for the farmer to change his management. As a rule of thumb, yield increase, for example, must be above 30% to be relevant for smallholders.

2) Analysis of variance by rank

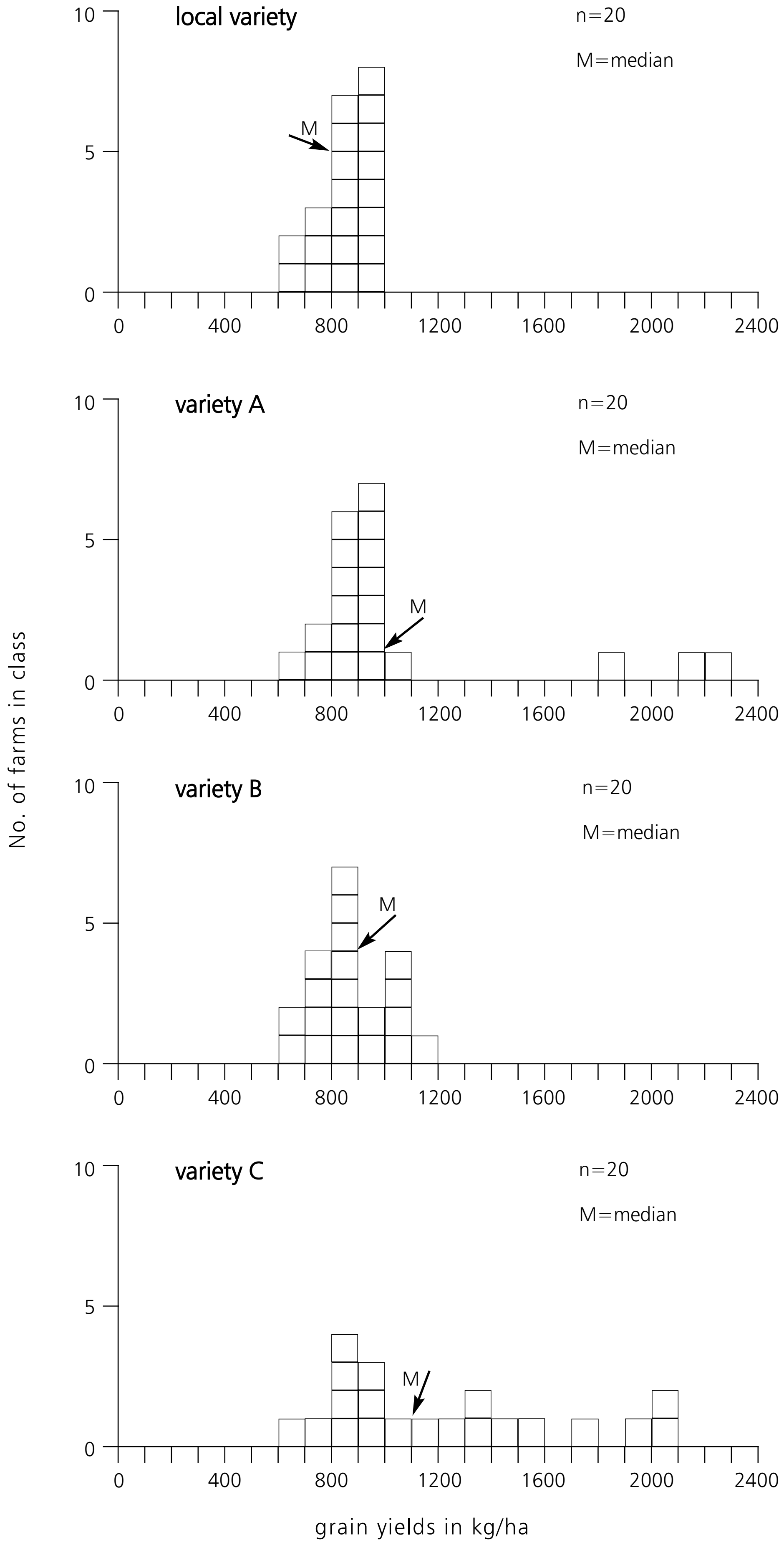
An analysis of variance (ANOVA) can only be applied to data that are normally distributed or that show a homogenous variance between groups (factor levels). In on-farm trials this is, however, usually not the case. But by converting the absolute figures into non-parametric values, by ranking the original figures, for example, ANOVA can nevertheless be applied. ANOVA by ranks indicates whether a certain treatment is always superior or not. Ranking is of special interest in a highly variable environment, such as a mountain region. Here it may indicate that the relative superiority of certain treatments changes from site to site, depending on slope, soil type, soil depth, rainfall distribution, temperature, etc. Thus, ranking may help to refine extension recommendations.

3) Frequency analysis

The frequency analysis can be used for crop data or economic data, particularly if they are not normally distributed. The analysis allows the formation of classes and subsequent analysis of the underlying reasons for the differences observed in the trials. For example, the frequency analysis may detect that only certain social groups benefit from a certain innovation, while others do not.

Procedure:

Regroup all data into classes (distribution histogram). The size and the number of the classes depend on the data, e.g. the interval between the highest and the lowest values or the number of observations. The analysis can be done with paper and pencil. The use of squared paper is helpful because one square can indicate one farm, household, or other unit. This facilitates an ex-post analysis of the underlying causes of the observed effects.


local variety
n=20
M=median
M
variety A
n=20
M=median
M
variety B
n=20
M=median
M
variety C
n=20
M=median
M
10
5
0
0
400
800
1200
1600
2000
2400
No. of farms in class
grain yields in kg/ha

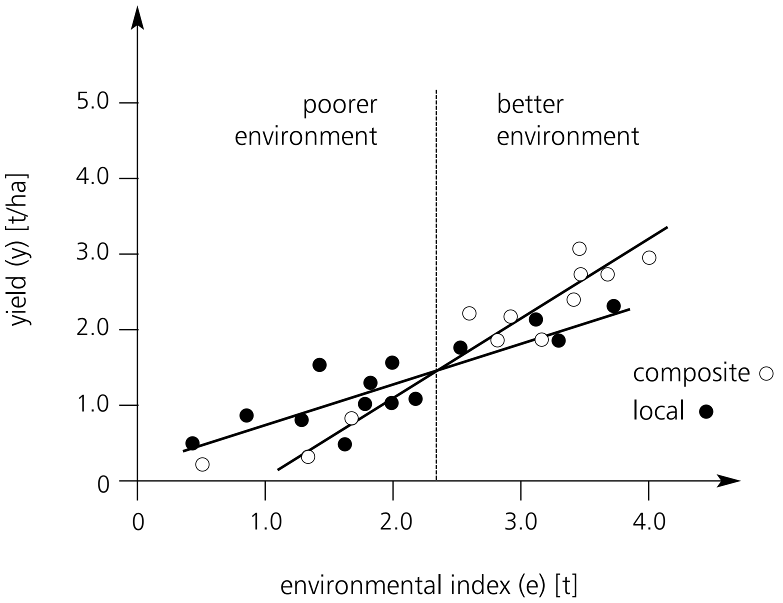
4) Stability analysis

This analysis is used to evaluate the stability of a certain treatment in different environments.

Procedure:

Calculation or plotting of linear regressions for each tested treatment (land management option): An environmental index can be established for a significant site x treatment effect. The index can be the mean yield (t/ha) of all treatments on a site, reflecting its productivity. Each site has a different environmental index depending on soil characteristic and rainfall distribution, to mention only the most important determining factors. The better the environment (higher index), the greater the mean productivity or crop yield. The basic idea of this environmental index is that crop yields with each treatment can be related to the environment by a simple linear regression.

By fitting the equation independently to each treatment (e.g. manure or fertiliser application) and plotting the yield response to the environment for each treatment on the same graph, a regression line is obtained for each treatment. The steepness of the lines is an indication of the stability of a certain treatment. The steeper the line, the more unstable the yield. The point where the lines cross divides the treatment that is more appropriate to the poorer environment (to the left of the point) from the treatment that is more appropriate to the better environment (to the right of the point). This allows the definition of different recommendation domains for each of the tested treatments.



5) Ex-post classification

Sometimes the first statistical analysis does not allow satisfactory conclusions to be drawn, if one of the tested technologies is not really superior to the others. It may be that a technology is superior only in certain cases, while it may be equal or even inferior to the control under other circumstances. In these cases it would be interesting to know if it is recommendable to divide the area into different recommendation domains, in one of which the tested technology is superior. In this case, an ex-post classification is indicated.

Procedure:

The possible interactions between tested technologies and other variables, such as soil type, fertility level, or crop rotation, are examined. In case there are indications of such interactions, the variable in question can be added to the model of the analysis of variance, or classes can be formed (e.g. high fertility - low fertility) and analysed separately with suitable statistical methods. For example: the profitability of liming can be analysed by forming classes of farms or fields with pH-values above and below 5. The hypothesis is that for acid soils ($pH < 5.0$) the application is profitable, while for non-acid soils ($pH > 5.0$) the application is not profitable. A separate analysis of variance can be calculated for each group. If the effect of liming is significant in one of the two groups, this group can form a recommendation domain.

6) Labour income (returns on labour)

Farmers are usually interested in labour income from their fields (especially for small farms), more than in the absolute returns of yields or gross margins per hectare. Farmers judge innovations mainly through changes in labour income.

Procedure:

Calculation of labour income involves data on labour requirements and opportunity costs. Labour data can be recorded either by field staff (which is expensive) or by farmers themselves after some training. Potential gains from alternative activities that are not chosen are seen as 'opportunity costs' and therefore need to be included in the calculation. In traditional societies such opportunity costs for work can also be calculated for social interactions: it is possible that in the eyes of a farmer a chat with neighbours is worth more in the longer run. This can strengthen the social network more than working overtime for an innovation that may stabilise or slightly increase yields or incomes only after some years.

The usual procedure for calculation of gross margins is applied. But it relates to person-days instead of hectares:

$$\text{gross margin} = \text{gross returns} - \text{variable costs}$$

$$\text{gross margin/person-day} = ((\text{yield} \times \text{price}) - \text{costs of inputs}) \;/\; \text{person-days}$$

In a further step, income distribution can be analysed using frequency analysis. This may show whether smaller or larger farms (often having access to better land) profit most from an innovation, and if the hypothesis of social equity is verified or rejected.

Analysis of Farmers' Assessments of On-Farm Trials

Analysis of farmers' assessments requires specific methods. Rating, ranking and paired comparison are among the most common quantitative methods. The superiority of an innovation in both agronomic and economic terms does not guarantee that it will be eventually adopted or adapted by farmers. A complementary farmers' assessment should ensure that criteria important to farmers are not overlooked in the analysis. The methods described are suitable for the analysis of relatively large and representative groups of farmers and a few different land management techniques (not more than 4 or 5). The techniques (treatments) are applicable during an advanced stage of a trial with only a limited choice of options remaining. Treatments of a more qualitative nature are applied for farmer assessments involving a greater number of options.

7) Rating

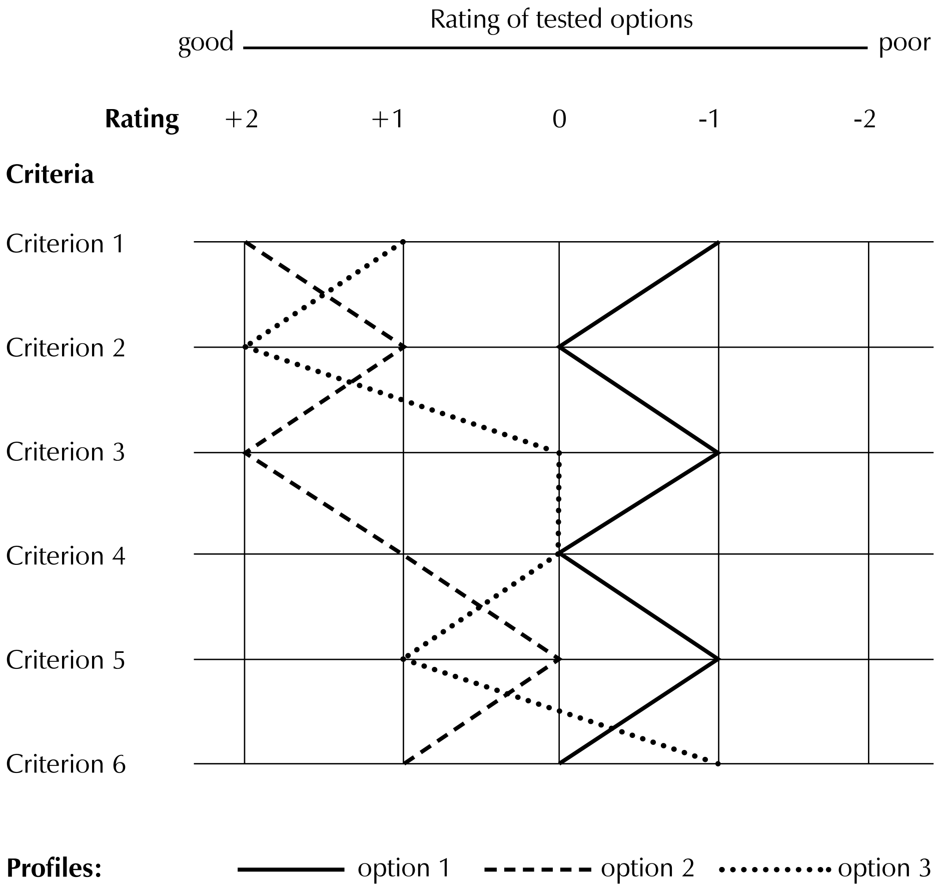
5-10 criteria that farmers consider most important are set out on a rating scale which is used to obtain a farmer-by-farmer rating of the quality of the tested treatments.

Rating scale for farmers' assessments of new varieties

Rating Criteria	*Varieties*	*Assessment*				
		very good		*fairly good*	*poor*	
		(2)	*(1)*	*(0)*	*(-1)*	*(-2)*
Compatibility with Cotton	*Var. X*					
	Var. Y					
	Var. Z					
Drought resistance	*Var. X*					
	Var. Y					
	Var. Z					
Taste & flavour	*Var. X*					
	Var. Y					
	Var. Z					

A mean rating is calculated for each treatment and criterion, either for all individual farmers or for suitable groups (i.e. all farmers in a village). The mean ratings for the tested options are tabulated or geographically compared on a profile diagram as shown below. The rating scale is the x axis of the diagram, the assessment criteria, in order of their importance, are on the y axis. Different symbols are used to mark the ratings of the different options to be compared. The "profiles" for every option are a good basis for a discussion of the overall rating of the different options tested. This is best done together with the farmers involved in the experiment.

Profile diagram for comparing farmers' ratings of different options tested in an on-farm experiment:



8) Matrix ranking

In matrix rankings farmers are asked to rank the experimental treatments with respect to defined assessment criteria. Assessment criteria are identified by farmers in advance. The most important 5 - 10 criteria are chosen for the matrix ranking. A rank is given to every treatment with respect to every criterion applied.

Matrix ranking of different cowpea varieties in a farmer's evaluation

Cowpea Variety	*Criteria*								
	overall ranking	*yield potential*	*early maturity*	*pest and disease resistance*	*compatability with cotton*	*grain colour*	*grain size*	*cooking time*	*taste and flavour*
K 80	***1***	*2*	*1*	*3*	*2*	*1*	*3*	*1*	*1*
M 66	***2***	*1*	*3*	*1*	*1*	*3*	*3*	*3*	*3*
K o95	***3***	*4*	*1*	*3*	*4*	*1*	*1*	*1*	*1*
Local	***4***	*3*	*4*	*2*	*3*	*4*	*1*	*4*	*4*

9) Paired comparison

By comparing pairs, each option tested can be judged as better or worse than another, which also involves giving reasons for evaluation. In a complete comparison of pairs with a maximum of 3 to 4 treatments (land management options), all treatments are compared with each other: A with B, A with C, A with D, B with C, B with D, C with D. This kind of comparison helps to identify the most important advantages and the most critical disadvantages of all options tested. It can eventually result in a ranking of the different options. This method is also useful in identifying suitable options for experimentation before trials are carried out.

Complete comparison by pairs of 4 cropping systems

options: *1 = coffee; 2 = vegetables; 3 = rice; 4 = maize*

pair compared	*reasons for assessment*	*score*			
		1	*2*	*3*	*4*
1 : 2	*Coffee is less risky than vegetables*	+	-		
1 : 3	*Coffee is more profitable than rice*	+		-	
1 : 4	*Maize is more difficult to market, price is low, only useful for home consumption*	+			-
2 : 3	*Vegetables are riskier than rice but more profitable when prices are good, although you can lose your shirt*		+	-	
2 : 4	*Maize only for consumption*		+		-
3 : 4	*Rice is not very profitable but necessary to grow for daily consumption; what remains is sold; maize not worth selling, only eaten occasionally; not everyday like rice*			+	-
total score and rank order	*positive (+)*	*3*	*2*	*1*	*0*
	negative (-)	*0*	*-1*	*-2*	*-3*

The positive (+) or negative (-) scores are entered into the score matrix as follows:

- *options 1 vs 2: 1 is scored (+), therefore 2 is scored (-)*
- *options 1 vs 3: 1 is scored (+), therefore 3 is scored (-), etc.*

When scoring is completed, the number of (+) signs can be summed up for each option in the matrix. This gives a rank order of the options. The final assessment should, however, not be based on the mere addition of scores but on a thorough discussion of the advantages and disadvantages mentioned.

10) Monitoring spontaneous adoption

Farmers' verbal assessments of trial options may not be the ultimate indicator of the quality of a potential innovation. However, they are available soon after a trial and therefore help to immediately improve the experimental design. But a positive verbal assessment does not necessarily mean that a proposed innovation will eventually be adopted by farmers. An experimental treatment that appeals to farmers at first glance may eventually not be feasible under real-life conditions. A better proof of the quality of a potential innovation is spontaneous adoption by farmers who were exposed to it. One way of investigating spontaneous adoption is a simple survey implemented during the season after the experiment was carried out. This survey should explore:

- the number or percentage of farmers exposed to the experiment and the trial options they adopted
- the reasons for adoption or non-adoption of trial options and modifications (adaptations) made in the original experimental treatments
- whether adoption or non-adoption depended on specific farmer group characteristics

Combining interview and observation in the field helps ensure that the information obtained reflects the actual situation. A quantitative assessment gives some indication of the extent to which a potential innovation can be adopted if it is promoted by the extension service. A high rate of spontaneous adoption suggests that a technology can be confidently promoted by the extension service. A high degree of rejection means that a trial innovation is not yet ready for extension recommendation. Knowing the reasons for non-adoption and observing which modifications are made by farmers helps researchers to improve experimental options and to adapt the trial design.

11) Analysing farmers' assessments for statistical differences between treatments

The most common statistical tests are applicable only in terms of measured (metric) figures, but not in terms of ordinal numbers originating from farmers' ranking or rating of treatments. There are, however, very simple non-parametric tests available which can be used to analyse whether significant differences exist between treatments with regard to their assessment by farmers. The following non-parametric tests are suitable:

- A very useful test is the **'Friedman's test'**, which is unfortunately not included in statistical computer programmes, but very easy to calculate by hand. It is used to test differences among treatment mean values when the same set of treatments was assessed by all farmers involved in the test. It allows comparison of more than 2 treatment mean values for a single variable (such as the overall assessment of treatments or any other defined assessment criterion) at a time. Scored (rated) as well as ranked data can be used.
- The **'Cochran's Q-test'** is a modification of Friedman's test which is applied when data exist only in two categories (for example: "above average" and "below average", or "adopted" and "not-adopted"). It therefore allows analysis of data from adoption surveys of differences between treatments with regard to adoption by farmers.
- The **'Mann-Whitney-Test'** can be applied to data from ratings or rankings if there are only two treatments to be compared.
- The **'Wilcoxon Matched Pairs Test'** is used to test differences between two paired groups of data, as they appear for example in the "paired comparison".
- Sometimes it is interesting to determine whether there is a relationship between specific target group characteristics of farmers and their preference for a particular treatment. This can be checked with an **analysis of frequencies** in a **two-way table.**

Aggregating Indicator Values by Rating - An Example

Gomez, A.A., Swete Kelly, D.E., Syers, J.K. and Coughlan, K.J. 1996. Measuring sustainability of agricultural systems at the farm level. In: Methods for assessing soil quality, SSSA Special Publication No. 49, Soil Science Society of America, Madison, USA, pp. 401-409.

In this particular case study land management was considered sustainable at farm level if the needs of the farmer are satisfied and natural resources are conserved. Indicators for the first issue were crop yield, net farm income, and frequency of crop failure; those for the second issue were soil depth, organic C, and permanent ground cover. Indicator values for ten farms in Guba, Philippines, are shown in the first table. Threshold values, denoting the boundary between sustainable and unsustainable indicator values, were defined (second table) and the indicator values for the ten farms were converted into the threshold values (third table). A converted value of one indicates that the specific indicator is at a sustainable level. Subsequently, the indices for farmers' satisfaction and natural resource conservation were computed as averages of their three respective indicators. To be considered sustainable, the individual converted values as well as both averages should exceed 1.0 (only farms 1 and 5). The final index for sustainablility is obtained by computing the average of both indices; the higher the value, the more sustainable land management is at farm level.

Sustainability indicators for 10 farms in Guba, Cebu, Philippines:

	Farmers' satisfaction			**Resource conservation**		
Farm No.	Yield t/ha	Net income $/ha	Frequency of crop failure %	Soil depth cm	Organic C %	Permanent ground cover %
1	1.88	252	15	117	1.15	25
2	1.42	163	20	80	0.52	14
3	1.43	195	20	87	0.72	17
4	2.02	247	30	37	0.60	14
5	1.75	203	25	86	1.26	16
6	1.62	227	25	70	0.80	14
7	0.88	38	20	47	1.61	7
8	0.52	30	15	27	0.82	0
9	0.98	116	20	100	1.74	0
10	0.81	29	15	42	0.82	1
Average	1.33	150	20.5	69.3	1.06	10.8
Threshold	1.60	180	20.0	69.3	1.06	15.0

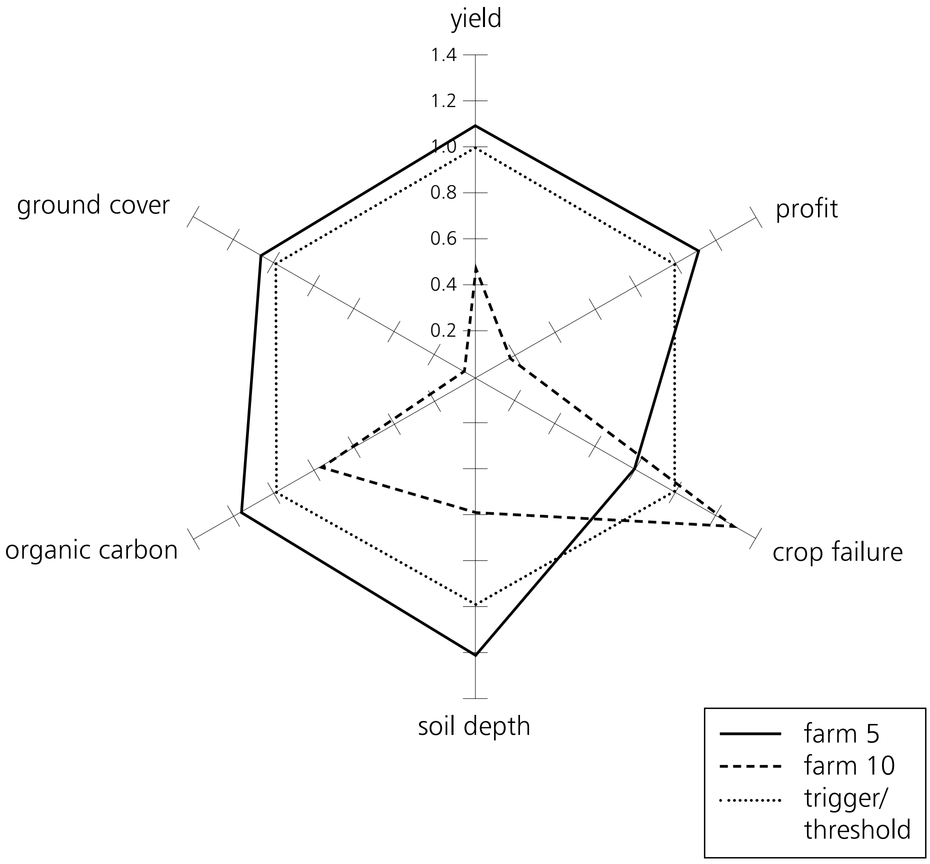
Threshold levels for sustainability indicators:

Indicator	Threshold level	Threshold formula
Yield (X1)	20 % higher than average yield in the community	1.2 (Mean X1)
Profit (X2)	20 % higher than average in the community	1.2 (Mean X2)
Frequency of crop failure (X3)	20 %, or average frequency for the community, whichever is lower	0.20 when the mean of X3 > 0.20, mean of X3 otherwise
Soil depth (X4)	50 cm or the average of similar soil types in the community, whichever is greater	Mean X4 or 50 cm, whichever is greater
Organic C (X5)	1 %, or average of community, whichever is higher	0.01 when mean X5 < 0.01, mean X5 otherwise
Permanent ground cover (X6)	15 %, or average of community, whichever is higher	0.15 when mean X6 < 0.15, mean X6 otherwise

Sustainability indices for 10 farms in Guba, Cebu, Philippines:

	Farmers' satisfaction				**Resource conservation**				
Farm No.	Yield	Profit	Crop failure	Index	Depth	Organic C	Ground cover	Index	Sustain-ability index
1	1.18	1.40	1.33	1.30	1.69	1.65	1.66	1.66	1.48
2	0.89	0.90	1.00	0.93	1.15	0.49	0.93	0.85	NS
3	0.89	1.08	1.00	0.99	1.25	0.68	1.13	1.02	NS
4	1.26	1.37	0.66	1.10	0.54	0.57	0.93	0.68	NS
5	1.09	1.13	0.80	1.01	1.24	1.18	1.07	1.16	1.08
6	1.01	1.26	0.80	1.02	1.01	0.75	0.93	0.89	NS
7	0.55	0.21	1.00	0.59	0.68	1.51	0.47	0.88	NS
8	0.32	0.16	1.33	0.60	0.39	0.77	0.00	0.38	NS
9	0.61	0.64	1.00	0.75	1.44	1.64	0.00	1.02	NS
10	0.51	0.16	1.33	0.67	0.61	0.77	0.07	0.48	NS

Star or spider diagram for SLM at farm level. Depicted are the indicator values for farms 5 and 10, as well as the threshold values for the example of the previous tables:



Barometer of Sustainability

IUCN 1997. (World Conservation Union). An approach to assessing progress towards sustainability - Tools and training series. IUCN/IDRC, Gland, Switzerland.

The "Barometer of sustainability" is a graphic representation of the state of an ecosystem with reference to the well-being of the human system and the ecosystem considered the two fundamental dimensions of sustainability (see Figure below). The barometer is aimed at facilitating progress towards sustainability (beyond SLM) by showing where the system under consideration is performing unsustainably, and by treating the ecological and human dimensions of sustainability as equally important. In the graphic representation these dimensions are orthogonal axes and are expressed in qualitative (from "*bad*" to "*good*") or in standardised quantitative values (from 0 to 100, or from 0.0 to 1.0). The rating needs to be determined together with stakeholders.

In judging the change in the system under study, progress towards sustainability is made only if the human or ecological dimensions of the system improve without a decrease in the complementary dimension. In this regard, lower scores always override higher ones (e.g. if an ecosystem scores *good* for human conditions, but *bad* for ecological ones), the overall assessment is that the ecosystem as a whole is *bad*, i.e. unsustainable. The same is true if human conditions are *bad* and ecological conditions are *good*. In the Figure, the categories *good*, *poor* on the x axis, etc., correspond to the same gradation and type of scale on the y axis. This may not always be the case, and one could imagine that scales may be different, i.e. the same category *good* could cover a different range on the numerical scale on each of the axes, and the scales themselves could be arithmetic or logarithmic.