Food and Agriculture Organization of the United Nations

LAND AND WATER DIVISION
WORKING PAPER 17

Land Degradation Assessment in Small Island Developing States (SIDS)

17 LAND AND WATER DIVISION
WORKING PAPER

Land Degradation Assessment in Small Island Developing States (SIDS)

By

Janie Rioux
Land and Water Division
FAO, Rome, Italy

Ronald Roopnarine
The University of the West Indies
Trinidad and Tobago

Riccardo Biancalani
Land and Water Division
FAO, Rome, Italy

Monica Petri
Land and Water Division
FAO, Rome, Italy

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2017

ISBN 978-92-5-109904-9

This publication has been printed using selected products and processes so as to ensure minimal environmental impact and to promote sustainable forest management.

Cover photo: © FAO/Daniel Hayduk

Contents

Abbreviations and acronyms

DPSIR	Drivers-Pressures-State-Impacts-Responses
FGD	Focus group discussion
LADA	Land degradation assessment in dry areas
LD	Land degradation
LUS	Land use systems
LUT	Land use types
FAO	Food and Agriculture Organization of the United Nations
NGO	Non-governmental organization and SLM
QM	Questionnaire for mapping land degradation
SIDS	Small Island Developing States
SLM	Sustainable land management
UNEP/GEO	United Nations Environment Programme/Global Environment Outlook

1. Introduction

LAND DEGRADATION ISSUES IN SIDS

Including Urbanization/Development process creating land degradation

Sustainable management of the natural resource base is a fundamental issue to support global environmental benefits provided by ecosystem services, and to ensure agricultural production and ultimately food security and livelihoods. Assessing Land degradation is a major component of effective sustainable land management particularly in Small Island Developing States (SIDS).

Land Degradation is considered to be "…any form of deterioration of the natural potential of land that affects ecosystems integrity, either in terms of reducing its sustainable ecological sustainability or in terms of reducing its biological richness and maintenance of its resilience" (GEF, 2003). Globally it affects over 100 countries on all continents with Antarctica being the only exception (Springer, 2006).

SIDS are generally characterized by high levels of chronic poverty, largely rural-based populations and heavy dependence on traditional agriculture and with specific reference to the Caribbean region, tourism based economies. In each instance land degradation has devastating effects on these countries such as significant structural constraints for economic growth, human development and environmental sustainability. At the same time, SIDS, possess unique characteristics, that further exacerbates the problems associated with land degradation, given the small size of the countries (in terms of both physical area and economy), limited infrastructure, distance from large international markets, high vulnerability to natural disasters low level of human resource development and increasing urbanization. Small size, combined with, diverse soil types, topography, climatic variation, lack or in some cases archaic and poor land use policies limits the area available for urban settlement, agriculture, mining, commercial forestry, tourism and other infrastructure, and creates intense competition between land use options. It is estimated that of the 400 ha of degraded land in SIDS worldwide, 120 ha occur in the Caribbean region and 30 percent of the reefs in the Caribbean are at risk (UNEP/GEO). In SIDS of the Caribbean, Land degradation has increased in the last 30 years related in some way to the following factors:

- **Economic:** market forces, trade agreements, structural adjustments, national economic and land use policies, land tenure policies etc.
- **Social:** urbanisation, immigration, population dynamics and growth, cultural changes etc.
- **Environmental:** rainfall variability, water quality and quantity, access to water etc

More specifically, land degradation is caused by poor land management practices such as slash and burn agriculture, uncontrolled livestock grazing on fragile lands, poor road construction and unplanned or poorly planned settlements in landslide-prone areas (Ahmad, 2011). Annually colossal amounts of valuable top-soil is eroded away and washed into rivers and out to sea during heavy rains. Over time, the productivity of land for agriculture is lost, as is the productivity of coral reefs as they become blanketed by silt. This presents challenges in maintaining food security as well as economic stability particularly on the islands with tourist based economies. Siltation of rivers increases the flood-risk in low-lying areas with potential for loss to life property and may also threaten agricultural productivity. Most aspects of environmental management in SIDS are directly dependent on, and influenced by, the planning and utilization of land resources, which in turn is intimately linked with coastal and marine management and protection. Consequently, land degradation also results in deteriorating water quality and wetlands particularly in coastal and marine areas.

In the SIDS of the Caribbean, and Latin America, Land degradation costs an estimated US$ 4 800 million dollars annually, and impacts approximately 125 million people within the region (UNEP, 2006). It directly impacts human livelihoods and survival, with significant negative implications for the most vulnerable groups in society. According to the Food and Agriculture Organization (FAO), land degradation is one of the root causes of declining agricultural productivity globally; if left uncontrolled, it will exacerbate the problems of food security within the region (Beckles, 2010). Additionally, it hampers the capacity of SIDS to adapt to climate change, which is one of most poignant developmental challenges facing SIDS. Degraded land is costly to reclaim. If severely degraded, it may no longer provide a range of ecosystem functions and services, and many other potential environmental, social, economic, and non-material benefits that are critical for society and development (LADA Secretariat, 2000).

OBJECTIVES OF THE ASSESSMENT

A key component of SLM planning is an overview of *where* land degradation takes place, *which* type, at *what* intensity and *how* land users are addressing this problem through sustainable land management. Moreover, the causes of land degradation and its impacts on ecosystem services and people livelihoods are often not fully understood resulting in a lack of appropriate and effective responses. The use of the LADA methodology is one tool that can contribute to filling these knowledge gaps.

The LADA Local assessment methodology aims to deliver an understanding, not only of the state and nature of change in the land resources (soil, water and biological resources) and ecosystems, but also of the drivers of and impacts of land degradation and sustainable land management, the impacts they have on ecosystem services and livelihoods, also the effects of recent response measures adopted by land users and other actors. The premise of this approach is that it is not the degradation of the land *per se* that is the problem, but the impacts this degradation has on things that matter to people: their livelihoods and ecosystem services.

This assessment approach, manual and associated training build on country experiences and are expected to enhance the capacity of users to conduct more integrated and participatory assessments of land degradation and to monitor impacts of interventions or changes in land management more effectively. The manual reflects a substantial shift in attention from the conventional focus on assessing degradation to a balanced assessment that looks at both the negative and positive effects and trends of land use/ management on natural resources and ecosystem services.

2. Approach and methodology

2.1 APPROACH AND LINKAGES BETWEEN THE LOCAL AND NATIONAL LADA ASSESSMENTS

The LADA methodology aims to assess and map land degradation and sustainable land management. The LADA assessment is carried out at two spatial scales: local, and national, and considers land degradation status, drivers and impacts within land use systems (LUS). Land use is the single most important driver of land degradation as it focuses on interventions on the land which directly affect its status and impacts on goods and services.

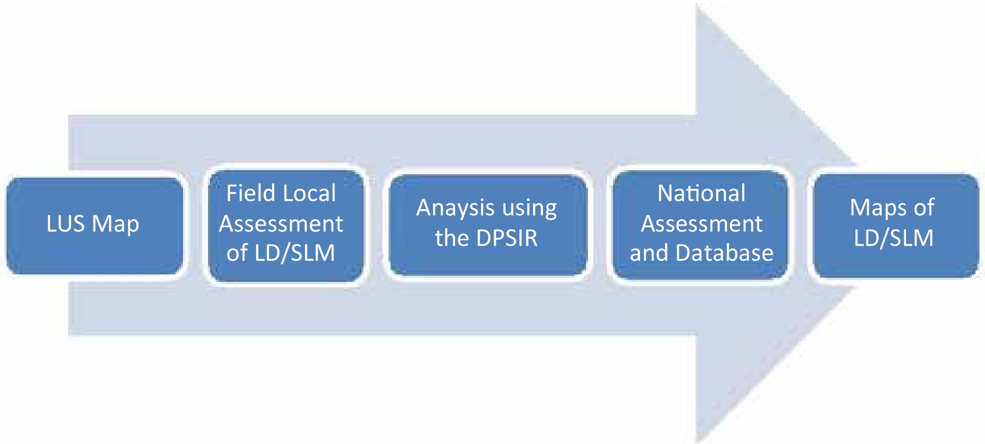
Knowledge of local biophysical and socio-economic conditions is needed to explain and relate the land use to land degradation and vice versa. Local policy makers and other stakeholders should be consulted and involved in the assessment where practicable as they will generally be interested in the assessment activities and results. The timing of the assessment in terms of seasonality is important and should be agreed with local stakeholders.

At the local level, the LADA assessment aims to provide a standard methodological approach and tool-kit for the assessment of land degradation processes, their causes and impacts at local level in collaboration with local stakeholders and communities. The focus is on human-induced land degradation; however, natural degradation processes are also considered. For a more balanced and complete understanding, the approach also assesses the extent to which land resources (soil, vegetation, water) and landscapes/ecosystems are being conserved and/or improved by sustainable land management (SLM) practices. The local assessment results can be used in the context of a monitoring and evaluation programme aiming at improved and responsive decision making on sustainable land management and rural development.

At national level, the LADA assessment aims to evaluate what type of land degradation is actually happening where and why and what is being done about it in terms of sustainable land management (SLM) in the form of a questionnaire. Linking the information obtained through the questionnaire to a geographical information system (GIS) allows the production of maps as well as area calculations on various aspects of land degradation and conservation. The map database and mapped outputs provide a powerful tool to obtain an overview of land degradation and conservation in a district, province, country,

For small-islands, the LADA approach starts with the development of the LUS map, the field based local assessment of land resources and livelihoods for the main LUS in each administrative unit (e.g. parishes in Grenada), and the assessment of land degradation and sustainable land management at national level by administrative units and LUS.

FIGURE 1
SUMMARY OF THE PROCEDURE FOR DEVELOPING LD/SLM MAPS



The main five steps of the approach are:

1. From the land cover map, developing the Land Use Systems map.
2. For each land use system and each administrative unit, land degradation and sustainable land management will be assessed - using the LADA local assessment methogology and tools, with modifications and aditions for the SIDS.
3. The results of the local assessments in all parishes will be analysed using the DPSIR framework,
4. Based on the local assessment data and analysis and secondary data, the national assessment will be done by experts using the QM software, and assemble into a harmonized national land degradation and conservation database.
5. Maps of land degradation and conservation will be produced on the basis of the national assessment.

2.2 ANALYTICAL FRAMEWORK

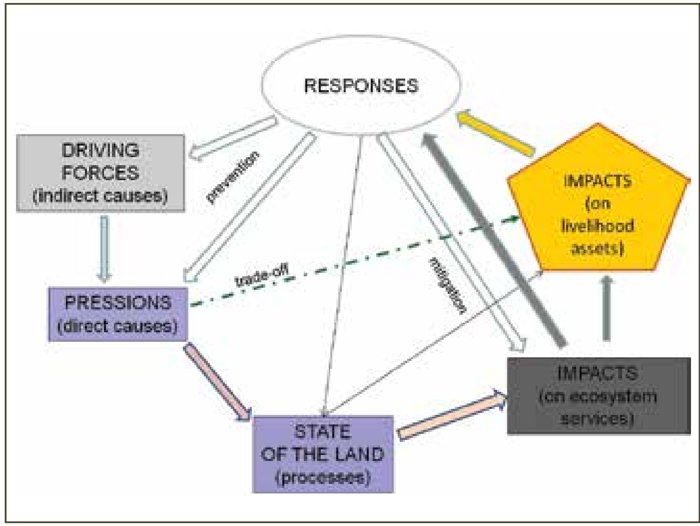
The DPSIR (Driving Forces-Pressures-State-Impacts-Responses) framework is used to help analyse the relationships between the State (status and trends) of land resources; the direct Pressures on land resources; the Driving Forces (the indirect drivers that act on the Pressures); the Impacts (of changes in the State) on ecosystem services and on people's livelihoods; and possible Responses from land users, policy makers and other stakeholders designed to mitigate land degradation, adapt to its impacts or promote SLM. The linkages between framework components are clearly represented in the DPSIR diagram. DPSIR analysis is core to the LADA assessment approach, as it helps the user link all parts of the assessment and guides the synthesis and analysis of the findings, including trade-offs among different stakeholders or land uses. The Ecosystem Services and Sustainable Livelihoods Frameworks are used to help understand the impacts of current/recent land uses and management practices on ecosystem goods and services and on the livelihoods of local people.

The objective of much of the primary data collection in the local assessment is to generate a picture of the State of land resources (soil, vegetation, water) and the nature of and change in these resources. A range of indicators and indices are included to do this, supplemented with information from land-users and data from secondary sources.

FIGURE 2
LADA LOCAL ANALYTICAL FRAMEWORK: TO ANALYZE FINDINGS OF THE LOCAL ASSESSMENT

Drivers
- Macroeconomic /environmental policies
- Land use planning/rural development strategies
- Population, poverty, land tenure
- Extreme events - climate change, civil strife
- Natural disasters (drought, flood)
- Population growth

Pressures
- Demands of sectors e.g. forestry, agriculture, urban
- Demands for services e.g. waste disposal, recreation
- Land use intensity
- over-cultivation (nutrient mining, pollution)
- overgrazing (compaction, vegetation decline)
- land abandonment



Responses
- Land use/management practices
- Support for conservation and rehabilitation
- Investments in land and water resources
- Land policies and policy instruments
- Macro-economic policies
- Monitoring and early warning systems
- Revise and implement national action plans (food security, environmental)

Impacts
- Crop/animal yield decline
- Poverty, heath and migration
- Goods & services derived from the land
- Availability of quality water
- Carbon storage/GHG emissions
- Loss of biodiversity (habitat, species, genetic resources)

State

Status	**Dynamic**
Soil quality (depth, fertility etc.)	Erosion, contamination, salinization
	Soil formation/sedimentation
Vegetation cover	Change in biological diversity
Water resources	

Trade offs

It is important to define the trade-offs between different land uses / management practices in order to design remedial actions/responses that will reduce pressures on land resources & ecosystems. Trade-offs can reflect one or more dimensions:

- Human - trade-offs among stakeholders (e.g. farmers versus herders interests)
- Temporal - trade-offs between short and long term responses (e.g. monocultures that give high yields for 1-2 years but cause fertility loss/salinization, etc. versus diversified systems that sustain yields and provide diverse products)
- Spatial - trade-offs that reflect differential on-site and off-site impacts (e.g. investment in upstream/upslope management that reduces damage downstream i.e. soil erosion, water quality, flood risk

The same mix of information sources is relied upon to help identify important Impacts caused by the State of the land resources on ecosystem services and on livelihoods. Community and land user interviews are particularly important in providing information on the Driving Forces (e.g. indirect reasons for adopting a practice that degrades land resources rather than a more sustainable practice). The most appropriate Responses, designed perhaps discourage use of the more degrading practices by land-users or encourage and improve SLM adoption, would generally be identified through discussing the assessment results with a wider group of people than those involved in the assessment, including local policy makers, project officers and government officials. In summary, users are encouraged to use DPSIR as the main framework to help with understanding, organizing and presenting the assessment results.

2.3 SELECTION OF THE ASSESSMENT AREAS

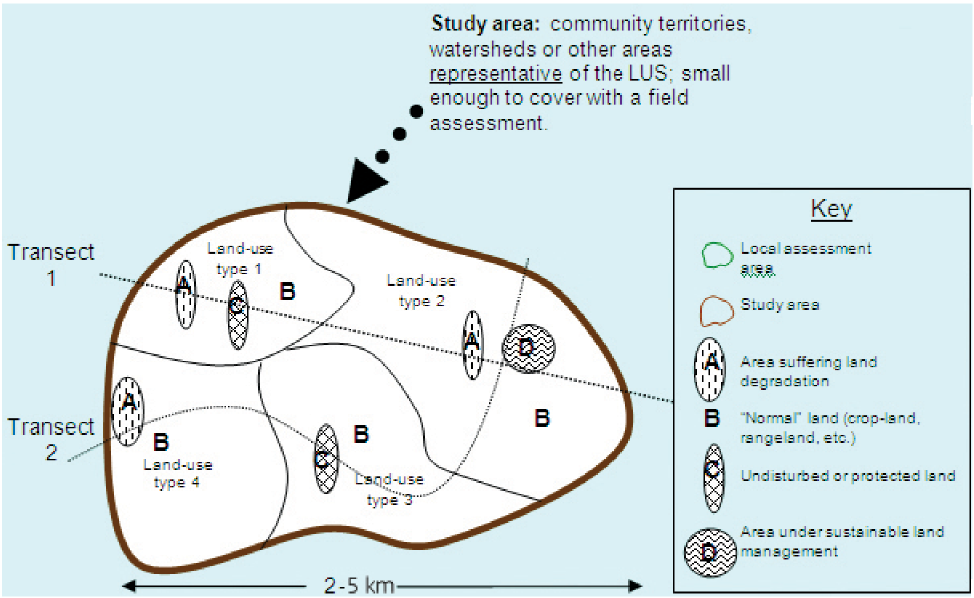
LD/SLM information is required from the local assessment that could be extrapolated to give a picture of land resources "status" for larger land units or land use systems. Thus it is important to select the local assessment areas to be representative of these larger areas or systems.

In small islands of 50-60 km of diameter max, we suggest to start with the local assessment, which results would be consolidated later into a national database. The main stratification to select the assessment areas is based on the LUS identified in each administrative unit (e.g. parish), as the local assessment will assess the state of the land resources within each LUS. Given the size of the islands, users are encouraged to sample each administrative units, with duplications if needed, in order to get information on all the LUS units and at the same time to have a density of information such to be able to create a national map at a suitable and meaningful scale. In each admin unit, one or more LUS should be sampled, in order to have a homogeneous and enough detailed coverage of the entire island (See Figure 4). Thus, in each admin unit the selection of the local assessment areas can be done either by targeting a specific land use system (LUS) of interest, or by selecting an area of interest and assessing the main (2-3) LUS within that area. The most suitable approach in a particular situation depends on the heterogeneity of the assessment area in terms of LUS and of the land management practices present within a LUS.

In order to be able to consolidate the local results to the national level, the reasoning behind the sampling should follow this sequence of steps:

1. Based on the LUS map, identify the nationally important LUS i.e. those most requiring in depth investigation;
2. In each admin unit, choose the areas where these important LUS are represented. These LUS can be analyzed several times in different admin units. However, given the scale required by the national consolidation, ALL the identified LUS units should be described at local level in at least one instance.
3. Carry out the local assessment in the identified areas. Again, for the sake of the consistency and robustness of the results at the needed scale level, it is essential that each LUS and each admin unit are analyzed at least ones. However, it is not necessary to do the local assessment in each LUS within each admin unit, as this would cause redundancy and excess of burden for the organization of the survey.

FIGURE 3
HIPOTHETICAL STUDY AREA MARKED WITH TWO TRANSECTS CUTTING ACROSS THE MAIN LUTS AND LAND UNITS AND REPRESENTATIVE AREAS SHOWING LAND DEGRADATION AND SLM



2.4 CONSOLIDATION INTO A NATIONAL DATABASE

The information collected during the local level assessment in the various LUS and administrative units will serve two purposes: the characterization of the local areas actually surveyed, and the creation of a national database founded on the consolidation of the local information.

While the characterization of the local areas follows the guidelines already provided in the relevant part of this manual, the consolidation is a specific activity of the small island assessment method. It should adhere to the following three main steps:

1. Recompilation of the local data and information

After the local surveys have been finalized, they should be reviewed in order to identify the similarities, differences and above all make a stock of all the indicators that have been used. Draft tables can be used to summarize the information available in the main groups of soil, biomass and water, as well as for the livelihood related information collected through the local interviews.

2. Cross-checking of that information with the indicators set described in the QM manual

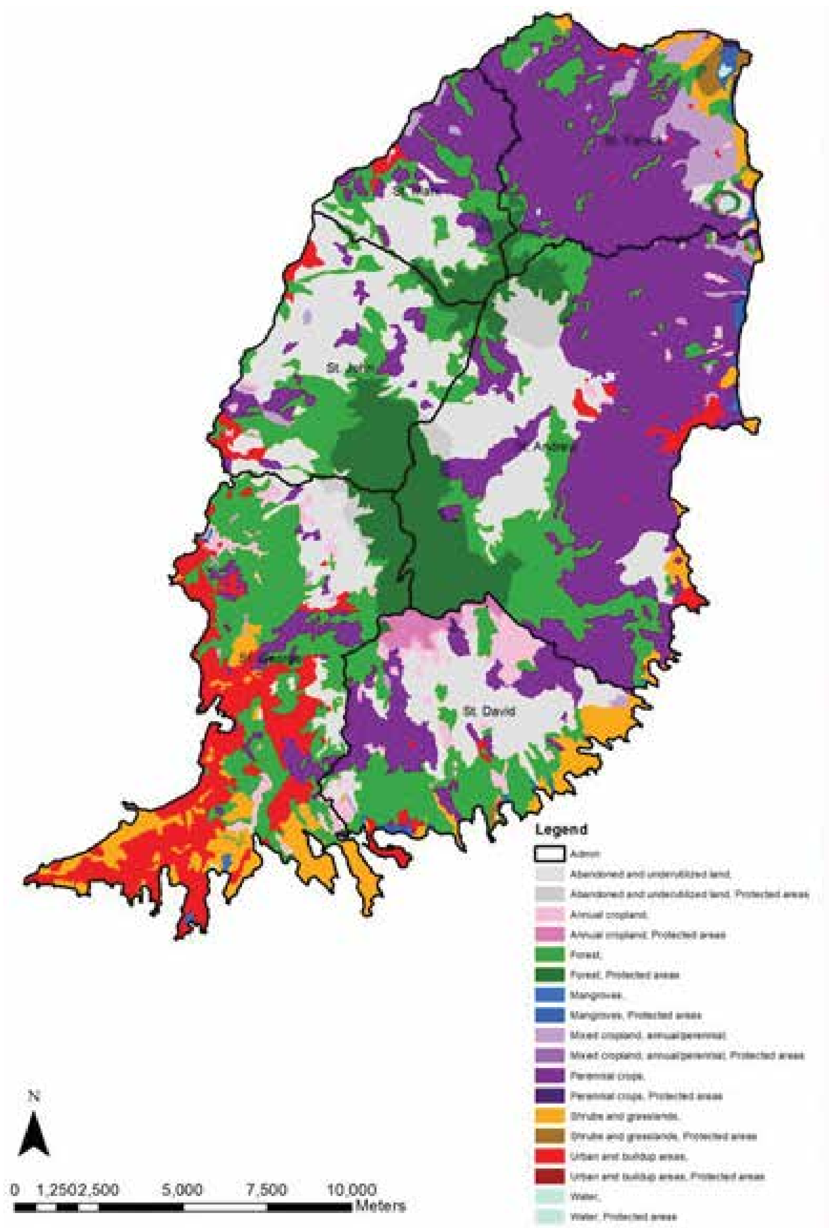
Once the information has been compiled, it should be cross-checked with the indicators actually present in the QM. This with the purpose to ensure that all relevant information can be described according to the available indicators. In the case that one or more indicators would be missing, they should be created following the guidelines provided by LADA, at http://www.fao.org/docrep/017/i3240e/i3240e.pdf

3. Filling of the QM database

The QM database can be filled according to the outcome of the consolidated local surveys. That can be done following the guidelines provided in the QM manual.

However, the national team should take in mind that the national assessment is supposed to describe the general, or average situation of land degradation and improvement in the country, not just the results obtained at the local sites. Hence, it is needed that the team makes an effort to spatialize those data, giving attention to the spatial part of the manual itself (area changes, percentages). Actually, the team should keep this need into consideration even during the local assessment survey, having care of noting not just the data collected on site, but also the changes and features that can be visible along the roads and during the transect walks, including taking pictures and GPS points.

FIGURE 4
LAND USE SYSTEMS MAP OF GRENADA



3. Characterization of the study area

INTRODUCTION

The characterization of the study area is organized and conducted using a participatory process with the selected local community/communities and resource people from local/ national technical sectors and local authorities. There are two main objectives:

Firstly, to provide an overview of the study area as the context within which land degradation and sustainable land management (LD/SLM) are occurring. The characterization should enable the team to confirm that the study area is representative of the larger local assessment area and/or one of the national level land use systems (LUS) within it.

Secondly, the characterization will provide the team with a rational basis for selecting the location of the transects and detailed assessment sites for the soil and vegetation assessments. The definition of the community depends on the settlement pattern; it may be a village or a dispersed population that is organized for administrative and/or productive purposes. It should be representative of the local population and include the full range of land users.

Two main tools are provided for the characterisation, which need to be backed-up by the following activities by the assessment team:

- Organise a general meeting with the local authorities to inform them of the assessment objectives and activities and request their support;
- Collect and review available secondary information sources where available
- Identify key stakeholders and relevant projects and NGOs located in the area;
- Conduct an initial field visit, ideally before the focus group discussion (FGD) with the selected community/ies. A tour by road with a few key informants will help the team to familiarise themselves with the study area, land uses, also the extent and severity of degradation. If this takes place before the FGD, it can reveal interesting land resources features and observations for discussion with the community.

TOOL 3.1 FOCUS GROUP DISCUSSION WITH THE COMMUNITY AND KEY INFORMANTS

The objective of the community focus group discussion (FGD) is to obtain information about the range of land-users, their individual and communal management regimes and the history of the area. This will help the team to gain a better understanding of how the socio-economic and institutional factors influence land users' perceptions and management of land resources at the community and landscape levels, also within the different land use systems present in the study area. The community focus group discussion can be used to stimulate debate about the types of land degradation, their degree, extent and trends in the study area, as well as the effectiveness of, or the need for, interventions to address degradation and restore or improve land resources. It will also help with interpreting the results from the detailed assessments of land degradation and effects of current land management practices.

The FGD is realised with a small number (around 10 people) of community members (male and female together or separately depending on local customs), selected on the basis of their knowledge of the territory, history and land uses, plus two members of the assessment team. After the discussion, the other team members need to be fully briefed on the findings before proceeding with the assessment.

Time required: 1-2h

The following outline questionnaire should be reviewed by the team prior to the focus group discussion, in order to adapt the questions to the local context and terminology. Questions can be modified, added and/or omitted. The length of the questionnaire can also be adjusted to suit the time available and the level of knowledge of community members and local informants.

Questionnaire - Checklist

1. What is the population of the whole community (number of people and of households)?
2. What is the history and pattern of settlement in the area?
3. What are the important land use types differentiated by the community and the main water resources available and used by the community in the study area?
4. What are the main livelihood/production activities during the i) rainy and ii) dry seasons (include the main things people do for subsistence and to generate income)?
5. What are the main natural resources that the community uses for production/ livelihoods? (e.g. grazing land, fuelwood, timber, medicinal plants, dry season water sources etc.).
6. What are the important types of land degradation[1] in the territory? For each distinct type: What do you consider are the main causes? What are the main impacts? What are the changes in the last 10 years, in terms of type, extent and severity?

To facilitate the discussion, the team may need to prompt for more details on the causes and impacts of soil, water and vegetation degradation and resource use, for example:

- **a. Soil:** Is soil erosion occurring or are there other types of soil degradation? What are the main causes? What indicators do the locals use to describe soil erosion/degradation (e.g. loss of fertility, soil loss, gully formation (active/ under control), build-up of sand or shifting sand dunes, sediment load or pollutants in water resources etc.)?

[1] In most cases land degradation will be interpreted as soil degradation, so deliberate efforts should be made to include vegetation and water resource degradation as well in the discussion.

b. **Vegetation**: Is deforestation occurring in the study area? Is this exploitation for local use, for transport to cities or both? Has it increased? What is the main local source of fuel for cooking (and heating)? Have the cover and/or species composition and quality of vegetation been increasing or diminishing? Have the abundance (number of plants) and richness (number of species) of i) palatable species for livestock or ii) invasive species increased or decreased in the area? Since when have the changes taken place? What are the causes? What conservation/management practices are used? Depending on the responses further questions can be asked for example: Are fires a serious problem? Has the frequency and severity increased–or decreased? Is burning used for pasture management and/or pest control? What are its effects? Are grazing rotations or rangeland enclosures practiced? Since when and why? Are there other related problems?

c. **Water**: What changes (over the last 10-20 years?) have there been in the amount and quality of water resources in the study area? (e.g. trends in rainfall amounts and seasonal distribution; drying up of water points, changes in levels of water in wells and boreholes; changes in river/stream flow, changes in water quality (salinity, pollution)). Is water used for irrigation and where is it sourced (e.g. rainwater harvesting, streams/rivers or wells/boreholes)? What crops are irrigated, when (all the growing season or only during specific critical period) and by whom? Do community members pay for water and under what circumstances?

7. Has the study area experienced i) drought, ii) flooding or any other extreme weather event (e.g. intense storms) in the last 10 years? Is this normal or exceptional?
8. What are the strategies and coping mechanisms adopted i) during drought or unusual dry years or ii) to reduce risk of flooding?
9. What are the livestock management strategies and related problems in terms of degradation or related benefits in terms of sustainable land management? Strategies could include, for example, range enclosures, rotational grazing, ranching, stall fed animals, seasonal livestock movements (agropastoralism), permanent livestock movements (nomadic pastoralism), cattle grazing corridors, as well as relevant bye-laws (e.g. relating to the control of livestock numbers or burning etc.)
10. Are there any conflicts in relation to land and water uses in the area?
11. What are the main livelihood problems (i.e. serious/long term)/difficulties (less serious/short term) faced by rural households (food insecurity, poverty, access to resources, access to markets)?
12. Are there successful areas where land degradation control (i.e. conservation, restoration and or improvement of land resources) has been achieved? What were the main sustainable land management (SLM) practices or measures (policies, legislation, bye-laws etc.) to prevent land degradation that were implemented in specific land use systems/types? Were they aimed: i) to improve or restore the productive capacity of the land (e.g. soil fertility, use of water); or ii) for conservation/protection of resources (soil, water, vegetation, wildlife, biodiversity). Indicate for each whether they are the result of an external intervention or a local/traditional practice.

13. If possible, identify any interventions that have gone beyond a focus on productivity to address wider ecosystem services (e.g. water catchment/supply, carbon sequestration, reduced greenhouse gas emissions, pest and disease regulation, protection of biodiversity and aesthetic landscape values etc.). What practices were used and what was achieved?
14. What are the various organizations that affect the way land (including water and vegetation resources) is managed in the community (e.g. informal groups or cooperatives of land-users, NGOs operating locally, private sector investors, local leaders or authorities, government departments or research agencies, etc.)? (Prompt for positive and negative effects).
15. What are the main informal and formal systems of tenure and rights to access land resources (crop land, pasture land, forest and water) in the community? How do they influence land degradation, conservation or improvement?
16. How do laws, rules and regulations concerning land resources affect the extent of land degradation and/or conservation? (Prompt for positive and negative effects).
17. What other major social divisions (apart from poverty/wealth) that exist in the community (e.g. religious or caste groupings, pastoralists or settled farmers, farmers practicing irrigation or rainfed cropping) that affect the differential access people have to resources and/or the ways in which they manage their land?

TOOL 3.2 RECONNAISSANCE VISIT AND TRANSECT WALK

Objectives

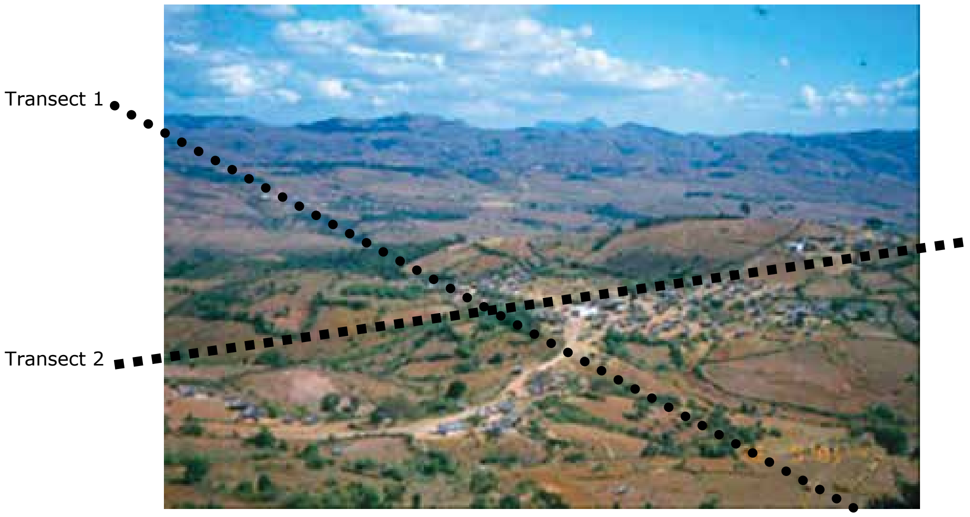
Using a google earth image or an aerial picture, it is a good idea to conduct an initial reconnaissance visit in the study area with a few key informants (such as extension officers) and the assessment team. This will help obtain a general understanding of the state of natural resources (vegetation, soil, water), what degradation types and processes are associated with which land use types (LUT) and management practices, also what are the main response measures and interventions being used.

The reconnaissance visit will help the team to appreciate the variation and identify the location and number of transects. It will also identify along each transect where are possible “key” sites for detailed assessments that will provide useful comparisons of different land management practices and to learn in more detail the causes for land resources degradation, conservation (stable) or restoration (improving) and the behaviour and reasoning of the land users.

The decision on the location and number of transects should be made with some community members, building on information collected during the community discussion. One to three transects per study area are recommended to capture most of the land resources and LD/SLM features of interest in the area. They should if possible cut across the major LUTs and different land units (reflecting changes in soil and terrain) or in the case of a very uniform landscape, cut across an area with as much variation as possible in land-user type and management practice. Some socio-economic criteria can also be used in identifying representative transect sites, such as population density.

A transect is not intended as a quantitative sampling tool, therefore the number, length and width are flexible. The length of each transect will depend on the variation in terrain and land type but in general some 2-5 km is adequate to capture the variation in land resources and in human management/land use. In heterogeneous areas, two or three short transects may be better than a single long one to capture the variation and issues of interest in LD/SLM within the study area. The transect width is effectively the land easily visible to the naked eye as one walks. It will be narrower in areas under complex and different land-uses, or in forest, than in extensive pasture or open savannah, because of visibility and the time required to record information.

PHOTO 1
EXAMPLE OF POSSIBLE TRANSECT WALK TO COVER DIFFERENT LANDUSE TYPES



The objectives of the transect walk are:

i) to identify the main land use systems (1-3) and the land use types within each study area;
ii) to obtain a general understanding on the ground of the landforms and resources status (vegetation, soil, water), what degradation types/processes are associated with which land use types (LUT) and which management practices, also what are the main response measures/interventions being used in the study area;
iii) to identify any wider off-site and landscape effects of land use pressures (e.g. deforestation, overgrazing, burning, encroachment of wetlands, overexploitation of fragile drylands) and resulting degradation processes (e.g., water erosion, downstream impact of runoff and sediment deposition, landslides, wind erosion and shifting sand dunes, water pollution, etc.);
iv) to help locate sampling sites for the detailed vegetation and soil assessment.

Comparison is at the heart of the sampling strategy. Detailed assessments are conducted in areas of LD, SLM and undisturbed or protected land, then the results are compared (e.g. A, B and C are compared in land-use 1; A, B and D are compared in land-use 2 etc.). The number of comparisons possible will depend on the heterogeneity of the study area.

Expected outputs

The transect diagram, in conjunction with the study area map and photos, provides a record of the land uses and state of resources in the study area (at the given date) and contributes to the selection of the detailed assessment sites. Reasoned/systematic decision-making on where to locate detailed comparative assessments (sampling sites) is enabled by the information and understanding of the area obtained during the reconnaissance visit and transect walk. The transect information and diagram also facilitates subsequent analysis with the community of the reasons for certain land uses and management practices and the consequences and responses in terms of degradation and conservation/SLM.

Participants

The local team should be accompanied by 2-3 local people/"informants" (selected from those involved in the community focus group discussion and the land users encountered, both men and women, with knowledge of land use changes, of vegetation species and uses (local names), their crop, livestock and forest management practices. It is important that the local community are supportive of the choice of informants.

Materials/preparations required:

- note-taking materials (paper and clipboard);
- maps, aerial photos and/or satellite image to locate transects, features and boundaries;
- GPS to record locations and altitude (of major changes in land use, land form, vegetation, soil) and detailed assessment sites;
- Digital camera;
- Abney level or clinometer to take slope.

Time required

Three to four hours per transect (depending on distance, complexity, ease of access etc.).

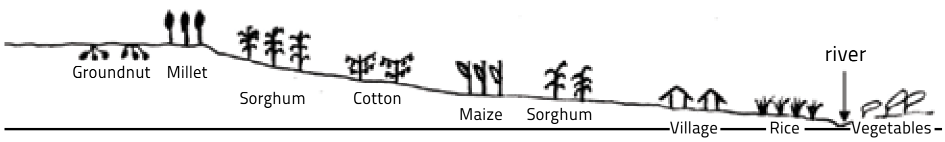
TABLE 1
Summary of the information to record on land use, resources, degradation types and management practices along transects

Theme/Issue	Indicators of land uses, resources, degradation and management
Natural resources status and trends	
Land use	▪ Land use system (LUS)–if available–and land use type (LUT) ▪ Land use intensity: density of homesteads/farms, farm size, fragmentation, individual to communal lands etc.)
Land unit/soil and terrain - ask what terms/criteria locals use to distinguish land units - take care not to mix degrees° and % slope	▪ Land form (plateau, summit, mountain/hill slope, foot-hill/filtration zone, valley, river terrace etc.) ▪ Average slope (% or degree; steep, moderate, gentle, flat) ▪ Aspect/direction of the slope(compass bearing e.g. N facing) ▪ Soil fertility (good, medium, poor) ▪ Soil texture (sandy–loamy-clayey) and colour(dark or light; red-yellow-brown-black reflects minerals and organic matter)
Land constraints - indicate main constraints for human use	▪ Steep/unstable slopes ▪ Extent of rock outcrops, shallow soils ▪ Surface hardness (crusts; laterite), stoniness/large clods ▪ Salinity-whitish salt deposits ▪ Surface waterlogging/ponding ▪ Exposed to strong/dry winds/dust storms
Main land degradation features	▪ Presence of sheet erosion, rills and gullies (slight, moderate, severe), and state (active, partly stabilised, stable) ▪ Sediment deposits from wind or water erosion ▪ Land slumping or landslides ▪ River/stream bank erosion ▪ Degraded vegetation (bush encroachment/deforestation/overgrazing burning-extent (h, m, l) and severity (h, m, l)
Vegetation cover, type, diversity and degradation sign	▪ Cover quality: living plants and residues/litter(low, medium, high); % ground and % canopy cover ▪ Type and structure (% grasses/other herbaceous spp.(perennial/annual), shrubs, trees) -planted or natural ▪ Species: dominant species; share of i) beneficial/economically valuable species and ii) harmful/unpalatable/invasive species; ▪ Plant health: extent/area of disease/pest/fire damage (h, m, l, n) and age structure(number of dead plants/seedlings/re-growth ▪ Indicator plants (salinity, waterlogging, infertile soils, fire resistant) ▪ Habitat diversity: fragmentation/connectedness; occurrence of trees, woods, field borders, live fences, fallow land etc.) ▪ Evidence of wildlife (pigs, rabbits, rodents, snakes, birds etc.)
Water sources, availability, quality, use and degradation signs	▪ Drainage pattern (dense, medium, light) ▪ Water source: river, stream spring (perennial/ephemeral) ▪ Wetland condition (protected, stable, degraded); % converted (e.g. drained and cropped) ▪ Water point: well, borehole, piped water, dam/pond, (perennial, seasonal, abandoned) ▪ Water quality: turbidity/sediment load (dark, light, clear) ; evidence of pollutants (smell, visible signs, aquatic weeds) ▪ Water availability (g, m, p), trend (increase, stable, decrease) and uses (household. livestock, irrigation, other) ▪ Access (distance/time in dry and wet season) ; public/private

Theme/Issue	Indicators of land uses, resources, degradation and management
Ecosystem integrity in selected catchment/ landscape	▪ Wider landscape value ▪ Threats/risks to sustained resources, ecosystems and productivity ▪ Resilience/opportunities for sustaining resources, ecosystems, productivity
Management practices/systems and their effects	
Watershed/soil and water management/ water storage harvesting/irrigation	▪ Type and % area under protection measures (e.g. protected, afforestation, protection of water sources, gully reclamation, dune stabilisation, etc.) ▪ Improved farming/soil and water conservation practices (e.g. contour farming, tied ridges, vegetation strips, stone lines, bunds, terraces, zai) ▪ Management and use of water storage structure (catchment of dam, pond, tank; controlled access livestock and grazing; troughs/pumping for irrigation) ▪ Type and source of contamination (domestic/livestock waste, agricultural or industrial pollutants) ▪ Water harvesting (type, extent, purpose) ▪ Irrigation type (sprinkler; furrow; drip; flood; border), water source, surface area, crop; use of waste water
Forestry system management	▪ Primary/secondary forest - main species; loss of useful species ▪ Planted/managed forest - main species, loss of useful species ▪ Forest health (g, m, p); quality (clearings, damage) and age structure (mortality/regrowth) ▪ Management practice (coppicing, firebreaks etc) ▪ Biomass (density, height and diameter of trees/shrubs-carbon content) and productivity (timber, firewood, other products) ▪ Degradation causes/trends: deforestation, overexploitation, burning, conversion to other uses (slight, moderate, severe)
Grazing system (rRange/pasture) management	▪ Livestock types, herd size and composition (age, sex) ▪ Extensive/intensive grazing (% area) ▪ Livestock management/feeding (free grazing, fenced, tethered, stall-fed, cut and carry, improved pastures; seasonal movements; grazing corridors, pest/disease management) ▪ Pasture health (g, m, p) and composition (% shrub/herbaceous species); indicator species, palatable/undesirable species-thorny poisonous, salt tolerant etc); ▪ Plant biomass (height and density) and productivity/livestock carrying capacity(from secondary information – see section 5.2 in Part 1 (FAO, 2011a)) ▪ Degradation causes/trends: overgrazing, burning, conversion to other uses (slight, moderate, severe)

Theme/Issue	Indicators of land uses, resources, degradation and management
Cropping and mixed systems management	▪ Crop types and diversity (annual/perennial species/varieties, mixes) ▪ Previous land use/crop rotation (1-4 years) ▪ Crop management practices: use of residues/mulch, organic matter, weeding, ▪ Agropastoral practices (use of manure for crops, of crop residues for feed/fuel) and livestock type(s) and management ▪ Agroforestry practices-tree species (indigenous/introduced), % area (e.g. alley cropping, contour planting, scattered) ▪ Tillage mode (% hand, oxen, tractor) ; % cultivated area under conservation agriculture (zero tillage, permanent cover) ▪ Fallow natural/improved % of land (fallow/cultivated), ▪ Recent losses of important crop species, varieties and uses, also of useful associated species (pollinators, predators of pests) ▪ Productivity (forage crops, grain, straw, tubers, fruits, other) ▪ Degradation causes/trends: nutrient mining, monocultures, inappropriate use of chemicals, poor cover/organic matter management.

FIGURE 5
EXAMPLE OF A TRANSECT DIAGRAM INCLUDING INFORMATION ON LAND USE, DEGRADATION TYPE, EXTENT AND CONTROL MEASURES

Description of land resources, degradation and management for each land use type along the transect walk				
LUS: .... Example: Annual cropping	Annual crops, grazing mix	Annual crop land, grazing mix, trees	Annual crops, grazing mix	Annual crops
Record where the transect crosses a road, river or other infrastructure or border (e.g. protected area)				
GPS location (from start to end)	XXX–YYY	XXX–YYY	XXX–YYY	XXX–YYY
Altitude range (from start to end)	XXX–YYY	XXX–YYY	XXX–YY	XXX–YYY
Average slope (in degree or %)	XX	XX	XX	XX
Land/soil resources ▪ soil texture ▪ soil colour ▪ soil fertility (G, M, P)	▪ Gravel, sand ▪ Red ▪ medium/shallow	▪ Sand, loamy-sand ▪ Red to brown ▪ poor	▪ Sandy loam to loam ▪ Brown to black ▪ good	▪ Clay ▪ Black ▪ good
Water sources/ hydrology	▪ none	▪ none	▪ 1 well and 1 borehole in the village	▪ Small river (dries up in some dry seasons)

Description of land resources, degradation and management for each land use type along the transect walk				
Major constraints to use	▪ Low moisture ▪ shallow soil, exposed rocks	▪ Erosion risk	▪ Soil sticky; land difficult to prepare ▪ Drying	▪ Water logging ▪ Land difficult to prepare
LUS: .... Example: Annual cropping	Annual crops, grazing mix	Annual crop land, grazing mix, trees	Annual crops, grazing mix	Annual crops
Natural vegetation ▪ type and cover ▪ main species ▪ indicator species	Poor cover, few trees ▪ **Combretum sp., Burkea africana** ▪	Negligible ground cover ▪ **Vitellaria paradoxa, small Parkia biglobosa** ▪	Healthier vegetation ▪ **Large Parkia biglobosa, and** ▪ **Vitellaria paradoxa, Daniellia oliveri**	Hydrophilous plants ▪ **Terminalia macroptera Mitragyna inermis**
Major crops, livestock and/ or planted tree species	Millet, groundnut Small ruminants tethe-red at homestead	Sorghum, millet, cotton, groundnut	Maize, sorghum, some cotton	▪ Rice, vegetables ▪ Small herd of cattle
Land degradation features–soil, water and vegetation (specify also extent and severity)	Drought prone Deforestation	Soil erosion–rills/ gullies Active-severe	Soil erosion–ill/ sheet Active-slight	▪ Waterlogging, ▪ water pollution, ▪ sedimentation
Land management/ soil and water conservation/ restoration measures (specify extent and effects)	Mulching on some fields	Contour tillage demo. Planted grass strips trees in some fields less erosion	None	None
Land use intensity (farm/field sizes; fragmentation, borders etc.)	▪ larger farms ▪ trees and shrubs in borders	▪ small field and farms	▪ small fields and farms	▪ very small fields

4. Vegetation assessment

INTRODUCTION

Sites: The sampling sites for the detailed investigations and scoring will have been identified during the transect walk and reconnaissance visit of the study area. They need to be representative of a specific land use type. It is important that selected sampling sites can be compared with a benchmark of similar vegetation/land use type in good conditions. Digital photographs should be taken of each sampling site and to the extent possible comparative pairs of sampling sites should be assessed (healthy forest versus a degraded forest etc.).

Equipment: In addition to the standard recording materials and maps, GPS, camera and abney level/clinometer for measuring slope, further tools that may be required include:

- machete to cut through thickets;
- plastic bags to take any vegetation samples;
- 50m tape measure (marked at 1 m, 2 m and 10 m intervals) to measure distances;
- conventional quadrat (1 metre metal/bamboo square with 10 cm grids of wire or string);
- calibrated Aluminium Disk Pasture Meter (optional);
- abney level will be used for measuring tree height (as appropriate).

Quadrat size: (see Table 2) A quadrat is a predetermined sample surface area (usually square) used repeatedly to sample vegetation and measure species presence, frequency, abundance and cover. The quadrat size that should be used depends on the vegetation type and density and should be decided on each particular site:

TABLE 2
Optimal size of quadrats in vegetation surveys

Type of vegetation	Vegetation height (m)	Size (m)
Moss/Lichens	<0.05	0.1 × 0.1
Short grassland (annual grassland))	<1	1 × 1
Tall grassland (perennial grassland)	<2	2 × 2
Shrub	<4	5 × 5
Young forest (sub-forest))	<8	10 × 10
Mature forest	>8	20 × 20

Source: http://hosho.ees.hokudai.ac.jp/~tsuyu/lecture/glossary/on_quadrat.html

For estimating tree density in field or rangeland, a 25 or 50 m quadrat can be paced out. To ensure a representative sample up to 3 quadrats may need to be taken.

There are three steps in assessing vegetation degradation:

Step 1: Information on changes in vegetation areas and intensity of use can be obtained from time-series aerial photos and satellite images, also from reports of natural resources/vegetation inventories and land cover surveys.

Step 2: Information on vegetation condition and health can be obtained through visual observations of vegetation cover and condition (dominant species, size/growth; mortality and regeneration) backed-up by vegetation sampling using quadrats and measurements to compare vegetation on sites/areas that have been subject to different levels of protection, management and utilisation. Specimens of indicator plants should be collected in plastic bags, (or in a plant press, if available) with labels to record the site and local plant names for later identification with specialists (botanists, foresters, pasture specialists, ecologists, etc.).

Step 3: As with the assessment of other land resources, it is important to supplement and triangulate the data from the vegetation observations with information provided by key informant interviews. This should help provide explanations of changes in vegetation area, intensity of use and products harvested. Household interviews should provide more detail on the quantity and quality of the products harvested from particular areas.

The following tools are provided:

Tool 3.1 Trees in forest/woodland

Tool 3.2 Land user interviews on grazing lands

Tool 3.3 Rangeland/Pasture

Tool 3.4 Annual Croplands

Tool 3.5 Tree/perennial crops

Tool 3.6 Land user interview on crop productivity and yield

TOOL 4.1 TREES IN FOREST/WOODLAND

It is important to understand the history and the stage of the vegetation in natural forests and woodlands (primary, secondary) and to relate the forest condition to pressures on the forest from local and other users of wood and non-wood forest products. This tool is used also for assessing the condition and productivity of trees outside of forests/woodlands (i.e. trees in grazing lands and croplands).

Trees in the landscape : grazing lands or fields
It is also important to assess the trees on grazing lands as they provide valuable shade for livestock and windbreaks, they help to maintain a cooler microclimate, provide firewood and other products.

- **Density and spatial distribution of trees in the grazing land;** provides a useful indicator of the extent to which trees have been maintained in the environment. (none; scattered/sparse; grouped in blocks; trees in lines (e.g. along fences, roads) in, plantations; other.
- **Tree health, condition and use of products:** where the trees are used for timber, or other non wood forests products the protocol on forest/woodland assessment can be used to assess the trees in the grazing landscape.

Sampling

An appropriate quadrat size should be selected with the advice of the vegetation specialist ecologist in the team (see Table) and used to determine the cover, condition and productivity of trees in woods/forests compared with a benchmark site which is assessed to be in good condition using the following indicators.

A field form is provided below to assist with systematic recording and documentation of the various vegetation indicators. This could be adapted as required by the assessment team during an initial pilot assessment

1. Vegetation cover: Each of these indicators should be assessed, as appropriate (none/ negligible <5 percent, little 5-10 percent, moderate 10-40 percent, high 40-70 percent; dense >70 percent cover)

1.1. Tree canopy cover: estimate the ground surface covered by the vertical projection of the tree canopies, as a percentage of the total ground area;

1.2. Shrub canopy cover: estimate the ground surface covered by the vertical projection of the shrub canopies percent of the total ground area; and,

1.3 Ground cover: estimate the ground surface covered by herbaceous vegetation or litter.

2. Species composition

2.1 Tree/shrub species: record either common/local (specifying local language) or scientific species name for all species if there are few, or the three dominant tree species and the three dominant shrub species if the vegetation is diverse. Compare to the benchmark site and ask the local informants/land users to indicate if there has been a change in the dominant species as this is a key indicator of degradation, also ask the reasons (overexploitation–by whom?, specific management practices, climate change etc.);

2.2. Indicator species: identify any species which is an indicator of problems or constraints (e.g. invasive species, weeds, plants that indicate salinity, waterlogging, low fertility etc.) and record the abundance (i.e. whether the number of each indicator species in the quadrat is-abundant (many); medium (common); or rare (few)).

2.3 Useful species and products: compare to the benchmark site and ask the local informants/land users to indicate:

1. If there has been a change in the dominant species, as this is a key indicator of degradation and ask the reasons (overexploitation, management practices, climate change etc.);
2. Which are useful tree/shrub species? What products they provide (timber, charcoal, food and medicinal products, other)? and for whom? (land use group; men or women) and whether there has been a change (i.e. loss of valuable species and products or decline in productivity)?;
3. Whether there has been a change in the share of beneficial/valuable species to harmful/unpalatable/invasive species or in the wildlife (e.g. loss of habitat, feed).

3. Condition and wood productivity

3.1 Growth: measure the average height (h in m) and diameter at breast height (Dbh in cm) for trees and for stumps with: i) a Dbh ≥ 20 cm in forest land; and ii) a Dbh ≥ 10 cm in non-forest land. For stumps lower than 1.3 m the diameter is measured at stump height (Dsh). For stumps, ask the land users if they can indicate the time since the tree was cut (<1, 1-5, 6-10, >10 years) as this will indicate recent pressures. Ask local informants/land users the age of planted trees - this is a useful measure of productivity and of carbon stocks.

3.2 Overall tree condition: record the condition where:

- good = no symptoms of disease/other effects on growth and vitality;
- slightly affected = some symptoms;
- severely affected = symptoms that substantially affect the tree's growth and vitality;
- dead/dying = damage that is or will lead to death or the tree has fallen.

3.3. Crown condition/health: good = dense, no dieback; moderate = dense, visible dieback, poor = less dense, significant dieback; dying = sparse, high dieback; dead = already killed.

3.4 Tree stem quality: for species used for timber/building materials, assess if the stem is straight and extent of damage due to fire, pests, diseases, animals, etc. (high: straight tree without visible damage; medium: some slight defects or damage; low: several defects or damage).

3.5 Causes of damage: ask local informant/land users if they know the causes of damage (e.g. due to insect infestation (defoliation, leaf feeding, etc.); presence of fungus (leaf spots, leaf or needle discolouration, etc.); burning; wild or domestic animals; human induced (cuttings, bark damage, logging, etc.); extreme climatic events (e.g. broken branches by wind, snow, lightning, etc.); or other causes).

3.6 Management practices ask local informant/land users what types of management practices are used in the forest/wood land, what is the intensity trend and whether there are any bye laws affecting management practices and use of products.

TABLE 3
Main internationally recognized territorial designations

Site No.	Tree	Shrub	Stump	Species		Growth				Canopy			Health			Products		Users	
				Common name	Scientific name	Av. Diameter Dbh.	Av. height	Year(s) since cut	Tree Stem quality	Tree canopy cover	Shrub cover	Ground cover	Crown condition	Tree/shrub condition	Cause of damage	Wood and building materials non wood food and medicinal products	Charcoal	Local use	Commercial use
						cm	m		C	%	%		C	C	C				

Notes:...

....

....

....

TOOL 4.2 LAND USER INTERVIEW ON GRAZING LANDS

Identifying plant indicators

1. Has the quality of the grazing land changed over the last 20 years? How and why?
2. What plants show that grazing land/soil quality is i) good? or ii) bad? Do they have any particular characteristics?
3. Which plants have appeared in grazing areas that indicate that land quality and productivity has:

   - improved? What do they indicate?
   - declined? What do they indicate?
   - (E.g. grazing land: palatability/toxicity, overgrazing, annual vs. perennial grasses etc.) (e.g. forest/wood land: loss of valuable species and products; invasive shrub species).(e.g. cropland – weed intensity, infertile soils (e.g. parasitic weeds such as Striga, species resilient to salinity)

Where possible, photograph the indicator plants and, as required, collect samples to obtain the botanical/scientific names.

Obtaining information on the grazing regime and stocking rate

4. How many and what type of livestock are supported (no./ha/annum) (this may need estimation of herd size and common grazing area) and what are the trends (e.g.over the last (approx) 10 years)?;
5. What are the main livestock products (milk, meat, hides), yields/annum and trends?;
6. What are the forage production trends (increasing , stable, decreasing)?
7. What other significant sources of fodder are there?

If possible, record any given reasons for the changes. Technical experts may be able to provide information on carrying capacity and recommended stocking rates for specific vegetation types and agro-ecological zones.

Obtaining information on fires and drought risk/resilience and coping/management strategies

Discuss with informants the intensity and frequency of fires and droughts and their effects on vegetation and uses/products.

8. How common are fires (rare, occasional, frequent)? Are they wild or controlled?
9. How severe is fire damage to the rangeland vegetation (none, low, moderate, severe)?
10. What effect (if any) does fire have on species composition in rangelands (e.g. loss of valued species/products, increase in less palatable species, percent of non re-sprouting shrubs that do not re-grow after severe fire/drought etc.)?
11. Are there any control measures (e.g. bye laws, fire breaks or fire committees)?
12. How frequent and severe are drought periods? (It may help to draw a timeline).
13. Has drought caused any changes in land- use over the last (approx.) 10 years?
14. Are there any drought coping strategies (e.g. resilient species, bye-laws on grazing/ livestock/forest management, water harvesting/irrigation)?

Obtaining information on laws and regulations that affect vegetation quality

It is common for there to be many formal and informal policies, regulations and arrangements governing access and use of vegetation resources. These should be identified and discussed. Specific questions are not detailed here but potentially interesting discussion points are:

15. Areas once heavily utilized may have become protected, preventing the use for grazing etc. What impact has this had on the vegetation and on the land-users livelihoods?
16. Customary (informal) regulations may be more significant/effective than formal policies and laws in controlling grazing periods, etc. Document both formal and informal mechanisms

TOOL 4.3 PASTURE/RANGELAND

Visual Indicators and Methods

A set of proposed indicators is outlined for a visual assessment of pasture/rangeland condition-comparison is the key between well and poorly managed land. The proposed scoring needs to be tested and adapted/calibrated for each situation. The findings should be integrated with the soil investigations.

The criteria for calibrating the scoring should be well documented and supported with photographs. This will allow the scoring to be consistently applied by different people at different times, improving their robustness and value for base-line setting and future monitoring.

Sampling

Select an appropriate quadrat size or use a line transect to determine the cover, condition and productivity of the pasture or rangeland for the selected assessment site using the indicators. Where possible, repeat the measures to compare the site in the given land use with another site in relatively good condition.

The score sheet should be used for each sample site or for each vegetation group identified. The bigger or more variable the area, the more observations are necessary to get a representative scoring of range quality. Avoid transition areas and make sure the visual assessment represents all major changes that have occurred in vegetation groups and conditions. Additional locally appropriate indicators can be included in the score sheet, or they can be used to make a more informed assessment of the existing indicators (Table 4).

TABLE 4
Indicators and classes for assessing pasture/rangeland quality

Issues and Core Indicators		Category
1.	Vegetation /litter cover	
1.1	Total bare soil/ vegetation cover	Estimation of % cover-for comparison (using a quadrat or line transect) [N.B. Cover is critical for soil protection from raindrop impact, high temperature and to reduce runoff volume and rates.]
		Cover can be divided into basal cover (herbacecous), shrub cover and tree canopy cover for a more in depth analysis.
1.2	Bare spots	Spots without vegetation. In savanna - 2 m or larger (the agreed size may change per ecological zone)
	None	None can be seen
	Little	Can be seen, but does not characterise of the area
	A lot	Characterises the area
	Dominating	More bare than covered
1.3	Litter cover/surface organic matter	The more, the better soil surface protection. [Gives an indication of moderate grazing practices.]
	Dense	Covers soil beneath tufts
	A lot	Bare soil can be seen
	Little	Seen but no notable cover effect
	None	None seen

Issues and Core Indicators		Category
2.	Vegetation quality and composition	
2.1	Vegetation height, diameter and vigour for perennial species (shrubs, trees) and herbaceous species (grasses, legumes)	Growth measurements-height and diameter at breast height (DBh) and growth pattern-e.g. stunted, defoliated) and vigour measurements-stem diameter, average shoot length and basal shoot diameter. Using representative quadrat or line transects and comparing between well and poorly managed land or protected areas, taking note of time of year and seasonality.
	Good	Vegetation height, diameter and plant vigour compare very well with representative site and is close to optimal considering the seasonality and climatic conditions (i.e. rainfall and drought)
	Moderate	Vegetation height, diameter and plant vigour slightly lower than the representative site
	Poor	Vegetation height, diameter and plant vigour significantly lower than representative site and sub-optimal
	Very poor	Serious reduction in biomass (vegetative production), resulting in stunted and defoliated growth and very little to no plant vigour
2.2	Proportion of perennial/annual species	Indication of grazing quality and resilience to drought (herbaceous species–lower lignin and higher protein; woody species-higher lignin, lower protein)
	Dominating	All grasses are perennial
	A lot	Single annuals are present
	Little	Perennials are present but not important
	None	Perennials not seen
2.3	Proportion (dominance) of useful species	This could include: - Ecological functions (e.g. canopy cover, deep rooting, resilience to drought, recovery after burning); palatability (browse/grazing); and products for human use
	Dominating	All or most species useful
	A lot	Moderate
	Little	Present–some useful species
	None	Not seen
3.	Ecological integrity, biodiversity and change dynamics	
3.1	Proportion of each vegetation strata	%/proportion of trees, bushes/shrubs, forbs[2], grasses (reflects exploitation and change in habitat)
3.2	Species that decrease with grazing pressure (i.e. preferred by livestock)	For each vegetation strata (herbaceous (grasses and forbs); shrubs/bushes; and trees): - Identify preferred species/decreasers-those species that decline with graze/browse pressure e.g. palatable spp. that play an important role in livestock diet (**T.triandra, Panicum maximum** and **D. eriantha** can be used as key species in South Africa) - Compare with protected sites.
3.3	Species that increase with grazing pressure (i.e. resilient to trampling, unpalatable species)	Identify key species that are known to increase with grazing pressure for each vegetation strata including species resilient to trampling (e.g. **Eragrostis spp. in particular E. rigidior** can be used as key species in South Africa). Compare with trampled sites; - key species not regularly utilised by livestock (e.g. **E. muticus, C. plurinodis** a nd **Bothriochloa radicans** ('stinkgrass") in South Africa). Compare with lightly or moderately utilised areas.
3.4	Poisonous plants	Identify plants poisonous to livestock; this will differ from area to area (e.g. in South Africa examples include **Homeria spp., Senecio spp., Lantana camara, Dicapetalum cymosum,** etc.)

2 Forbs are herbaceous flowering plants that are not grasses, sedges or rushes

Issues and Core Indicators		Category
3.5	Alien invasive or proliferous weed species	Identify specific alien invasive or weed species that have reduced pasture/range or crop productivity (e.g. presence (low, moderate, high) or % **cover of Prosopis, Lantana,** etc.)
3.6	Pest damage	Indicate extent and severity of damage by termites (defoliated vegetation and termite nests visible), rodents, locusts or others
	None	Not seen
	Little	Single localities, no real damage
	A lot	Damage seen, but not over whole area
	Dominating	Whole area damaged
3.7	Damage due to diseases	Evaluate as in pest damage
3.8	Bush/shrub encroachment	A key factor of pasture/range degradation is an increase in woody, invasive, unpalatable/toxic species. Too many bushes/trees depress grass production (reduce livestock carrying capacity) and may reduce access to water
	None/sparse	Trees 30 m + apart
	Open	Present. Visibility 200 m and more
	Dense	Visibility 50 m. People and livestock can still move with ease
	Very dense	Not easy to penetrate
3.9	Deforestation	Deforestation is the loss of forests, woodland and savanna areas to other land uses due to over-cutting of trees. One consequence is soil erosion, which results in the loss of protective soil cover and water-holding capacity of the soil
	None	There are no signs of deforestation
	Some	There are some indications of deforestation, but the process is still in an initial phase. With minor efforts it can be easily stopped and damage repaired
	Moderate	Deforestation is apparent, but its control and full rehabilitation of the land is still possible with considerable efforts
	Severe	Evident signs of deforestation. Changes in land properties are significant, or even beyond restoration, and very difficult to restore within reasonable time limits
3.10	Biomass decline*	Reduced vegetative production for different land use (e.g. on forest land through clear felling, secondary vegetation with reduced productivity). Depending on the time of year, biomass estimates can be made and compared between poorly and well managed/protected sites to give an indication of reduced vegetation production-trees, grasses, shrubs
	None	There are no signs of biomass decline
	Some	There are some indications of biomass decline, but the process is still in an initial phase. It can be easily stopped and damage repaired with minor efforts
	Moderate	Biomass decline is apparent, but its control and full rehabilitation of the land is still possible with considerable efforts
	Severe	Evident signs of biomass decline. Changes in land properties are significant, or even beyond restoration, and very difficult to restore within reasonable time limits

Scoring

Once the class has been assigned for each indicator, the range/pasture condition can now be scored. Using Table 5, for each indicator mark one of the columns. Columns have the following values: column 1 = 5, column 2 = 3, column 3 = 1, column 4 = 0. Sum the number of marks in each column. Multiply it with the value of each column. Sum all to give a total index for each site/pasture.

TABLE 5
Scoring using visual indicators for assessing range quality

Range condition indicator		Best Class	Moderate	Poor	Worst class
1.1	Total bare soil	None	Little	Lot	Dominating
1.2	Bare spots	None	Little	Lot	Dominating
1.3	Litter cover/surface organic matter	Dense	Lot	Little	None
2.1	Vegetation height, diameter and vigour	Good	Moderate	Poor	Very poor
2.2	Proportion of perennial/annual species	Dominating	Lot	Little	None
2.3	Proportion of useful species	Dominating	Lot	Little	None
3.1	Proportion of each vegetation strata (grasses, shrubs, bushes and trees)	Dominating	Lot	Little	None
3.2	Species that decrease with grazing pressure	Dominating	Lot	Little	None
3.3	Species that increase with grazing pressure	None	Little	Lot	Dominating
3.4	Poisonous plants	None	Little	Lot	Dominating
3.5	Alien invasive or proliferous weed species	None	Little	Lot	Dominating
3.6	Pest damage	None	Little	Lot	Dominating
3.7	Damage due to diseases	None	Little	Lot	Dominating
3.8	Bush/shrub encroachment	Sparse	Open	Dense	Very dense
3.9	Deforestation	None	Some	Moderate	Severe
3.10	Biomass decline	None	Little	Lot	Dominating
Score	**5**	**3**	**1**	**0**	
Sum of scores					

Convert the score to a percentage (score/number of points X 100) and interpret the condition using the following classes:

TABLE 6
Score conversion

Score %	Grassland condition	**Trend (indicate if it is...)**
100–90	Excellent	
71–90	Good	Stable
70–51	Average	Improving
50–31	Bad	Deteriorating
0–30	Extremely bad	

TOOL 4.4 ANNUAL CROPLANDS

Natural vegetation is also important in croplands. In addition to the indicators specified under crop productivity below (Table 7), five other vegetation indicators are included here that should be observed in the field and assessed through the land user and household interviews:

- **Ground cover:** as with pasture and forest land soil, ground cover by live vegetation, mulch (see Photo 11) or crop residues is a key factor in protecting the soil from raindrop impact, soil erosion, high temperatures and excess evaporation;
- **Permanence of the crops or period of cover:** determines exposure of bare soil and erosion risk;
- **Cropping system diversity:** diverse crop systems provide resilience to pests/diseases, capacity to restore and make better use of nutrients/organic matter and reduce erosion risk (e.g. a multi-storey agroforestry system will intercept and make better use of rainwater and the deep soil profile and protect the ground from erosion more than a cereal field; a crop rotation will make better use of nutrients and water in the soil profile);
- **Diversity of natural vegetation within the cropland:** natural vegetation provides habitat for associated species and their beneficial ecological interactions (e.g. pollination). In drier farming systems, there is a need to minimise competition for water between species through the use of appropriate species and management practices;
- **Land fragmentation/proximity to natural vegetation:** increased fragmentation and reduced proximity to natural vegetation will indicate intensification pressure;
- **Use of natural vegetation** for restoring soil protection and organic matter content, also other uses (e.g. wood and non wood forest products etc.).

TABLE 7
Indicators of vegetation condition in croplands

Indicators	Value
Ground cover (inverse of bare soil)	
- cover by crops	%
- cover by mulch	%
- cover by plant residues	%
Permanence of the various crops and cover	
– period of cover	low, moderate, high
– cover in the dry season(s)	low, moderate, high
– cover at start of rainy season (s) when wind and water erosion are greatest risk	low, moderate, high
Crop diversity	
– crop species diversity (number and share of local/indigenous to introduced species)	no.; low/medium/high
– crop varieties (number for 3 main crops)	no.; low/medium/high
– harvested products diversity (grain, straw, beans, fruit, fibre, low/medium/high etc.)	no.; low/medium/high

Indicators	Value
Fragmentation/proximity to natural vegetation	
– average farm/field size	ha
– average number of parcels	no
– extent/share of fallow land	%
Diversity of natural vegetation in/around cropland	
– distance of cropland from natural vegetation (grazing, forest/wood, managed fallow, unmanaged)	none/close/far
– landscape features-presence of hedgerows, trees, grassed bunds/waterways, windbreaks, etc.-specify	none/few/many
– contribution to household of gathered products (e.g. share of fuelwood, wild foods, charcoal, materials, medicinal plants,...)	low/moderate/high
– reduction/loss of useful species and products	low/moderate/high
Use of natural vegetation	
- for protective mulch	low/medium/high
- for restoring organic matter management	low/medium/high
- for other products (wood, firewood, etc)-specify	low/medium/high

Assessing crop biodiversity (can be done for both tree crops as well as food crops)

Simple diversity measurements of richness, evenness and divergence can be used to compare the status and trends in on-farm crop species and varietal diversity. In many countries, biodiversity is of increasing interest and especially its relationship to land degradation/SLM and climate change. The following indicators can be used:

- Identify and list the range of species and varieties grown in a sample of farm households (small, medium, large farms) (e.g. there may be 30 species in total and for one crop species e.g. maize there may be 5 varieties grown etc.);
- Assess the average species and varietal richness for each farm size-the number of different kinds of individuals (regardless of their frequencies), for example: –average number of i) plant species and ii) average number of plant varieties per household iii) number and share (percent) of traditional plant varieties per household;
- Assess the evenness among farms and among the whole community-how similar are the frequencies of the different variants (low evenness indicates dominance by one or a few crop types);
- Assess divergence (as a percent) (i.e. the partition of diversity between and within farms) this can be measured by the difference between community and farm index values divided by the community value (high divergence may indicate high potential of households in the community to grow different varieties).

Through discussions with land users, explain the findings, for example:

- Crop genetic diversity may continue to be maintained on farm, in the form of many species and/or several traditional crop varieties. Alternatively, crop diversity may be very low, in which case there are few species and few varieties maintained;
- A large part of crop diversity may be held in the larger community, rather than in any one farmer's fields.(i.e. the diversity is spread throughout the community);

- There may be a close relationship between traditional varieties richness and evenness (i.e. farmers who grow traditional species will also grow several varieties of each crop);
- In some cases, crops may be maintained at farm and community level with one or two dominant varieties and a large number of other varieties that occur at lower frequencies. This suggests that farmers maintain the low frequency varieties as an insurance to meet future environmental changes or for social and/or economic reasons. For other crops that show a more even frequency of distribution of traditional varieties, this implies that farmers are selecting varieties to serve current needs;
- Divergence estimates across crops and varieties may show that small-scale farmers who manage different varieties in different ways are a major force for maintaining crop genetic diversity;
- Climate change and variability as well as natural disasters may be influencing which crops/varieties farmers grow, as they adapt to reduce risk of crop failure.

TOOL 4.5 PERENNIAL TREE CROPS

Sampling

An appropriate quadrat size should be selected with the advice of the vegetation specialist ecologist in the team (see Table 8) and used to determine the cover, condition and productivity of trees in woods/forests compared with a benchmark site which is assessed to be in good condition using the following indicators.

A field form is provided below to assist with systematic recording and documentation of the various vegetation indicators. This could be adapted as required by the assessment team during an initial pilot assessment

1. Vegetation cover: Each of these indicators should be assessed, as appropriate (none/ negligible <5 percent, little 5-10 percent, moderate 10-40 percent, high 40-70 percent; dense >70 percent cover)

1.1 Tree canopy cover: estimate the ground surface covered by the vertical projection of the tree canopies, as a percentage of the total ground area;

1.2 Ground cover: estimate the ground surface covered by vegetation or litter.

2. Species composition

2.1 Perennial Tree crop species: record either common/local (specifying local language) or scientific species name for all species if there are few, or the three dominant tree species and the three dominant shrub species if the vegetation is diverse. Compare to the benchmark site and ask the local informants/land users to indicate if there has been a change in the dominant species as this is a key indicator of degradation, also ask the reasons (overexploitation–by whom?, specific management practices, climate change etc.);

2.2. Indicator species: identify any species which is an indicator of problems or constraints (e.g. invasive species, weeds, plants that indicate salinity, waterlogging, low fertility etc.) and record the abundance (i.e. whether the number of each indicator species in the quadrat is-abundant (many); medium (common); or rare (few)).

3. Condition and wood productivity

3.1 Growth : measure the average height (h in m) and diameter at breast height (Dbh in cm) for trees and for stumps with: i) a Dbh ≥ 20 cm in forest land; and ii) a Dbh ≥ 10 cm in non-forest land. For stumps lower than 1.3 m the diameter is measured at stump height (Dsh). For stumps, ask the land users if they can indicate the time since the tree was cut (<1, 1-5, 6-10, >10 years) as this will indicate recent pressures. Ask local informants/land users the age of planted trees-this is a useful measure of productivity and of carbon stocks.

3.2 Overall tree condition: record the condition where:

- good = no symptoms of disease/other effects on growth and vitality;
- slightly affected = some symptoms;
- severely affected = symptoms that substantially affect the tree's growth and vitality;
- dead/dying = damage that is or will lead to death or the tree has fallen.

3.3. Crown condition/health: good = dense, no dieback; moderate = dense, visible dieback, poor = less dense, significant dieback; dying = sparse, high dieback; dead = already killed.

3.4 Tree stem quality: for species used for timber/building materials, assess if the stem is straight and extent of damage due to fire, pests, diseases, animals, etc. (high: straight tree without visible damage; medium: some slight defects or damage; low: several defects or damage).

3.5 Causes of damage: ask local informant/land users if they know the causes of damage (e.g. due to insect infestation (defoliation, leaf feeding, etc.); presence of fungus (leaf spots, leaf or needle discolouration, etc.); burning; wild or domestic animals; human induced (cuttings, bark damage, logging, etc.); extreme climatic events (e.g. broken branches by wind, snow, lightning, etc.); or other causes).

3.6 Management practices ask local informant/land users what types of management practices are used in the forest/wood land, what is the intensity trend and whether there are any bye laws affecting management practices and use of products (see Photo 6 and Table 8).

3.7 Ground cover: as with pasture and forest land soil, ground cover by live vegetation, mulch (see Photo 11) or crop residues is a key factor in protecting the soil from raindrop impact, soil erosion, high temperatures and excess evaporation;

3.8 Permanence of the crops or period of cover: determines exposure of bare soil and erosion risk;

3.9 Cropping system diversity: diverse crop systems provide resilience to pests/diseases, capacity to restore and make better use of nutrients/organic matter and reduce erosion risk (e.g. a multi-storey agroforestry system will intercept and make better use of rainwater and the deep soil profile and protect the ground from erosion more than a cereal field; a crop rotation will make better use of nutrients and water in the soil profile);

4.0 Diversity of natural vegetation within the treecropland: natural vegetation provides habitat for associated species and their beneficial ecological interactions (e.g. pollination). In drier farming systems, there is a need to minimize competition for water between species through the use of appropriate species and management practices;

4.1 Land fragmentation/proximity to natural vegetation: increased fragmentation and reduced proximity to natural vegetation will indicate intensification pressure;

TABLE 8
Indicators for treecrops

Indicators	Value
Vegetation cover	%
Tree crop canopy cover	%
Perrenial Treecrop species diversity	High med low
Indicator Species	Sp.Namesand frequency in terms of %
Growth	
Overall Tree condition	Good/moderate/bad
Crown condition/Health	Good/moderate/bad
Tree stem quality	Good/moderate/bad
Causes of damage	
Management practices	
Ground cover (inverse of bare soil) - cover by crops - cover by mulch - cover by plant residues	 % % %
Permanence of the various crops and cover – period of cover – cover in the dry season(s) – cover at start of rainy season (s) when wind and water erosion are greatest risk	 low, moderate, high low, moderate, high low, moderate, high
Permanence of the various crops and cover – period of cover – cover in the dry season(s) – cover at start of rainy season (s) when wind and water erosion are greatest risk	 low, moderate, high low, moderate, high low, moderate, high
Crop diversity – crop species diversity (number and share of. local/indigenous to introduced species) – crop varieties (number for 3 main crops) – harvested products diversity (grain, straw, beans, fruit, fibre, etc.)	 no.; low/medium/high no.; low/medium/high no.; low/medium/high

Indicators	Value
Fragmentation/proximity to natural vegetation	
– average farm/field size	ha
– average number of parcels	no.
– extent/share of fallow land	%
Diversity of natural vegetation in/around cropland	
– distance of cropland from natural vegetation (grazing, forest/ wood, managed fallow, unmanaged)	none/close/far
– landscape features- presence of hedgerows, trees, grassed bunds/waterways, windbreaks, etc. -specify	none/few/many
– contribution to household of gathered products (e.g. share of fuelwood, wild foods, charcoal, materials, medicinal plants,...)	low/moderate/high
– reduction/loss of useful species and products	low/moderate/high
Use of natural vegetation	
- for protective mulch	low/medium/high
- for restoring organic matter management	low/medium/high
- for other products (wood, firewood, etc)- specify	low/medium/high

Site No.	Tree	Shrub	Stump	Species		Growth				Canopy			Health			Products		Users	
				Common name	Scientific name	Av. Diameter Dbh.	Av. height	Year(s) since cut	Tree Stem quality	Tree canopy cover	Shrub cover	Ground cover	Crown condition	Tree/shrub condition	Cause of damage	Wood and building materials non wood food and medicinal products	Charcoal	Local use	Commercial use
						cm	m		C	%	%		C	C	C				

TOOL 4.6 INTERVIEW WITH LAND USER ON CROP PRODUCTIVITY AND YIELD

Understanding the characteristics, management and environmental history of the sample sites is imperative. Discussions with farmers, is the best way in which to do this. The best way to do this is to interview farmers in the field next to the plot of interest.

The following checklist can be used (not all factors will be relevant, dependant on the land use):

- land uses changes in terms of crop production;
- crops (type, health, yield-above or below expectations);
- land preparation/tillage: type, direction and depths;
- power: hand, animal, tractor (size);
- presence of minimum or no till (and for how many years/seasons);
- crop residues (kept in field, removed–partially or totally etc);
- fertilization (and response to)–organic (includes manures) and mineral;
- other soil ameliorants applied, for example lime, g ypsum;
- land management such as bunding, levelling, terracing, (and if in specific areas of the site);
- rainfall (recent and historical) (e.g. "very wet at last harvest");
- water for domestic and agricultural use:
  - Are additional water resources besides rainfall used (rivers, streams, boreholes, etc.)?
  - Are there problems with availability of water, flooding, water quality?
  - Are there difficulties in accessing water (perhaps prohibited by rules or laws or ownership issues)?
- have there been changes (in the last 1, 5, 10 years) in quality, quantity, access?
- what attempts have been made to introduce "best" or altered practices?
- land degradation observations–location, type, history, apparent causes.

This is a "check-list" rather than a fixed list of questions. Ask additional questions and/or explore additional areas if raised during discussion and relevant. It is important to probe on trends and changes when appropriate e.g. changes in land degradation and people's perceptions of its effects or the extent to which land-users engage with conservation/SLM.

Note: Although the objective of this interview is to provide contextual and management information to accompany the land degradation assessment it is important that the household livelihoods interview builds on this interview and does not duplicate it when the land user is interviewed for both.

5. Soil assessment

INTRODUCTION

There are two parts to the soil assessment, firstly assessing soil properties which results in a scoring of soil health, and secondly, assessing and scoring soil erosion activity, type and severity. The procedures for selecting and describing the sites for detailed assessment have been outlined in the above sections.

Soil Properties and Health: The tools for assessing soil properties and health are taken from the VS-Fast methodolog y (McGarry, 2006) and selected VSA methods of Shepherd (2000). Emphasis with VS-Fast is on the assessment, both qualitative and quantitative, of soil physical condition conducted during field visits. The core set of indicators used provides a robust, yet rapid and inexpensive approach to assessing the following soil characteristics:

- description of the soil sample (depth, texture, structure, colour, layering);
- aggregate size distribution;
- soil crust;
- tillage and other pans;
- biota (particularly earthworms and roots);
- slaking and dispersion;
- pH;
- water infiltration;
- organic carbon;
- soil and water salinity.

The measures are designed to be reproducible and quickly learned. Additionally, as they are field methods, they provide immediate indications of soil quality, quickly interpretable for the farmers and land owners present during testing. The methodology generates quantitative data on soil quality and condition, also providing guidelines for scoring and ranking the results to enable comparisons to be made between soils at the detailed assessment sites.

The soil zone of greatest interest in terms of VS-Fast occurs from the soil surface to approximately 0.4 m depth. This represents the most important zone in cropland and improved pastures for seedbed development, early germination and plant growth. In crop, forest and pasture land, it is the zone with the greatest potential for negative impacts on water infiltration, soil carbon losses etc., due to soil compaction also erosion by wind and water.

Spade technique, hole size and depth: The following procedures (Tool 4.1) are based on the examination of an excavated spadeful of soil at a site selected for detailed assessment.

A spade with a flat (though usually slightly curved) blade is used to remove an intact "block" of soil, commonly up to 0.3 or 0.4 m deep and 0.25 m wide from the site under investigation. The soil is left on the blade of the spade for subsequent observations. The spade, with the block of soil on the blade, is commonly "propped-up" on a rock or against a car or fence for description, sketch or photograph. A photograph is recommended.

Scoring of soil health: Guidelines are provided for scoring each of these and weighting/ integrating the scorings into two measures of soil quality, one based on visual observations (Tool 5.1) and the other based on the soil measurements (Tool 5.2).

TOOL 5.1 VISUAL ASSESSMENT OF SOIL QUALITY

Seven visual indicators of soil quality, determined on the excavated soil block with supporting information from the soil surface around the excavated pit, are recommended for the core LADA-L assessment, these are:

1. Soil depth;
2. Soil texture;
3. Soil structure (tillage pan, aggregate size distribution);
4. Surface crust;
5. Soil colour;
6. Soil life (i.e. earthworms and other biota);
7. Roots.

With the exceptions of soil depth, texture and colour, guidelines are provided below for the scoring of each of these indicators and the integration of these scorings into a soil quality assessment.

1. Soil depth

Soil depth is important as it determines rooting depth. If the soil is shallow, this will be a limiting factor to plant growth (reducing access to water and nutrients) and hence land productivity. Soil erosion and compaction may reduce the soil depth available to the plant.

Firstly, using a measuring tape, ruler or stick graduated in centimetres, assess and measure the location (depth and thickness) of any visible soil layers; in terms of colour, soil structure (see below), root density etc. The depth to any hard compacted layer or "hardpan" should be recorded, this may be caused by mineralization of certain compounds or by repeated hoeing/ploughing at a certain depth.

Record these depths and prepare a sketch of the soil profile, annotated with depth and principal soil features.

2. Soil texture

Soil texture refers to the relative proportions of sand, silt and clay size particles in a sample of soil.

- Clay particles are the smallest particles, less than 0.002 mm in size.
- Silt is a medium size particle between 0.002 and 0.05 mm in size.
- Sand is the largest particle, diameters from 0.05 to 2.00 mm; commonly divided into fine sand (0.05–0.5 mm) and coarse sand (0.5–2.00 mm)

Texture has important effects on a wide variety of soil properties (e.g. soil's water holding capacity, aeration and porosity, hydraulic conductivity, compaction potential, resistance to root penetration, nutrient holding capacity (i.e. cation exchange capacity) and resistance to acidification). Soils that are dominated by clay are called fine textured soils, while those dominated by larger particles are referred to as coarse textured soils. Soil scientists group soil textures into soil texture classes (Figure 2).

Figure 2 also shows the PERCENT of sand, silt and clay in the textural classes. Note: specify diagram for sandy soils (source: FAO, 2006. Guidelines for soil description).

Texture can be determined in the field by taking one or two table-spoonfuls of soil (from a soil layer of interest) in one hand and adding water, drop by drop, to the soil as it is being worked in the hand until a sticky consistency is reached. The soil is then rolled into a ball and texture determined, through ability to form various shapes from the rolled ball. Compare the shape achieved to Table 9 and refer to Figure 4. Record the texture class determined, on the field sheet.

The point, at which the soil becomes malleable and can be hand-shaped, indicates its texture (use Figure 4 in conjunction with Table 9).

3. Soil structure

In the VS-Fast system, the description of soil structure focuses on each of: (a) the presence of "pans" in the soil; these being platy and massive, continuous, horizontal layers; and the (b) description of the size and shape of the soil units, present in the excavated cube of soil and exposed for description by manipulating the cube of soil to facilitate breakages along natural lines of weakness.

3a. Tillage and other soil pans

Tillage pans (formed by plough or hoe) and other forms of pans are important negative indicators of soil condition as well as being symptomatic of non-sustainable land management practices. Soil pans are located and described by comparing the lower and upper parts of the excavated spadeful of soil. As an example, the upper layer may be small to medium granular structure, overlying a tillage pan, where the structure is clearly compacted, massive, smeared or "platy" (like large dinner plates).

FIGURE 6
SOIL TEXTURAL TRIANGLE

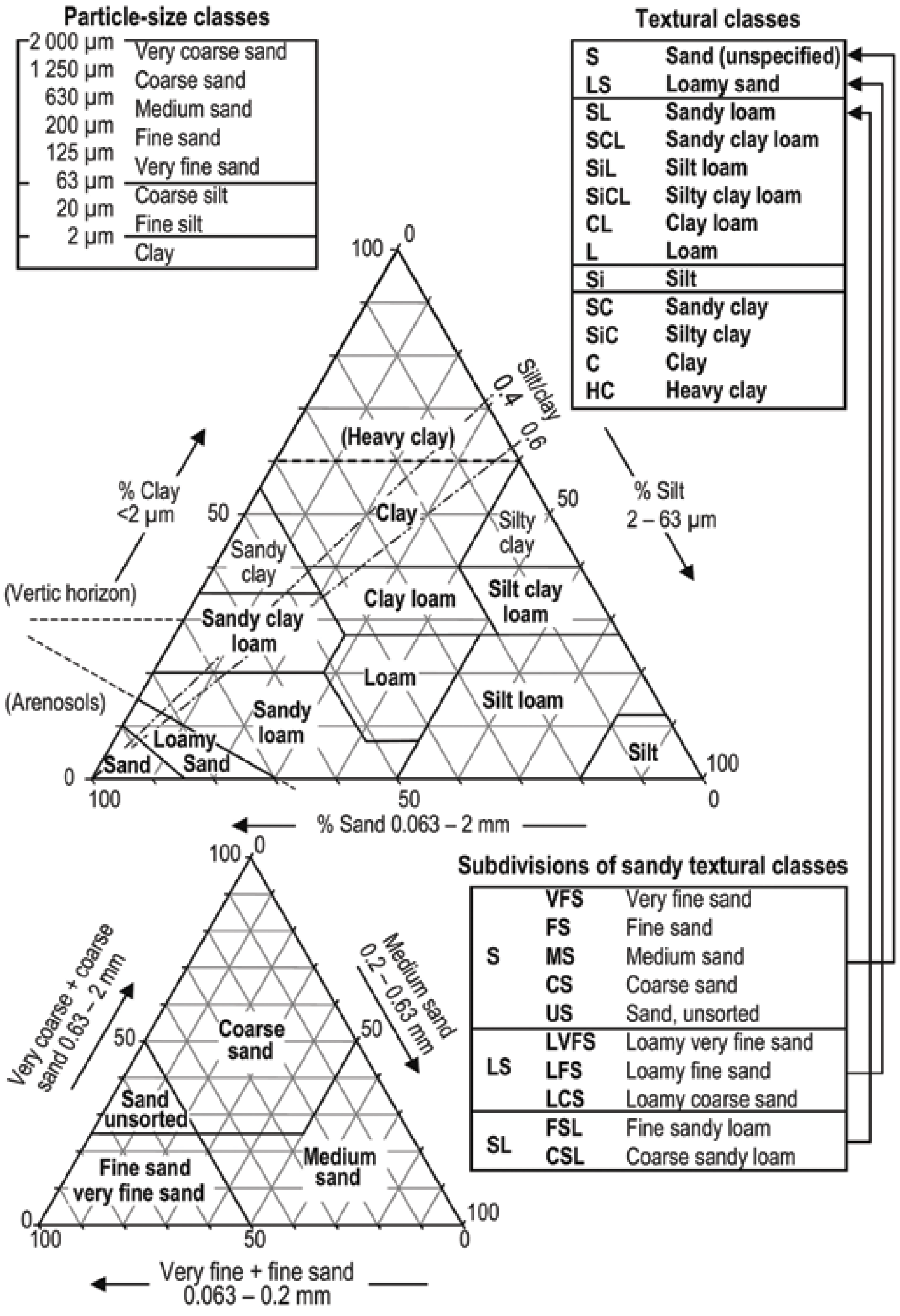


FIGURE 7
HAND ASSESSMENT OF SOIL TEXTURE

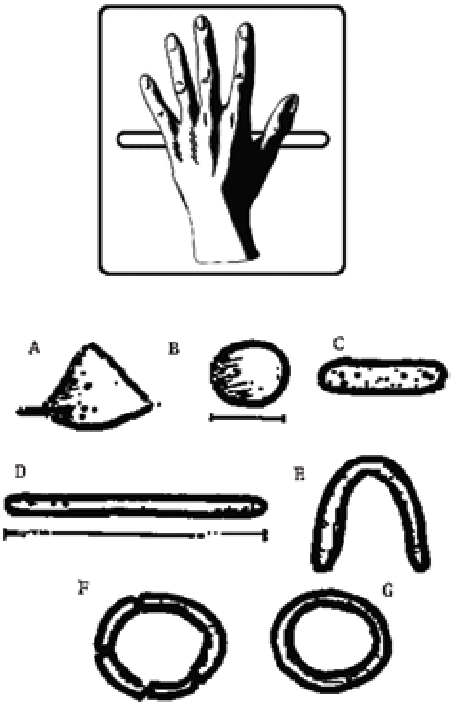


TABLE 9
Textural classes description

Textural Classes	Description
A Sandy Loam	The soils stays loose and separated accumulated only form of a pyramid
B Sandy Loam	The soil silt and clay to become sticky, and can be given the shape of an easy-to-take-apart ball
C Silty Loam	Similar to sandy loam but the soil can be shaped by rolling it into a small short cylinder
D Loam	Contains amounts of sand, silt and clay. Can be rolled into approx. cylinder that breaks when bent
E Clayey Loam	Similar to the loam, but the rolled cylinder can be bent and given a Ü"shape (without without breaking
F Fine Clay	The soil cylinder can be bent into a circle, but show some cracks
G Heavy Clay	The soil can be shaped as a circle cracks

Tillage pans only occur in cultivated land, either from metal implements working soil or repeated trafficking by tractors; both giving the worst compaction (tillage pan) when conducted in moist to wet soil.

Other types of "pans" can be found in each of grazing and fodder producing lands (e.g. growing perennial grass swards). In these situations the "pan" is commonly on the immediate soil surface, resulting either from surface trampling" by animal feet (particularly if animals were present in large numbers in moist to wet soil conditions) or from repeated passes of harvests and balers, cutting and packing animal fodder; again worsened by random (criss-crossing) traffic in moist to wet soil conditions.

Record the presence, thickness and degree of development of any pan.

Scoring (after Shepherd 2000):

- Good condition (score = 2): no tillage pan (or any other type of pan), with friable structure and soil pores from topsoil to subsoil
- Moderate condition (score = 1): firm, moderately developed tillage pan in the lower topsoil (or upper subsoil), or surface pan from animals or repeated traffic. The pan is clearly platy or massive but contains one or more of: areas of better soil structure recorded above or below the pan, cracks or continuous pores through the pan.
- Poor condition (score = 0): a well developed tillage pan in the lower topsoil (or upper subsoil), or surface pan from animals or repeated traffic. The pan has massive or platy structure with firm to extremely firm consistency and very few or no vertical cracks or pores through the pan.

3b. Aggregate size distribution

In order to bring some uniformity to the method of manipulating the soil (on the spade) and to get it to break along natural cleavage planes, Shepherd (2000) has further developed the "drop-shatter" test. In this, a spadeful of soil is dropped three times from a uniform height either onto a plastic sheet (lying on the ground) or into a rectangular shaped "washing-up" basin. If the soil does not completely shatter into individual units, then gentle hand manipulation is used to break the soil along natural breakage lines. Once the soil is broken into its individual aggregates, these are sorted so that the largest are placed at the top and the smallest at the bottom (Figure 5).

Effectively, this is a field method of aggregate size distribution. Degraded soil tends to have a greater proportion of coarse structure units than a well structured soil (Figure 5).

FIGURE 8
AGGREGATE SIZE DISTRIBUTION

Good conditions vs=2	Moderate conditions Vs=1	Poor conditions Vs=0

Examples of (left) finely structured soil and (right) coarsely aggregated soils are differentiated using the "drop-shatter" test with subsequent arrangement into coarse–fine aggregate size distribution (from Shepherd 2000).

PHOTO 2
SOIL ANALYSIS IN GRENADA

A problem with this test is the strong interdependency between what is achieved with the "drop test" and the current soil water content. The wetter the soil, the less will be achieved when the soil is dropped. Every effort should be made to conduct comparisons at the same water content. Another problem occurs in sandy soils where the aggregates cannot be sorted by hand due to their inherent weakness (i.e. the structure grade is "weak").

Scoring (after Shepherd 2000):

- Good condition (score = 2): good distribution of friable, smaller aggregates with no significant number of clods
- Moderate condition (score = 1): soil contains significant proportions of both large, firm clods and friable, small aggregates
- Poor condition (score = 0): soil dominated by large, extremely firm clods with very few small, friable aggregates.

4. Soil crusts

Soil crusts are a soil surface phenomenon, most commonly regarded as a negative soil feature, however, in certain circumstances they can have positive effects on soil moisture and landscape health. There are two main types:

4a Chemical and Physical Crust

Chemical and physical crusts are inorganic features such as a salt crust or platy surface crust, often formed by trampling. They comprise a consolidated layer commonly <10 mm thick that can be separated from and lifted off the soil beneath, on drying. Inorganic crusting is most common in fine textured soils (loams and sands), though clays with low aggregate stability (see stability test Tool 4.2.1 below) from high sodium levels and/or low organic matter content can also crust. In such soils, soil crusts impact negatively on soil health through reducing water infiltration (hence increased erosion risk, prolonged water ponding in flat and concave areas, and reduced water storage in the soil) as well as reduced seedling germination. The degree of negative impact increases with both greater crust thickness and continuity (i.e. degree of cracking).

4b Biological Crust

Biological soil crusts are formed by living organisms and their by-products, creating a crust of soil particles bound together by organic materials at the surface of desert soils. They are predominantly composed of cyanobacteria (formerly called blue-green algae), green and brown algae, mosses, and lichens. Liverworts, fungi, and bacteria can also be important components. (These soil crusts are also known as microbiotic, cryptogamic, cryptobiotic, and microphytic crusts depending on the organisms concerned). See Figures 4 and 5. These are "positive" crusts specific to arid, desert areas (e.g. north west China), where their widespread occurrence has a strong positive impact on the soil and landscape condition through binding the soil surface, hence greatly reducing wind erosion (specifically windblown sand). As they are concentrated in the top 1 to 4 mm of soil, they primarily affect processes that occur at the land surface or soil-air interface. These include soil stability and erosion (both by wind and by water), atmospheric nitrogen-fixation, nutrient contributions to plants, soil-plant-water relations, infiltration, seedling germination, and plant growth.

Aboveground biological crust thickness can reach up to 0.10 m. Their appearance in terms of colour, surface topography and surface coverage varies. Mature biological soil crusts are usually darker than the surrounding soil due to the density of the organisms and the often dark colour of cyanobacteria, lichens, and mosses. Biological soil crusts generally cover all soil spaces not occupied by vascular plants, and may be 70 percent or more of the living cover.

Crust-forming cyanobacteria have filamentous growth forms that bind soil particles. Fungi, both free-living and as a part of lichens, contribute to soil stability by binding soil particles with hyphae. Lichens and mosses assist in soil stability by binding particles with rhizines/rhizoids, increasing resistance to wind and water erosion. The increased surface topography of some crusts, along with increased aggregate stability, further improves resistance to wind and water erosion.

Studies show that biological crusts can alter water infiltration: where crusts greatly increase surface roughness water infiltration may be increased, but where effects on surface roughness are not significant, infiltration is generally reduced due to the presence of cyanobacterial filaments. These effects are site-specific and also related to soil texture and chemical properties. In dryland and grassland regions, such crusts may prevent infiltration into the soil so most rainwater is evaporated, therefore, they potentially affect the hydrological circulation in the upper layer in sandy land. For measurement and assessment of biological soil crust, 3 indicators can be used:

- coverage (percent) of the biological soil crust in the assessment area;
- thickness (mm) of the biological soil crust;
- impacts of the biological soil crust on rainwater infiltration into soil (using a double ring infiltrometer,).

Record observations of surface crusting in the general notes or photograph the surface crust. Observations and scoring are best conducted after a period without rain and on ground that is not cultivated or disturbed by animals.

Scoring

A. Chemical and physical crusting (negative):

- Good condition (score = 2): little or no surface crusts;
- Moderate condition (score = 1): Crusts present, up to 3 mm thick, broken by cracking ;
- Poor condition (score = 0): Crusts present, up to 10 mm thick, continuous with almost no cracking.

B. Biological soil crusting (positive) (only relevant in arid/desert lands):

- Good (score = 2): almost continuous, surface biological crust, commonly with increased soil surface roughness (pinnacle formation);
- Moderate (score = 1): discontinuous (patchy formation) of biological crust with minimal evidence of pinnacles;
- Poor (score = 0): no biological crust present.

Biological soil crusts can be monitored using visually defined categories in areas dominated by cyanobacteria. Figure 6 shows six categories selected in the Colorado Plateau, USA. that are easily distinguished by both trained and untrained observers and are closely related to cyanobacterial biomass and the resistance of the soil surface.

5. Soil colour

Soil colour indicates many important soil properties. First and foremost, soil colour provides much information on the source material(s) of the soil and the climatic/human factors that have altered the original rocks and sediments to give the current soil condition. Secondly, soil colour is a strong indicator of current soil water (or aeration) status. Generally, bright colours, and reds/oranges in particular, show good soil aeration and drainage (the iron in the soil is in the ferric (oxidised) state).

Dull and grey colours show reduced aeration and a tendency for low-oxygen status and waterlogging. The dull grey/black colours in a waterlogged soil often occur as mottles (ie a secondary colour within the main soil colour). Thirdly, soil colour may reflect the organic matter status of the soil, particularly useful when comparing the topsoils of long term cropping land with treelines and fencelines. Generally, the darker the soil the greater the organic matter content.

PHOTO 3
DEVELOPMENT OF BIOLOGICAL SOIL CRUST IN SANDLAND OF DRYLAND REGION, CHINA

Source: Kebin Zhang

PHOTO 4
VISUAL CATEGORIES OF SOIL CRUSTING
(COLORADO PLATEAU, USA)

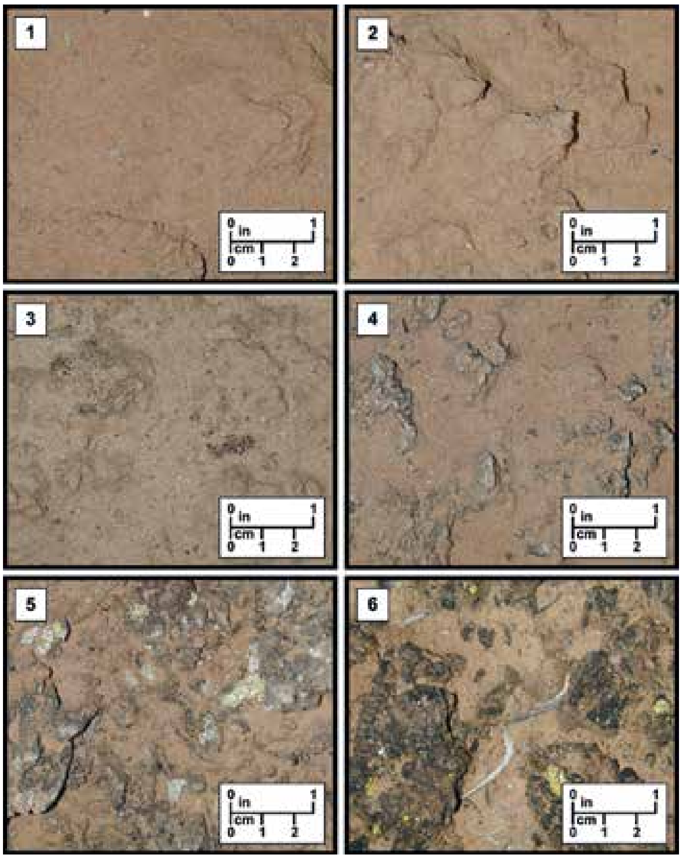


PHOTO 5
ASSESSING EFFECT OF SOIL COMPACTION OR CRUSTING ON WATER INFILTRATION

How to assess soil colour?

1. Take a lump of soil from the layer/horizon to be described. Break the lump to expose a fresh face (Figure 4).
2. If the soil is dry, moisten the face by adding water drop by drop (Figure 7)
3. Wait for the water to seep into the soil.
4. Now name the soil colour (e.g. red, brown, grey, black, white etc.).
5. If a soil has more than one colour, record a maximum of two and indicate (1) the main (dominant) colour and the (2) secondary colour.
6. *If available*, match the soil with a chip on the Munsell Soil Colour Chart.Record the soil as the Hue/Value/Chroma and the name of the colour.

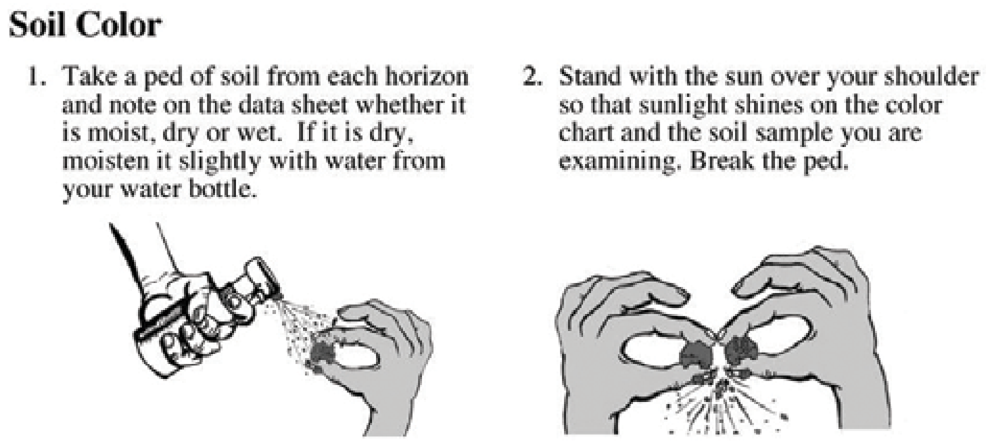
6. Earthworms (and other soil biota)

Soil biota are usually an indicator of good quality. Earthworms are particularly good indicators as they incorporate organic matter into the soil and improve aeration with associated improvements in water infiltration and crust prevention. They also increase soil fertility *via* their caste material.

The presence of large numbers of species in good concentrations reflects and integrates many positive aspects of soil condition: good aeration (no waterlogging), structure (no compaction), plentiful food supply (for earthworms, the retained crop residues and stubble) and the lack of disturbance by cultivation (no-till). As such, the presence of biota is a most important, and fortunately in terms of the macro-biota, an easy-to-measure, attribute. Earthworms are used as indicators here for two reasons:

- they are easily seen and captured; and
- they are good indicator species, indicating the presence of a healthy soil biota and a good soil.

FIGURE 9
PROCEDURE FOR DETERMINING SOIL COLOUR IN THE FEILD



Source: NASA, 2004

Earthworms are rarely found in sandy soils and may only occur in deep soil layers of arid (infrequently wetted) landscapes, hence are a poor indicator species for soil health in such situations. Termites, ants, beetles and collembolan (commonly called “springtails”) are also considered important indicators of good soil condition, as well as causing the development of fertile soils. Ants are known to move and aerate considerable quantities of soil, while termites affect both nutrient pools and the flow of water into the soil through their interconnected galleries. Currently, research is limited on the link between the presence and abundance of ants and selected termite types and their use in monitoring soil condition.

It is important to recognize that all soil biota are seasonal and migratory animals (seeking warmth, food and moisture). Because of this, it may well be that during a soil inspection earthworms (and other soil indicator fauna) are not found but strong evidence of their earlier presence may be visible (i.e.namely earthworm burrows (large, round and continuous pore spaces) in the soil profile and caste (faecal) material on the soil surface, termite burrows and mounds, buried stores of organic material etc.). In the absence of actually capturing and counting earthworms and other soil fauna, note should be taken of the number and concentration of related soil fauna features.

The assessment team should use local knowledge to decide whether earthworms are the most appropriate animal group to use as an indicator. If not, then they should identify and use a more appropriate group.

Method:

- While manipulating the soil on the spade blade for soil structure description, pick- out and place to one side all earthworms found in the soil sample.
- Observe the presence (number and size) of earthworm burrows and castes.

Record earthworm numbers on a 1 m^2 (a square meter) spade depth basis. So if the spadeful of soil is a 0.2 m cube, that equates to a 1/25 square metre of soil, so multiply numbers of earthworms by 25 to convert to m^2 basis.

Scoring (after Shepherd 2000):

- Earthworms plentiful (score = 2) if >8 earthworms counted;
- Moderate earthworm numbers (score = 1) if 4 to 8 earthworms counted;
- Few or no earthworms present (score = 0) if <4 earthworms counted.

FIGURE 10
ESTIMATING % BARE SOIL

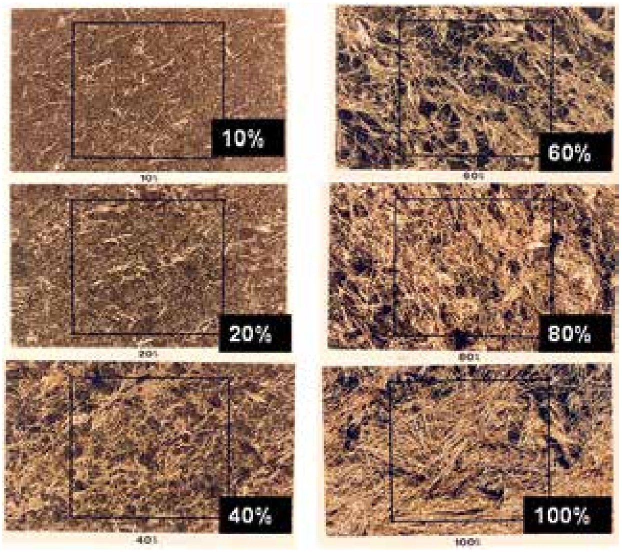
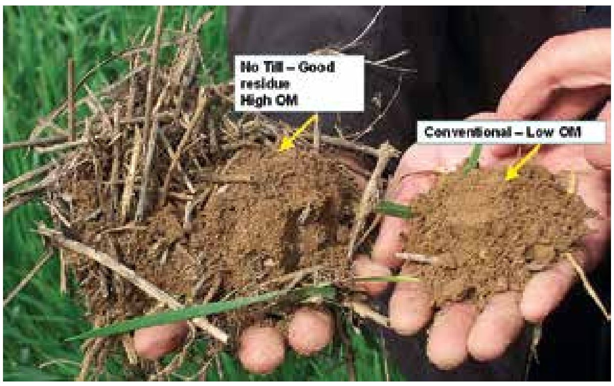


PHOTO 6
SOIL PROFILE TO OBSERVE THE DEPTH AND DISTINCT LAYERS

PHOTO 7
SOIL COLOUR UNDER NO-TILL AND CONVENTIONAL TILLAGE



Source: Linfen, Shanxi, China

PHOTO 8
EARTHWORMS IN SOIL AFTER 12 YEARS ZERO TILL, PAMPAS OF ARGENTINA

PHOTO 9
RESTRICTED ROOT GROWTH

7. Quantifying roots

The development of root systems into the soil is a prime biological indicator of soil and vegetation condition. Where plant root growth is not impeded, it will reach its optimal form (root depth, lateral spread, density of roots and root hairs) and optimize uptake of water and nutrients to meet plant demand. However, when root growth is impeded by rocks, hard or compacted soil layers, high groundwater or saturated conditions, nutrient deficiencies, salinity or toxicity, or water shortage, the result will be visibly stunted or deformed roots that in turn will lead to restricted growth of above ground parts of the plant. Triangulation with other indicators/observations will help identify the precise causes of the root deformations.

The determination of the extent and development of the plant root system is best done:

1. by examining the root system emanating from the sides of the block of excavated soil (on the spade blade); and
2. then, similarly, as the excavated block of soil is manipulated and broken up for soil structure description;

3. these observations can be supplemented with observations of any exposed soil profiles around the site where plant rooting is visible (e.g. road or drainage cuttings etc.).

Observations (recorded and leading to scoring on the field sheet) will include the following :

- evidence of stunted/deformed roots or acute, sharp changes in root penetration into the soil (the "L" shaped root syndrome, particularly evident in tap rooted crops like cotton and sunflower);
- disproportionate number and concentration of roots in the immediate surface layer, demonstrating that extension into the layers beneath is difficult;
- concentration of roots on ploughpans (hardpans)–at the greatest depth of ploughing ;
- evidence of roots "squashed' in fissures between strong soil units, demonstrating their inability to penetrate into these units, and access water/nutrients within; and/or
- an absence of fine root hairs, or an over-abundance of strong primary roots, showing the
- difficulty (and hence loss of vigour) experienced by the fine roots, penetrating the soil.

Record observations in the general notes on the field sheet or annotate the photograph or soil profile sketch with root shapes and concentrations.

Scoring (after Shepherd 2000):

- Good condition (score = 2): unrestricted root development;
- Moderate condition (score = 1): limited horizontal and/or vertical root development;
- Poor condition (score=0): severe restriction of horizontal and vertical root development; presence of "L" shaped roots, over-thickening of roots, or roots squashed between soil units.

Date:

Site #:

Location:

Sketch of soil profile

<table>
<tr><th colspan="7">Visual assessment</th></tr>
<tr><td>Test</td><td colspan="3">Results</td><td colspan="3">Additional data</td></tr>
<tr><td>Soil colour</td><td colspan="3"></td><td colspan="3"></td></tr>
<tr><td>Soil texture</td><td colspan="3"></td><td colspan="3"></td></tr>
<tr><td rowspan="3">Soil structure</td><td>Type of pan</td><td>Thickness</td><td>Asd</td><td>Vs fast score</td><td>Weight</td><td>Fvs</td></tr>
<tr><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td>Pan type:</td><td>X3</td><td></td></tr>
<tr><td>Asd:</td><td>X3</td><td></td></tr>
<tr><td rowspan="3">Soil crust</td><td colspan="2">Crust type</td><td>Thickness</td><td>Vs fast score</td><td>Weight</td><td>Fvs</td></tr>
<tr><td colspan="2" rowspan="2"></td><td rowspan="2"></td><td>Chemical:</td><td>X2</td><td></td></tr>
<tr><td>Biological:</td><td>X2</td><td></td></tr>
<tr><td rowspan="3">Soil organisms</td><td colspan="2" rowspan="3">Species:</td><td rowspan="3">#'s in $1m^2$</td><td colspan="3">Additional observation:</td></tr>
<tr><td rowspan="2">Vs fast score:</td><td>Weight</td><td>Fvs</td></tr>
<tr><td>X2</td><td></td></tr>
<tr><td rowspan="3">Root quantification</td><td colspan="3" rowspan="3">General observations:</td><td rowspan="3">Vs fast score:</td><td>Weight</td><td>Fvs</td></tr>
<tr><td>X3</td><td></td></tr>
<tr><td></td><td></td></tr>
</table>

TOOL 5.2 SOIL MEASUREMENTS

Five soil properties are measured or assessed in this section. Each is scored and integrated to give a value for the soil quality assessment.

1. Slaking and dispersion (Tool 5.2.1)
2. Soil pH (Tool 5.2.2)
3. Water infiltration (Tool 5.2.3)
4. Organic carbon (labile fraction) (Tool5.2.4)
5. Soil and water salinity (electrical conductivity) (Tool 5.2.5)

The soil measurements have been chosen for a combination of simplicity, reproducibility and rapidity, focusing on measures that are directly affected by land management. In some cases, assessment teams may wish to carry out more conventional sampling and soil laboratory analysis but these conventional tests are not part of this rapid field assessment.

If possible, the VS-Fast field soil measures and tests should be conducted at the assessment sites.

There are two principal reasons for this:

Firstly, it allows an immediate sharing and discussion of findings with land users. Secondly, it is possible to record, in a field photograph, a site record of the pH test (in the porcelain plate) alongside the result of the dispersion test (samples from the same depth in the dispersion dishes) with the soil profile on the blade of the spade. Used in conjunction with the Site Photo and Sketch, this gives an additional lasting record of the site and soil at the time of the assessment.

The one test that lends itself more to "analysis at the end of the working day" is the organic carbon (labile fraction) test. With increased proficiency of use, it may be conducted more widely in the field. However, in early days of using these methodologies, to save time, soil samples can be collected (from the same layers or sites where the other measures were conducted) and the test done later in the day, then information collated into the overall results by the team.

Clearly, not all of the following tests are suitable for all soil types and the interpretation of the results can also change between soils. For example, rapid hydraulic conductivity, that indicates good soil structure in a clay or loam is an unattractive attribute in a sand–showing rapid drying of the soil, following rain or irrigation. These possible ambiguities in the results are discussed in the relevant sections below.

Tool 5.2.1 Slaking and dispersion

The inherent ability of a soil, particularly the soil surface, to withstand the impact of several types of land degradation, principally wind and water erosion, is strongly dependent on the soil's response when wetted.

There are two main types of aggregate collapse when water is added to soil: slaking which describes the breakdown of aggregates into micro aggregates and dispersion which describes the breakdown of aggregates into the primary soil particles of sand, silt and clay.

The differentiation between slaking and dispersion is most important. Generally, the products of slaking can re-form to produce larger aggregates whereas dispersion into primary particles is irreversible and results in an undesirable, massive structure. On the soil surface, dispersed soil appears either as a hard setting layer (or a surface crust) or as loose fine (white) sand grains. Crusts (see section 4.2.4) and sealing are major impediments to both water penetration (causing rain water to pond on the soil surface with strong potential for erosion) and to the germination of seeds. Additionally, fine, loose (dispersed) material on the soil surface has strong potential for wind erosion.

The amount of organic carbon in a soil strongly influences the ability of a soil to maintain aggregation (and not disperse) when wetted. Organic matter binds soil particles together and particularly in sand and loam soils this is the principal material causing aggregation.

The determination of the slaking or dispersive nature of a soil is commonly a laboratory test but an appreciation of the phenomenon can be gained in a short time during soil description in the field (Field *et al.*, 1997).

The procedure is as follows. Drop an air-dried aggregate from the layer under investigation into a dish (e.g. a saucer) or a small, clear container (glass or cup) containing water (use rain water or local irrigation water). Ensure the entire aggregate is submerged below the water. After each of 10 minutes and 2 hours (when possible) following immersion, a visual judgement should be made of the degree of dispersion on a scale of 0–4 (see Figure 1 and 2).

NOTE 1: The scoring should be the reverse of the scoring in Field et al. (1997), as the VS-Fast methodology gives a higher (not lower) score for better conditions.

NOTE 2: The following descriptors of the degree of dispersion are more suited to clay rich soils (clays to clay loams) where dispersion of the original aggregate gives an obvious "halo" of dispersed clay. Sandy soils, because they contain less clay, do not give such visible clay halos. With these soils, greater emphasis should be given to the degree of aggregate breakdown and whether individual mineral grains become visible (sand and silt).

Scoring:

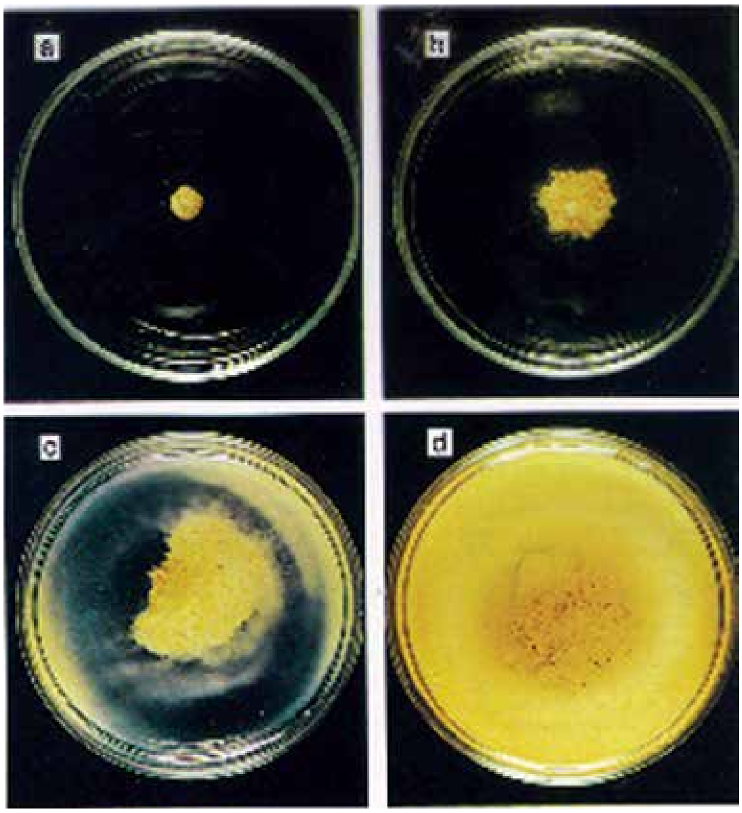
- No dispersion (though the aggregate may fall apart, i.e. slake) but with no signs of individual mineral grains (score = 4);
- Slight dispersion, recognised either by a slight milkiness in the water adjacent to the aggregate, and/or the aggregate falls apart with only a few individual mineral grains evident (score = 3);
- Moderate dispersion with obvious milkiness (score = 2);
- Strong dispersion with considerable milkiness and about half the original aggregate volume dispersed outwards and/ or individual mineral grains separated-out and clearly evident (score = 1);
- Complete dispersion, the original aggregate completely dispersed into clay, silt and sand (individual mineral) grains (score = 0).

Record the score value on the field sheet

- the aggregate remained intact with no slaking or dispersion [score = 4];
- a slaked aggregate with no dispersion i.e. no visible individual mineral grains [score 4];
- the aggregate slaked and moderately dispersed i.e. evident individual mineral grains [score = 2];
- the aggregate completely slaked and dispersed with clearly evident and abundant mineral grains [score = 0].

PHOTO 10
AREA SEVERELY AFFECTED BY SALINITY AS SEEN BY STRONG SOIL DISPERSION IN WATER (GRANMA, CUBA)

FIGURE 11
EXAMPLES OF THE NATURE AND RANGE OF DISPERSION CLASSES IN THE SOIL DISPERSION TEST FOR A CLAY RICH SOIL



Source: McKenzie *et al.*, 1992.

Tool 5.2.2 Soil pH

Soil pH measures the molar activity (concentration) of hydrogen ions in the soil solution. It is a negative logarithmic scale, so a decrease of 1 pH unit increases the hydrogen ion concentration ten-fold. At a pH of 7 (neutrality), the activity of hydrogen ions is equivalent to the activity of hydroxyl ions. At pH values less than 7, the soil is acidic, whereas at pH values greater than 7, the soil is alkaline.

In summary, strongly acidic soils can have the following negative characteristics:

- aluminium and/or manganese toxicity;
- phosphorus deficiency;
- calcium and/or magnesium deficiency;
- reduced nitrogen mineralisation because of restricted microbial activity;
- reduced boron, zinc, molybdenum and copper availability.
- surface sealing and crusting problems due to excessive sodium;
- reduced availability of iron, manganese, zinc, phosphorus and copper;
- reduced microbial activity and reduction in fungal population.

The pH test presented here utilises a "field test kit" developed by CSIRO, Australia. It is the field test kit used by Australian field pedologists (soil surveyors).

The pH kit is used in the VS-Fast system, in preference to other methodologies of determining soil pH such as (electrical) meters, principally as the pH kit provides a visible output–the coloured barium sulphate. This visible outcome lends itself to the "alignment" procedure (mentioned above) where the samples from the exposed soil profile are placed in the porcelain dish in the correct (depth) order and positioned beside the exposed soil profile for photography. In this way, a lasting record is provided of pH with the corresponding, visible soil layers/features. The procedure is as follows:

- Take a small amount of soil from the centre of a layer of interest. Crumb it up and place onto a white tile or piece of flat plastic.
- Add some of the black/purple liquid from the Test Kit (this is Universal "Raupach" indicator).
- Add just enough of the liquid to thoroughly moisten the soil. [It is important not to flood the soil.]
- Mix the soil and the indicator well together with a plastic or wooden rod (e.g. a clean stick or old "biro" pen).
- Let the mixture sit for two minutes (to allow the two to react).
- Using the little "puffer" bottle, gently "puff " a fine layer of the barium sulphate powder over the mix. A colour will develop in the powder.
- Match this colour with the closest match on the Test Kit colour chart.

Record the pH value on the field sheet (to an accuracy of 0.5 of a unit.)

Tool 5.2.3 Water infiltration

A major determinant of the cropping or grazing potential of a soil is the rate and amount of water that can infiltrate both through the soil surface and within the soil profile.

Interpretation of the measured rates of hydraulic conductivity, similar to the interpretation of crust observations changes with soil type. Rapid hydraulic conductivity, that indicates good soil structure in a clay or loam, is an unattractive attribute in a sand – showing rapid drying of the soil, following rain or irrigation, hence loss of water for subsequent plant use. Comparably, on paddy (rice) soils, zero hydraulic conductivity is an attractive soil situation. Hence, two scoring systems will be presented–one solely for use on sandy soils and paddy soils, the other for all other situations.

The following simple but robust method for the rapid estimation of soil hydraulic conductivity, based on fundamental, globally tested and accepted soil physical principles. The method considers two scenarios:

- in the first, the ring is only pressed a short distance (a few millimetres) into the soil surface (this facilitates 3 dimensional flow–where the water can flow both vertically and horizontally into the soil), and
- in the second, the ring is push in to a considerable depth (> diameter of ring), so that the flow is essentially 1 dimensional (i.e. the water mostly flows vertically into the soil).

Where possible, always use the 3-D method, as results will be obtained more quickly and the time data is more sensitive to the hydraulic conductivity. The 1-D method is more appropriate when soil cracking or the aggregation of the soil makes it difficult to seal the ring onto the soil without leaks occurring.

Field equipment required: a 0.1 m (length) x 0.1 m (diameter) ring (metal or PVC with a sharpened tip), a container holding exactly 0.4 l of water and a watch with a “seconds” hand or digital stopwatch. The procedure is as follows:

- Select a level area and carefully brush away any loose surface litter. If vegetation is present, clip it close to the soil surface and remove the clippings.
- Place the metal ring on the soil surface and push it a few mm into the soil to get a seal between the ring and the soil surface but ensuring minimal soil disturbance inside the ring.
- Pre-wet the soil surface in the ring by applying 50 to 100 millilitres (ml) of water. This is important, to reduce the initial, commonly rapid and non-steady state infiltration component of hydraulic conductivity, termed sorptivity (where the soil absorbs water due mainly to capillary forces rather than gravity). This pre-wetting reduces errors associated with assumptions in the method.
- After 15 to 30 minutes, add 0.4l of water to the ring ; this being equivalent to applying 50 mm water (rainfall or irrigation water). (Note: during this wetting and the pre-wetting the water should not be poured directly onto the soil surface, to minimize changes to the soil surface.
- One method is to use a squeezable “wash bottle”, apply the water to the inner sides of the ring until water ponds on the soil surface, then gently add the remainder of the water to this water surface)
- Note the time for the water to disappear (infiltrate) into the soil.
- Tables 10 and 11 allow conversion of the infiltration time to a permeability class for each of the 3-D and 1-D scenarios respectively.

Record whether 1-D or 3-D infiltration was measured and “fast”, medium” or “slow” rate using the times in Tables 1 and 2.

NOTE: the same “result” in terms of hydraulic conductivity rate needs to be interpreted as “negative” for sands and “positive” for all other soils, as follows:

- Fast rate/Very slow (score = 0);
- Medium rate (score = 2);
- Very slow rate (score = 1).

PHOTO 11
FEILD ASSESSMENT OF SOIL PH AND INFILTRATION

TABLE 10
Simple estimation of K on the basis of 3-D flow from a pond

Time for 400 ml of water to be gone from ring with radius 50 mm	Hydraulic conductivity-K (mm/hr)	VS-Fast Score
<10 min	>36 (fast)	0
>10 min, <1 hr	>3.6 (medium)	2
>1 hr, <2hr	<1 (slow)	1
>2hr	< 0.5 (very slow)	0

TABLE 11
Simple estimatio n of K on the basis of 1-D flow from a pond

Time for 400 ml of water to be gone from ring with radius 50 mm	Hydraulic conductivity - K (mm/hr)	VS-Fast score
<30 min	>36 (fast)	0
>30 min, <10 hr	>3.6 (medium)	2
>10 hr, <12hr	<1 (slow)	1
>12 hr	<0.5 (very slow)	0

Tool 5.2.4 Soil Carbon

NOTE: **Laboratory testing of total soil C versus field testing of labile soil carbon**

As the soil labile carbon procedure is time consuming in the field and the calibration of the reagents is rather complicated, LADA countries tended to prefer to analyse the soil carbon in the laboratory. however, the standard lab tests give a value of total soil carbon, which is felt to give a less accurate measure of recent changes in soil organic matter as the labile carbon fraction.

It is suggested that the proposed labile carbon measurement method is used, but either the same day of or the next day after the field survey, in a suitable room with a person experienced in laboratory tests, to test all the soil samples collected from the field. The results will then be available while the team is still in the field, so that the findings can be consolidated and discussed with the land users and community members.

Most (routine) soil chemical laboratories provide a determination of total soil organic matter or soil organic carbon (SOM and SOC). This is reported as something generally between 0.5 percent and 7 percent in soil. These cannot be field tests, as they are based either on total (high temperature) combustion of a soil sample or require strong chemical reagents. Another problem is that they are insensitive to management practices because they include recalcitrant (inert) forms of organic matter (such as charcoal) which remain unchanged for decades, regardless of management practices.

Techniques have developed to fractionate carbon on the basis of lability (ease of oxidation), recognising that these sub-pools of "active" carbon may have greater effect on soil physical stability and be more sensitive indicators of carbon dynamics in agricultural systems than total carbon values (Weil *et al*., 2003). The labile fraction of soil carbon is the component of organic matter that feeds the soil food web and is closely associated with nutrient cycling and other important biological functions in the soil.

Weil *et al*., (2003) have developed a "field kit method" for the determination of potassium permanganate (KMnO4) oxidisable carbon. The field procedure has been further refined in the SCAMP manual (Moody and Phan Thi Cong (2008); Moody *et al*., in press). In this test, a dilute solution of KMnO4 is used to oxidize organic carbon. Generally, in the course of the experimental procedure the greater the loss in colour of the KMnO4, the lower the absorbance reading will be, hence the greater the amount of oxidisable carbon in the soil.

The method requires a field kit consisting of:

Equipment

- 50 ml graduated disposable plastic centrifuge tubes (internal diameter: 30 mm) with screw-on caps;
- plastic rack(s) to hold the tubes vertical;
- 5 ml standard teaspoon (equivalent to 5 g ± 0.5 g soil);
- 550 nm wavelength Hach brand pocket colorimeter (or similar);
- 1 ml graduated pipette (plastic, disposable);
- 25 ml dispenser (plastic syringe) or measuring cylinder;
- deionised or distilled water;
- 1 funnel and cleaned glass wool.

Reagents

Analytical grade reagents should be used.

- *M* CaCl2.2H2O
- 33 *mM* KMnO4

Preparation of reagents

- To prepare 0.1 *M* CaCl2 weigh 1.47 g CaCl2.2H2O into a volumetric flask and dilute to 100 mL with deionised water.

- To prepare 33 *mM* $KMnO_4$, weigh 5.21 g $KMnO_4$ into a small beaker with 200 to 300 ml of deionised water, heat the solution on a hot plate (optional, no hotter than 60° Celsius) and stir until dissolved. Filter the solution through a funnel containing a plug of cleaned glass wool and dilute with deionised water to 1 L in a volumetric flask. Store the solution in an amber glass bottle or in a dark place.

The soil testing procedure is as follows:

1. Air-dry 20 g of the soil under investigation (commonly 2 or 3 depths from the 30 cm or 40 cm soil profile on the spade) for 15-30 minutes by laying out on plastic in the sun. In wet/overcast weather, the soil may need to be taken indoors for drying and subsequent analysis.
2. Crumble the soil to approximately 2 mm aggregate size, carefully removing all stones and root and vegetative materials.
3. Add five cc of the crumbled soil with 25 ml of the $KMnO_4$ solution and one ml of the $CaCl_2$ solution (to assist flocculation of the soil particles) in one of the centrifuge tubes, and firmly cap the tube.
4. Shake vigorously for exactly two minutes.
5. Stand upright for 5 minutes, in the plastic rack and protected from direct sunlight.
6. Pipette-off 1 ml of liquid from the top 1 cm of the “soil sample” solution and dilute in a centrifuge tube to 50 ml with deionised water, ensuring (through repeatedly flushing the contents of the pipette) that all the “soil sample” solution is added to the tube.
7. Zero the colorimeter using deionised water as in the calibration procedure
8. Measure the absorbance of the sample (soil) as in the calibration procedure
9. From the standard curve (Figure 13), calculate the concentration of $KMnO_4$ (mM) left in the sample after the oxidation period.

NOTE:

The calibration procedure is as follows using varying concentrations of the stock solution:

1. Zero the colorimeter by filling the colorimeter cuvette (to the mark) with deionised water, place cuvette in colorimeter, cover with cap (lightproof), press the “zero” or “tare” button. Readout should be 0.00
2. Add 25 ml of the stock solution to a centrifuge tube, add 1 ml of the CaCl solution.
3. Pipette-off 1 ml of liquid from the solution and dilute in a centrifuge tube to 50 mL with deionised water, ensuring (through repeatedly flushing the contents of the pipette) that all the stock solution is added to the tube.
4. Fill the colorimeter cuvette and place in colorimeter as before. Press “read” button. Note reading. [Note: this is the strongest (darkest) concentration of the KMnO solution; representing zero labile organic carbon in subsequent soil samples] (Figure 9).
5. Pour out sufficient of the remaining solution in the centrifuge tube so only 25 ml remains. Make up this remainder to 50 ml with deionised water, pipette off 1 ml and repeat the colorimeter measurement procedure. The reading obtained is for ½ strength $KMnO_4$.

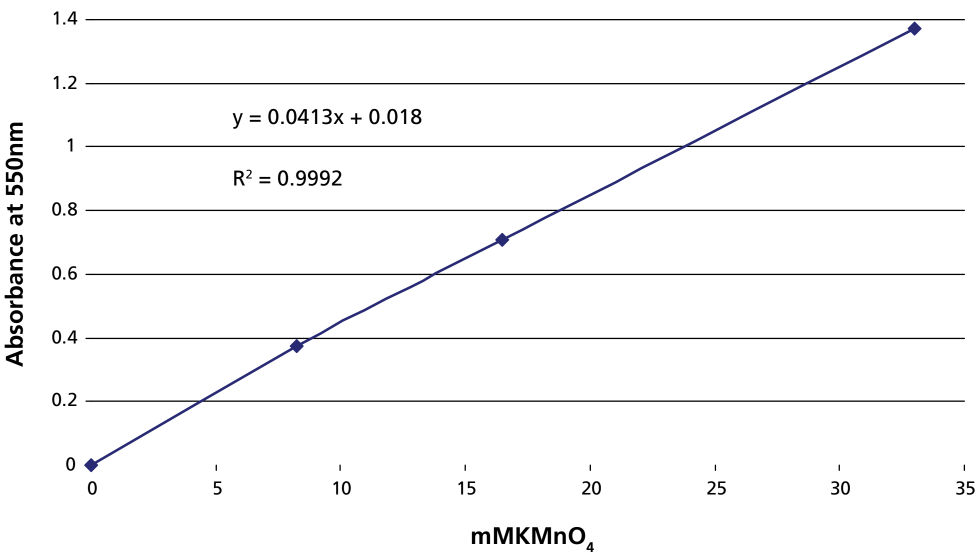
6. Again, pour out sufficient of the remaining solution in the centrifuge tube so only 25 ml remains and make up the remainder to 50 ml with deionised water, pipette off 1 ml and repeat the colorimeter measurement procedure; so gaining a ¼ strength solution.
7. Plot the above data (a straight line fit); as mM of KMnO4 (x-axis) versus the absorbance reading (y-axis), as in Figure 9. A regression line can be fitted to the relationship.

NOTE: If the absorbance of any sample is less than a reading of 0.4 (on the colorimeter at 550 nm), repeat the extraction using 2.5 g soil instead of 5 g soil. The implication is that the soil is rich in labile organic matter, hence a smaller soil quantity needs to be used to achieve oxidisation by the KMnO4 solution. Calculation of results need to suitably altered, considering only half the soil quantity was used; i.e. the unit "5" in equation - 1 becomes "2.5"

NOTE: The period of time the soil is in contact with the permanganate solution is critical, therefore 2 minutes shaking and 5 minutes settling time should be strictly adhered to. Calculation:

It is assumed that 1 M MnO_4^- is consumed (reduced from Mn^{7+} to Mn^{2+}) in the oxidation of 0.75 mmol or 9 mg of carbon. So, the amount of labile Carbon in the soil sample (grams of carbon in a kilogram of soil) is calculated as follows:

FIGURE 12
STANDARD CALIBRATION CURVE OF FOUR STRENGTHS OF 33MM KMNO4 (X-AXIS) WITH COLORIMETRIC READ-OUT(Y-AXIS)



$$C(g/kg) = \frac{(Mo - M1) \times 26 \times 9}{1000 \times 5} \text{ equation (1)}$$

Where:

Mo = initial concentration of KMnO4 (33 *mM*) *M*1 = concentration of KMnO4 (*mM*) after oxidation (calculated from standard calibration curve: Figure 9)

Final volume of KMnO4 solution = 26 ml Weight of soil = 5 g (or as used)

Record the amount of active carbon present (mg/g) using Figure 10

Scoring (from Table 12 and dependent on soil texture):

- good organic matter status (score = 2);
- moderate organic matter status (score = 1);
- poor organic matter status (score = 0).

This uses the four strengths of 33 *mM* $KMnO_4$ of Figure 9 and equation 1.

This shows the relationship between "total" organic carbon (percent) by the Leco method and active (labile) carbon from the permanganate field method for several soils. (Data and analysis of Dr P. Moody (NR&W, Queensland, Australia) with fitted line & regression equation with R2.)

The relationship between the measured quantities of labile organic carbon fraction (as determined here) and total soil organic carbon (as commonly required for carbon "trading" and sequestering in consideration of climate change) is not straightforward; being inter- related with soil type, clay content and climate (organic matter weathering and volatisation). Dr Phil Moody (pers. comm.), from analysis of several tropical and semi-arid agricultural soils states that the total organic carbon fraction by the Leco method (percent) = 5.36 active C by the 33 *mM* $KMnO_4$ (mg/kg) method as described here). Future studies relating these two fractions of organic carbon will improve the fit and the understanding of this relationship.

FIGURE 13
RELATIONSHIP BETWEEN THE COLORIMETER READOUT (ABSORBANCE) AND THE AMOUNT OF LABILE ("ACTIVE") CARBON(G/KG)

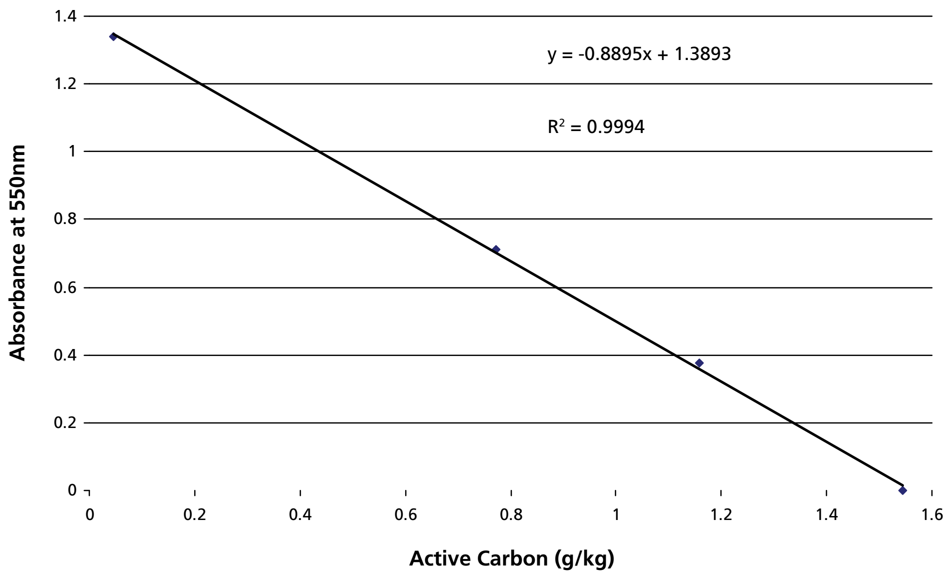


FIGURE 14
RELATIONSHIP BETWEEN 'TOTAL" ORGANIC CARBON AND ACTIVE CARBON

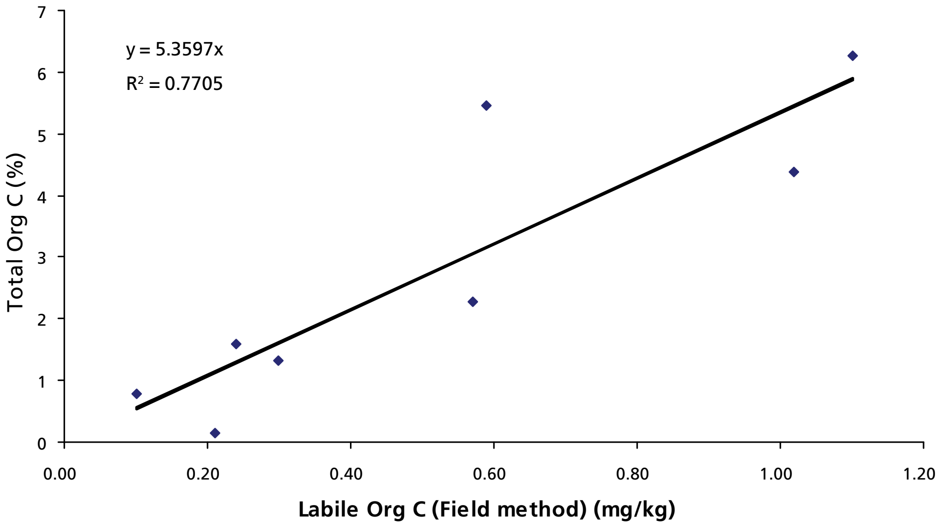


TABLE 12
Permanganate (33mM) oxidisible carbon contents (g/kg) for soils of various textures

Soil organic carbon status	Sand	Sandy loam	Loam	Clay loam/clay
Good	>2	>0.28	>0.36	>0.4
Moderate	0.1-0.2	0.14-0.28	0.18-0.36	0.2-0.4
Poor	<0.1	<0.14	<0.18	<0.24

Values (mg/g) of labile carbon considered to be 'good", 'moderate" and 'poor" for soils of different textures. The table is taken from Moody and Phan Thi Cong (2008) and the values are based on the analysis of several soils covering a wide range in total organic C.

Tool 5.2.5 Soil and water salinity measurements (Electrical conductivity)

Salinity is the presence of soluble salts in soils or waters (Shaw and Gordon, 1997). Salinity processes are natural processes, however, human activities can accelerate these, contributing to long term land and water degradation. Salinity becomes a land issue when the concentration of salt adversely affects plant growth or limits plant species selection (to salt tolerant plants) or degrades soil structure (surface crusting and scalding). It becomes a water issue (surface and groundwater) when the potential use of water (for irrigation and human/animal use) is limited by its salt content (Shaw and Gordon, 1997). Tables 13 and 17 give some visual indicators of salinity for the field.

TABLE 13
Assessing salinity using visual indicators in the feild

Visual indicators	Salinity	Sodicity
Plant Indicators	▪ Salt tolerant species e.g. couch grass *(Cynodon)* and other halophytes (that tolerate or favour an environment with elevated salt concentrations) ▪ Water stress symptoms in a crop (rolled and/or drooping leaves) even though the soil is wet	▪ Poorer vegetation than normal, few or stunted plants and trees ▪ Variable height growth in a growing crop and yield variations at harvest ▪ Symptoms of water stress not long after a rainfall or irrigation event
Soil Indicators	▪ Saline soils often exhibit a fluffy surface ▪ Whitish salt crusts often observed on top of mounds, aggregates or slightly elevated areas in the field when the surface is dry	▪ Hard-setting surface horizon often observed in soils with a sandy loam topsoil ▪ Surface crusting ▪ Soapy feel when wetting and working up for texture assessment ▪ pH >8.5 ▪ Poor penetration of rain or irrigation water into the soil due to surface crusting ▪ Cloudy water in puddles that may form on the soil surface ▪ Shallow rooting depth
Water Indicators	Depth to water table and salinity of water (measurements)	
Populations of salt-sensitive plants	Decreased germination rate, slow growth rate, incomplete life cycle (e.g. plants do not flower), diminished abundance, depressed health (e.g. yellowing and stunting of crop or pasture species), greater susceptibility to disease and decreased seed viability	

Particularly in sandy and/or arid areas, the presence of a shallow (< 2 m depth) and non-saline (electrical conductivity of <1 dS/m) water table can radically improve the potential agricultural productivity. Conversely, the presence of a shallow water table that is saline can be ruinous to almost all land uses, thus long term sustainability and productivity.

Limitations to field assessment of salinity

If the assessment is taking place in years of below average rainfall, there may be very little plant germination or growth. Thus the use of plants as salt indicators will be restricted. Conversely, in years of above average rainfall the full extent of salinity may be underestimated due to the leaching effect. In both cases, it is preferable to delay the assessment until favourable climatic conditions return.

Salinity in soils and waters can be estimated conveniently from the electrical conductivity (EC) of a soil solution, or directly on a water sample. Many salts dissociate (separate out) to ionic form in water, so the EC of a solution provides a measure of the total concentration of salts (Shaw and Gordon. 1997).

Electrical conductivity is defined as a measure of a solution's ability to conduct electricity, and as such can be used to express salinity levels in soil (a soil extract in water) or water. When salt is dissolved in water the conductivity increases, so the more salt, the greater the EC value. EC is measured by passing an electric current between two metal plates (electrodes) in the solution and measuring how readily current flows (i.e. conducted) between the plates. EC measures the charge carrying ability (i.e. conductance) of liquid in a measuring cell of specific dimensions. It is necessary, therefore, to state the units of both conductance and length in considering EC. EC units vary between institutes and countries but most common is the use of "decisiemen per metre" (dS/m)11, and commonly at 25°C, as temperature at time of measurement effects result.

Soil salinity generally affects plant growth by increasing osmotic tension in the soil making it more difficult for the plants to absorb water from the soil. Excessive uptake of salts by plants from the soil may also have a direct toxic effect on the plants. Crops vary considerably in their capacity to withstand adverse effects of salinity. Saline water, apart from being unpalatable to humans and stock, can also cause direct damage to crop leaves, depending on the concentration of salts, applied through sprinkler irrigation.

Electrical conductivity (EC) can be measured in the field using a portable EC meter. The Milwaukee® C66 "pen" electrical conductivity meter has been used in LADA assessments to date, as it was found to fulfil many of the requirements of the testing procedure, including operational range (0 to 10 dS/m), waterproof, cost, ease of use, lightweight and being (automatically) temperature compensated.

- ***To aid in conversions: 1 decisiemen per metre (dS/m) = 100 millisiemens per metre (mS/m) = 1000 microsiemens per metre (µS/m) = 640 parts per million (ppm) of** total **dissolved salts (TDS). Note: 640 is a commonly accepted average as the correct factor varies from 530 to 900 depending on the type of salt present and its concentration. Note also, ppm is equivalent to mg/l (milligrams per litre).***

Methods

The method tests EC on a soil saturation extract (ECse) using a portable field EC meter.

Before measuring EC in the field, ensure that the EC meter has been calibrated against a standard salt solution. The technique is one of manual calibration at 1 point using the small screwdriver supplied with the meter. This procedure is included in the "instruction booklet" provided with each C66 pen, and is as follows:

1. Place electrode into clean water to clean and rinse it;
2. Shake off excess water;
3. Unscrew the battery compartment cap on the top of the meter;
4. Place meter into calibration fluid (commonly used is Milwaukee 1413 µS/m EC solution) until electrodes are covered. (Note: pour just sufficient from the bulk container into a small container for this calibration procedure and then discard the solution; i.e. never re-use the calibration solution or return it to the bulk container);
5. Allow the reading to stabilise and use the small screwdriver supplied with the meter, to turn the small brass screw (the "calibration trimmer") until the readout says 1.41 mS/cm. Note: the Milwaukee C66 pen gives a readout in millisiemens per centimetre (mS/cm). So, these can be read directly as dS/m;
6. Replace the battery compartment cap;
7. The pen is now calibrated.

The technique of determining the EC of a soil sample is as follows:

1. Take 50 to 100 g of soil from the layer(s) of interest (commonly the top and bottom of the spadeful of soil);
2. Remove all stones and organic/vegetative materials;
3. Prepare a soil paste by stirring deionised water into the soil in a tube or cup (wide enough to take the tip of the EC probe) until a smooth paste is obtained. An indicator that the correct amount of water has been added is that the "paste" glistens (mirror-like) and just begins to flow. It is important to standardise this wetness "end point" as the value of ECse changes as the concentration of salts changes (with more or less water added);
4. Ensure that the EC meter has been calibrated against a standard salt solution (Note: EC is influenced by current temperature conditions, however, if the EC probe is temperature-compensated (as in the case of the Milwaukee C66 as recommended here) there is no need for temperature recording and post-compensation of calibration or solution readings);
5. Carefully insert the EC probe into the soil paste until the electrodes are covered and wait for the EC reading to become steady. Record the reading (exactly as displayed on the wand) in dS/m;
6. After reading, remove the probe, wash with deionised water while removing excess soil from around the probes with a soft brush (e.g. a toothbrush), ready for the next soil solution.

Salinity (ECw) in water, whether irrigation, surface or groundwater can be measured directly by collecting a suitable (fresh, non-stagnant) water sample, ensuring calibration of the meter, placing the EC probe directly into the sample and taking the reading in dS/m.

The quality of groundwater is of particular importance in sandy and/or arid areas, where the presence of a shallow (<2 m depth) and non-saline (electrical conductivity of <1 dS/m) water table can radically improve the potential agricultural productivity. Conversely, the presence of a shallow water table that is saline can be ruinous to almost all land uses and long term sustainability and productivity. Relevant, too, is the measured change in level of such water tables–both short and long term. It is important to determine the linkages between the nature and extent of (local) land use changes and the link (if any) with monitored changes in groundwater levels (perhaps information available from local water authorities).

TABLE 14
Relative values of ECse, VS-Fast and plant salinity tolerance classes

Level of Soil Salinity	Plant salt tolerance grouping	ECse Range (dS/m)	VS- fast score
'not" saline	Sensitive crops	<1	Good = 2
Mildly saline	Moderately sensitive crops	1-2	Good = 1.5
Moderately saline	Moderately tolerant crops	2-4.5	Moderate = 1
	Tolerant crops	4.5-8	Moderate = 0.5
Strongly saline	Very tolerant crops	8-12	Poor = 0
Very strongly saline	Generally too saline for crops	>12	Poor = 0

ECse values, with corresponding VS-Fast class and score, corresponding to the plant salinity tolerance classes of Maas and Hoffman (1977).

Values of soil and water EC can be related to available tables on: (i) plant salinity tolerance classes and the ability of specific crops to tolerate salt (Table 14 and 18) that is part of the VS-Fast scoring sheet at the end of this section, (ii) plant hazard of salinity in irrigation waters (Table 15), (iii) water quality for domestic use and stock supplies (Table 16). If measured, these values should be noted on the VS Fast score sheet.

TABLE 15
Plant hazard of salinity in irrigation water (ECw)

Hazard	dS/m
None	<0.75
Slight	0.75-1.5
Moderate	1.5-3
Severe	>3

Source: Morris and Devitt (1991).

TABLE 16
Water quality guidelines (ECw) for domestic and livestock supply

ECw range (dS/m)	Use fulness of water supply
0-0.8	▪ Good drinking water for humans (if no organic pollution and minimal suspended clay) ▪ Generally good for irrigation, though above 0.3 dS/m overhead sprinklers may cause leaf scorch on salt sensitive plants. ▪ Suitable for livestock
0.8-2.5	OK for humans - lower half of range preferred ▪ For irrigation, requires special management including suitable soils, good drainage and consideration of salt tolerance of plants. ▪ Suitable for livestock
2.5-10	▪ Not recommended for humans. Up to 3 dS/m OK if nothing else available ▪ Not suitable for irrigation. Up to 6 dS/m OK on very salt tolerant crops ▪ >6 dS/m-occasional emergency irrigation OK ▪ For poultry and pig supply <6 dS/m OK. Other stock <10 dS/m ▪ >4 dS/m-causes shell cracking in laying hens
>10	▪ Not suitable for human consumption or irrigation ▪ Not suitable for pigs, poultry or any lactating animals ▪ Beef cattle can use water up to 17 dS/m; adult dry sheep tolerate 23 dS/m

TABLE 17
Salinity class range

Level of Salinity	Visual indicators	ECe Range
S0 (not saline)	▪ No vegetation appears affected by salinity and a wide range of plants present.	<2 dS/m
S1 (slightly saline)	▪ Salt tolerant species e.g. sea barley grass often abundant. ▪ Salt sensitive plants in general show a reduction in number and vigour especially salt sensitive legumes (eg. white and sub–clover, soybeans, chick pea, etc.). ▪ At the upper end of the range, grasses and shrubs may be prominent in the plant community. ▪ No bare saline patches or salt stain/crystals are evident on bare ground.	2-4 dS/m
S2 (Moderately saline)	▪ Salt tolerant species begin to dominate the vegetation community and all salt sensitive plants are markedly affected by soil salinity levels. ▪ At the upper end of the range, some slightly tolerant species disappear and are replaced by others with higher salt tolerance. The plant community is dominated by grasses, shrubs and flat weeds. Legumes are almost non-existent. ▪ Small bare areas up to 1 m^2 may be present and salt stain/ crystals may be visible on bare soil at the upper end of the range.	4-8 dS/m
S3 (Highly saline)	▪ Salt tolerant species like sea barley grass and buck's horn plantain may dominate large areas and only salt tolerant plants remain unaffected. ▪ In low rainfall areas, unlikely that any improved species will be present; trees may show some effects (i.e. dieback). ▪ Large, bare saline areas may occur showing salt stains or crystals (on some soils a dark organic stain may be visible), or the top soil may be flowery or puffy with some plants surviving on small pedestals and the B horizon may be exposed in some areas. ▪ In moderate to high rainfall areas, bare patches may be minimal but vegetation will be dominated by one or two highly salt-tolerant plant species (e.g. Puccinellia, Spurrey, Gahnia). ▪ In higher rainfall regions, where soils may be waterlogged or flooded for considerable periods, some plant species display both salt tolerance and waterlogging tolerance. In drier areas, salt tolerant plants generally do not have high waterlogging tolerance. ▪ At the upper end of the range, halophytic plants may dominate the plant community and some species may show a reddening of the leaves.	8-16 dS
S4 (Extremely saline)	▪ Only highly salt tolerant plants survive and the community will be dominated by 2 or 3 species. Moderately and highly salt tolerant species may show a reddening of the leaves and at the upper end of the range even highly salt tolerant plants may be scattered and in poor condition. ▪ Trees will be dead or dying. ▪ Extensive bare saline areas occur with salt stains and or crystals evident (on some soils a dark organic stain may be visible). Topsoil may be flowery or puffy with some plants surviving on small pedestals and the B horizon may be exposed in some areas.	>16 dS/m

Source: Victorian Resources Online: Salinity Class Range

TABLE 18
USDA ratings of relative crop tolerance to salinity

Plant grouping	High salt tolerance	Medium salt tolerance	Low salt tolerance
Vegetable crops	ECse = 12 – 10 Garden beets; Kale; Asparagus;	ECse = 10 – 4 Tomato; Broccoli; Cabbage; Bell pepper; Cauliflower; Lettuce; Sweet corn; Potatoes (White rose); Carrot; Onion; Peas; Squash; Cucumber;	ECse = 4 – 3 Radish; Celery; Green beans;
Forage crops	ECse = 18 – 12 Alkali sacaton; Salt grass; Nuttall alkali grass Bermuda grass; Rhodes grass; Fescue grass; Canada wild rye; Western wheat grass; Barley (hay); Bird's-foot trefoil;	ECse = 12 – 4 White sweet clover; Yellow sweet clover; grass; Perennial rye grass; Mountain brome; Strawberry clover; Dallis grass; Sudan grass; Huban clover; Alfalfa (California common); Tall fescue; Rye (hay); Wheat (hay); Oats (hay); Orchard grass; Blue grama; Meadow fescue; Reed canary; Big trefoil; Smooth brome; Tall meadow oat grass; Cicer milk-vetch; Sour clover; Sickle milk-vetch;	
Field crops	ECse = 16 – 10 Barley (grain); Sugarbeet; Rape;	ECse = 10 – 4 Rye (grain); Wheat (grain); Oats (grain); Rice; Sorghum (grain); Sugarcane; Corn (field); Sunflower; Castor beans;	ECse = 4 – 3 Field beans Flax

Plants are listed within groups in order of decreasing tolerance to salinity. ECse values (dS/m) correspond to 50% decrease in yield.

Source: Van Lynden et al., 2004

FEILD SCORE CARD

Soil Condition Assessed using VS-Fast Methodology
PART A: SOIL VISUAL DESCRIPTORS
Date:
Land Use (Current and Past): Site Location:
Recent Weather Conditions:
Soil Type:
Soil Structure:
Soil Texture:
Soil Colour:
'Walk in" Observations (soil/crop residues):

Soil Profile Sketch

Visual Indicator of Soil Quality	**Visual Score** 0 = Poor Condition 1 = Moderate Condition 2 = Good Condition	Weighting	VS- Fast Score
Tillage pan	**(negative)** 2 = no crust 1 = some cracking 0 = continuous crust	x 3	
Aggregate Size		x 3	
Soil Crusts* Physical/Chemical 'negative"		x 2	
Earthworms (or other more pertinent soil		x 2	
Roots		x 3	
Sum of visual vS-Fast			

Soil visual assessment	Sum of visual VS-Fast Scores
'Poor"	<7
'Moderate"	7-14
'Good"	15-26

FEILD SCORE CARD

Soil Condition Assessed using VS-Fast Methodology
PART B: FIELD SOIL MEASUREMENTS

Field Measurement	Actual Condition	**Visual Score (vS)*** 0 = Poor 1 = Moderate Condition 2 = Good Condition	Weighting	VS-Fast value score
Slaking and Dispersion		(scores: 0-4)	x 1.5	
Soil pH		Not scored	Not scored	
Water Infiltration 'negative" = sands 'positive" = other soils		**0 = Fast Rate/Very slow** **1 = Slow rate** **2 = Medium Rate**	x 3	
Organic C–labile fraction			x 2	
Soil salinity (EC)			x 3	
Sum of soil measurement vS-Fast scores				

*These scores not applicable to slake/dispersion test, where scores range from 0 to 4 (hence weighting value)

Soil visual assessment	Sum of visual VS-Fast Scores
'Poor"	<7
'Moderate"	7-14
'Good"	15-26

Total VS-Fast score (Part A+ Part B) scores	
'Poor"	<14
'Moderate"	14-28
'Good"	30-48

Other Notes, e.g. Site photo; soil photo; or sketches of soil, pit, location

TOOL 5.3 SOIL EROSION ASSESSMENT

Introduction

The presence of soil erosion in arable, forest and pasturelands is a prime indicator of soil degradation by water or by wind; often caused by a reduction in protective vegetation cover. It may reflect imbalance in the co-achievement of productive capacity and ecologically sustainable land management, i.e. intensification for increased production without adequate means to restore land resources and ecological functions. Soil erosion through topsoil loss is an indicator and cause of reduced land fertility, and hence potential productivity. It may also hinder access to land for crop/forest production. Moreover, the transported sediments and nutrients may cause problems downstream in terms of sediment deposits and reduced water quality. Despite the recognised importance of controlling and reversing soil erosion through soil and water conservation practices, there are few attempts to systematically observe and measure soil erosion as part of an integrated assessment of degradation and management (soil, vegetation, water and ecosystems) as this manual tries to do.

For the most part, the methods presented here are designed to be used in the field, during the assessment by the multidisciplinary technical team, and in the presence of land users-crop, pasture, forest-and, if possible, representatives of local government. This will aid interpretation of the observed erosion features and their impacts, for example, in regard to recent management, weather patterns and policy and technical interventions, if any.

Soil erosion is a commonly used indicator of negative land quality or condition as it is more visible than some other types of degradation such as nutrient mining or salinization. The immediate causes of soil erosion are wind and water as energy sources that translocate soil particles but unsuitable land use and management practices greatly exacerbate the problem (indirect causes), particularly on land prone to runoff and exposed to strong winds and soil movement (e.g. steeper slopes, loose or bare soil, inappropriate cultivation, etc.).

- Erosion by water is the detachment and transport of soil particles downslope through a number of processes, driven principally by the energ y and the concentration of the water as it passes over the land.
- Erosion by wind is the detachment and transport of soil particles by wind action and commonly considers also the effect of the abrasive action of the particles as they are transported and of the soil deposits or sediments.

Measurement of wind and water erosion may include descriptions and measures of the erosion and deposition features but above all should focus on the impacts of the soil movement, *e.g.* the effects on the land potential through the loss of soil and nutrients and the effects of the transported and deposited particles, for example: silting of wetlands or floodplains, sandstorms, moving sand dunes, sediment load in rivers and streams). While erosion and hence loss of soil particles and nutrients will negatively impact on land productivity in the upper part of a catchment, it may provide fertile silts and nutrients downstream in the floodplains, i.e. having a positive impact on productivity. This section is a composite of two sources: the erosion concepts and indicators from Stocking and Murnaghan (2001) as well as a more recent GITEC/ADB/GEF project on Sustainable Pasturelands in Tajikistan by Mulder and McGarry (2010).

What to Measure?

This section provides a set of simple, field usable indicators and measurements to observe, quantify and report on soil erosion at detailed assessment sites in the various land use systems and land use types (bare field, rainfed or irrigated cropland, pasture/ rangelands, natural or planted forests, etc.). The specific tools need to be selected on the basis of the soil erosion features observed in the field: sheet erosion, rills, gullies/ ravines, exposed rock, sediment deposits, sand dunes, etc. The field measurements are robust, relatively rapid (once the team members are familiar with the tools), cheap and replicable. The aim is to compare erosion status and trends under different sites (varied topography, exposure, etc.) and different land uses and management practices.

The methods aim to achieve clarity and uniformity in recording visible soil erosion features, in terms of three distinct but inter- related qualifiers and quantifiers:

- field observations that describe soil erosion by wind or water using four descriptors of the erosion feature: type, state, extent and severity; (Tool 4.3.1);
- a field scoring method, based on the descriptors in the field observations, to provide a more quantified basis for inter-site comparisons (Tool 4.3.2). This was developed and tested by the LADA team in Tunisia (DG/ACTA, 2010) and further reviewed (McGarry, 2011); and,
- fieldmeasurements of specified dimensions of erosion features to provide quantification of rates and quantity of soil loss in a study area. (Tool 4.3.3). These draw from the Field Guide for Soil Degradation Assessment (Stocking & Murnaghan, 2001).

The information gathered on soil erosion can also be related to the community map (Tool 1.4) and other land use and topographic maps of the study area to understand wider implications of soil erosion in the landscape. Through discussions with land users and informants the assessment team should try to estimate the main effects of the erosion and sedimentation processes on productivity and other ecosystem services, on-site and off-site, including damage to infrastructure and effects on human welfare (e.g. sandstorms).

The outputs of the soil erosion assessment could include:

a. an overview of the major erosion features (type, state, extent and severity) affecting different land use types and land use systems in a selected study area and, to the extent possible, an indication of their potential impacts on-and off-site (productive land area lost, reduced productivity etc.);
b. identification and understanding of the main direct and indirect causes of erosion in the study area through observations of local causative factors and their interactions and cumulative effects:
    - rainfall amount and intensity,
    - slope of land,
    - soil type (sands and silts being more erosion prone than clays and loams;
    - degree of soil cover (litter, crop, tree, residues) as related to land use, time of the year (bare fields post harvest or after land preparation), crop/ pasture/ forest age and management practices (young, emerging crops, and young or well-thinned forest have less cover to protect the soil), extent of land clearing, etc.

c. the planning and design of soil and water conservation measures and land management practices for:
   - the affected sites to prevent or mitigate the main causes of erosion identified in the study area (direct and indirect) and, where feasible, to repair the erosion features and restore productivity or
   - new areas being opened up to production or undergoing land use changes, to ensure minimal erosion problems from the intervention (e.g. biofuel production, conversion of marginal lands to forest land, pasture or cropping, conversion of agro-pastoral areas to intensive cropping or ranching).

d. a baseline for subsequent monitoring of the status of erosion features by repeating the given observations and measurements on a specified time period, for a given area i.e. to monitor continued degradation in a "non- intervention" scenario (control) compared to an area with interventions that lead to reduced erosion, prevention of erosion, or restoration of eroded lands.

PHOTO 12
PLANTING OF CYMBOPOGON NARDUS AND CYMBOPOGON WINTERIANUS "LEMON GRASS" TO REDUCE SOIL LOSS., ST. PATRICK , GRENADA

Tool 5.3.1 Field observations of erosion

– Type, state, extent and severity
How to select observation sites

The following process is foreseen to identify areas for the required erosion observations and measurements in order to understand cause, type, extent, severity, etc. and, in turn, enable to propose and plan improved land management or rehabilitation actions:

1) conduct if possible a "desktop" study of the intended study areas using any available maps and remote sensing images (topographic and cadastral maps, Google Earth®, air photos, satellite imagery, digital elevation models-(DEM), soil/geology maps, etc.) and previous studies and reports to elucidate any major erosion features, their place in the landscape (land unit, slope) and their association with recognizable land uses in the area, etc.

2) seek out representative sites in the various land use types (LUT) in the area under consideration (e.g. cropping land, forest, pasture or fodder producing land, orchard, vegetable production, etc); and 3) be led by locals who live or work in the area (i.e. land users, farmers, herders, forestry workers, state farm managers, etc. as a follow up to the Community Focus Group Discussion, see Tool 1.1) to those areas that they believe are most degraded, or on which they are most dependent (e.g. for food production, forest replanting, winter pasture regrowth, etc.) or previously eroded areas that have been effectively restored through effective management measures.

It is important to collect information on timescales of relevance to soil formation and erosion processes in order to understand the impact of the different erosion types/ processes and particularly the capacity to repair or diminish their impact.

- sheetwash may be an annual event or more frequent occurrence;
- rills may form after a series of heavy rainfall events on ploughed land;
- gullies and ravines are most commonly the effect of several seasons or years of water concentration that result in deep incisions;
- landslides and mudflows are often rare events but these more serious erosion types are more likely to occur certain soil types and sedimentary materials.

Repair strategies, therefore must be prepared and designed for relevant timescales. For example, rills may be readily ploughed out and can be prevented by appropriate vegetation cover and soil and water management practices but gullies will require years to reclaim by installing physical barriers (e.g. gabions and check dams) and through vegetation enrichment with suitable trees, shrubs and grasses.

The "secondary data" from maps, images and reports can be validated and updated in the study area using the observations and measurements outlined below (Tools 4.3.1 to 4.3.3). This on- site ground truthing should be backed up by interviews/discussions with land users/other knowledgeable persons to cross-reference the observed types, extent and severity of erosion features with recent and historic land practices and weather observations; rainfall periodicity and intensities for water erosion and wind intensity for wind erosion features. This should provide good understanding of the processes, timescales and causes that have resulted in the currently observed erosion features.

Describing soil erosion on the community sketch map-initial observations STEP 1

As described in Tool 1.4, the community sketch map that is prepared with land users as part of the community focus group discussion should highlight major visible features in the area to be evaluated, in terms of terrain, land use, soils/geology, water resources, their relative proportion of the total land area; degradation features, including soil erosion (sheet erosion, rills, gullies) and causes (overgrazing, intensive cropping, wetland encroachment, etc.) and existing conservation/sustainable land management measures and their effects (negative and positive) on land productivity. If the sketch map has not clearly indicated erosion features or if more specific information is required for a selected study area, a few community members can be asked to reassess these issues and highlight if and where erosion by water or wind is a significant factor and the main causes.

Once the main erosion features are drawn on the "community sketch map", each soil erosion area can be qualified in terms of four descriptors: type, state, extent and severity. Each of these is defined below to the extent possible (though wider application of the tools and feedback is envisaged to lead to better definition of the classes and terms).

On the community sketch map (Figure 2), which reflects the landscape view showed on Figure 1, discussion with locals led to delineation and description of the main erosion features, other relevant information (vegetation, main land uses, slopes, villages, roads, streams, etc) and location (latitude, longitude, elevation and north point) of the observation point using a GPS unit.

Erosion Type, STEP 2: Erosion types are specified progressing from those that are the least evident to those that are most evident i.e. from (rain) splash and sheet wash, to rills, to gullies, to ravines and landslides and other mass movements (see Annex 1). It is important to specify that "type", as used in this guide, describes the physical nature of an erosion feature and indicates the boundaries that determine when one erosion type becomes another (e.g. When does a rill become a gully?). This will ensure more commonality of erosion type definition, hence replicability between users and geographic areas.

PHOTO 13
EXAMPLE OF A "DISTANT VIEW" OF AN AREA OF LAND TO BE INVESTIGATED FOR EROSION FEATURES (NORTH OF DUSHANBE, TAJIKISTAN)

FIGURE 15
COMMUNITY MAP" SKETCHED ON-SITE, OVERLOOKING THE AREA IN PHOTO 13

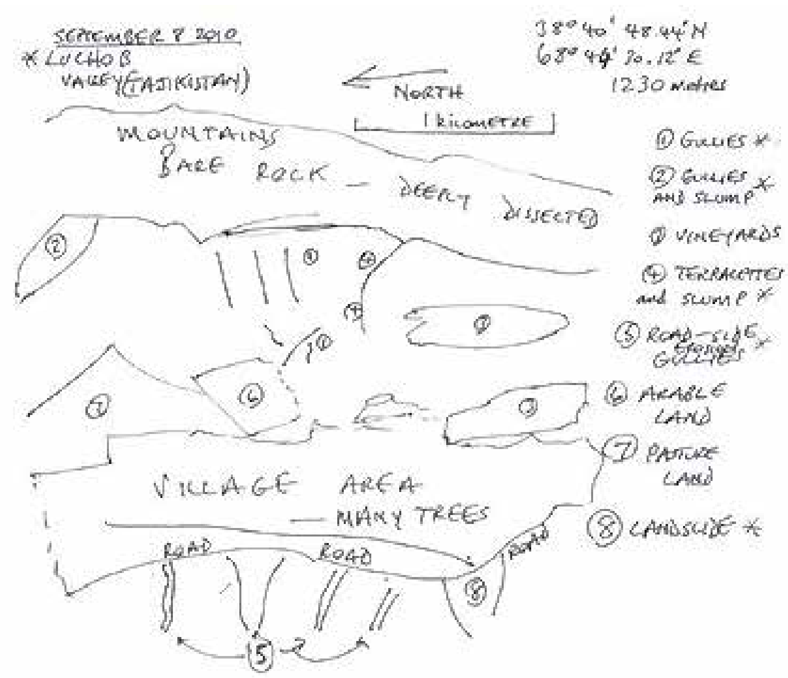


TABLE 19
Types of Soil Erosion- definitions, indicators and boundaries

Type of soil erosion	Code	Definition	Indicator (how to recognise)
Splash (1)	SP	Raindrop impact displaces soil particles vertically and downslope	Soil articles on lower parts of plants and/or a compacted (or dispersed) soil surface crust
Sheet wash/ Sheet (2)	S	Erosion of the top layer/sheet of the soil as differentiated from linear erosion (rill, gully, ravine)	Gravel/stones protruding from soil surface; root exposure; loss of darker topsoil horizon; subsoil exposure
Rill (3)	R	Irregular, downslope, linear channels, shallow (up to 0.3 m deep and wide)	Shallow, commonly long channels running downslope
Gully (4)	G	Irregular, V-shaped, steep-sided, linear channel formed in loose material, deep (0.3 –2.0 m deep) formed by water erosion	Deep, pronounced channels
Ravine (4)	A	As in the definition for 'gully" but very deep and wide (>2 m deep and wide)	Very deep and wide, pronounced channels
Landslide (4)	L	Sudden downslope movement of a concentrated mass of soil and rock, mainly under influence of gravity, triggered by water saturation or earthquakes (sometimes termed mass movement)	Almost vertical sides; rounded head (gully has narrow or sharp head)

Type of soil erosion	Code	Definition	Indicator (how to recognise)
Slumping (2)	SL	Slow, irregular, downward progression or of a thin (< 1m) layer of soil, due to water saturation, but possibly in combination with freezing- thawing	Rounded scar; irregular, uneven, downslope surface
Rotational slumping (3)	RS	A form of mass movement where rock and soil move downwards along a concave face. The rock or soil rotates backwards as it moves in a rotational slip. They always have a concave sliding plane and multiple scars (while slides have relatively straight shear planes).	Series of rregular scars and wide cracks
Terracettes (2)	T	Irregular small step-like formations, from a combination of slumping and preferential animal movements (tracks) on the surface of moderate to steep slopes	Irregular on-contour steps of about 0.1 to 0.2 m height on moderate to steep slopes in grasslands
Tunnel (3)	TU	Sometimes hidden, sub-surface holes and tunnels that can break-through to form surface gullies	Often hidden but may break through the soil surface as potholes and gullies
Roadside Erosion (2 or 3)	RE	Erosion (mostly gullies) caused by concentrated water flow over the impervious road surface; cutting back into the road and causing damage to roads or erosion downslope. Score depends on gully or tunnel intensity.	Erosion features below the point where water runs off the road.
Stream Bank erosion (2 or 3)	SE	Undercutting of streambank by running water. Score depends on gully or tunnel intensity.	Fresh cuts in banks; exposed tree roots; collapsed structures.
Wind Erosion (variable)	WE	Detachment and transport of soil particles by wind. Score difficult as the features observed are almost always 'effects" of wind erosion: dunes, scouring of vegetation, posts, etc	Scouring on windward side or deposits at leeward side of obstacles. Sand dunes (stable or moving)
		COASTAL EROSION	
Hydraulic Action (2)	HA	Occurs when waves striking a cliff face compress air in cracks on the cliff face.	Exerts pressure on the surrounding rock, and can progressively splinter and remove pieces. Over time, the cracks can grow, sometimes forming a cave.
Attrition (1)	A	Occurs when waves causes loose pieces of rock debris (scree) to collide with each other, grinding and chipping each other.	Smooth rounded particles.
Corrasion and corrosion (1)	CC	Corrasion (abrasion) occurs when waves break on cliff faces and slowly erode it. Corrosion or solution/chemical weathering occurs when the sea's pH (anything below pH 7.0) corrodes rocks on a cliff face.	Wave actions batters and break off pieces of rock from higher up the cliff face. For corrosion, rock tends to be friable and brittle, colour changes are also seen.

NOTE: Costal Erosion is normal however its rate can be increased by anthropogenic factors such as resource extraction and improper coastal zone management.

PHOTO 14
ACCELERATED COAST EROSION AS A RESULT OF EXTENSIVE SAND MINING, IN GRENADA

Erosion State: STEP 3, For each erosion type, one of four classes below is used to describe the level of activity:

(i) Active–erosion feature is increasing in size or extent;
(ii) partly stabilized–between active and stable;
(iii) stable–it is either an historic (relic) feature from past climate and land use, or a more recent erosion feature for which recent anthropogenic interventions (e.g. contour bunds or change in land management) have slowed or stopped the erosion process;
(iv) decreasing–where recent anthropogenic interventions have begun to reverse the erosion process i.e. rock, sediment and vegetation filling of gullies, leading to stabilization and increased soil organic matter and plant growth.

Erosion Extent, STEP 4: An estimation is made of the spatial extent of each erosion type. The intent is less to measure actual areas, in hectares or square metres (though some may choose to do this) and more to provide a good estimate of the area under consideration that is affected by the erosion types recorded. As such, it is considered that extent (used in this way) implies the proportion of a stated area that is affected by the recorded erosion type. The five terms used to define extent are:

- negligible (0-2 percent of the area under study)
- localised (3-15 percent of the area)
- moderate (16-30 percent of the area)
- widespread (typically 31-50 percent of the area)

Note that the class "widespread" is intentionally maximised at 50 percent of the area under consideration. This reflects that each erosion type is classed individually, so it is possible (in one area) that there is, for example, sheet wash, terracettes and gullies, with localised (10 percent), widespread (50 percent) and moderate extent (20 percent) respectively – showing that 80% of the area is eroded but by these three different erosion types.

There are various ways to record extent.

1. The areas affected by the specified erosion types can be drawn on a "community map" as in Figure 2.
2. Where available, the erosion features can be either located or drawn onto available maps (topographic, soil, etc), aerial photos, ortho-photos, satellite images, Google Earth® images, etc.
3. If required for detailed study, a theodolite or dumpy level can be used for accurate mapping and geo-placement of recorded erosion features; though this requires a high level skill set with related expense and time considerations.

Erosion Severity, STEP 5: Severity in terms of soil erosion is often defined as the "degree of the effect of the (specified) erosion type". A more pragmatic definition is the rate or "average amount of soil that is moved by water or wind", expressed as units of mass/area/time (Leys, 2010). Based on this definition, a field usable estimate of erosion severity is made using five classes, recognising that the mass of soil loss will rarely be known (particularly with historic erosion features) (Leys, 2010). Over time with wider usage, these classes may be better defined and perhaps oriented to specific geographic areas.

- **low**–minimal erosion types evident;most commonly splash or rill erosion
- **moderate**–evidence of erosion but eroded sediment remains within the area under study
- **high–**evidence that sediment is being exported off site
- **severe**–sediment is exported off site and surface lowering <0.1 m
- **extreme**–sediment exported off site and surface lowering >0.1 m.

An important consideration is that certain erosion types, by their nature, will never be described as of "low" or "moderate" severity. The most obvious examples (from Table 19) are gully, ravine, landslide, tunnelling – all of which immediately fall into the severe and extreme classes as the erosion feature is >0.1 m deep. Nonetheless, it is important to bear in mind that insidious sheet or rill erosion, that is continuous throughout rainy seasons and year by year over large areas, may be equally or more serious to widely spaced gully erosion in terms of total soil loss and impacts, especially in shallow soils.

Tool 5.3.2 Field scoring method for soil erosion features

A simple scoring system is presented for the erosion types present and recorded in a study area. This scoring system has been substantially adapted from a first version developed and tested by the LADA team in Tunisia as part of an earlier version of the LADA-Local manual (FAO, 2010). As such the scoring aims to provide a quantitative judgment of erosion and to allocate an erosion class. The aim is to provide a basis for inter-comparisons of erosion status and trends that may vary between land uses, management practices, topography, etc. and over time.

The scoring system is based on the classifications of type, state, extent and severity as defined above. Each of the classes in these four sets of descriptors will be allocated a score and the sum of the scores (for any one area, however defined) will allow the allocation of an erosion class (Table 20).

Important is that this scoring system is taken and used for what it is: a simple methodology of better quantifying erosion degradation for a given area. There are several, recognised problems with the scoring system, some of which will be covered here, so users should be aware of these in interpreting the cumulative scores obtained and the resultant allocation of an erosion class :

- The allocation of the score classes to the erosion types (Table 19) is somewhat arbitrary. The concept is that either end of the scale (1 and 4) is readily ascribed. In most circumstances splash erosion is a minor feature (score = 1), whereas gully, ravine, landslide, tunnel erosion are considered very serious landscape features as they cannot be readily repaired (score = 4). Between the two extremes, the current score allocations are based on the author's experience and may change with time and wider use of this system
- As discussed above, certain erosion types, by their very nature, will never be describable as of "low" or "moderate" severity. The most obvious examples from Table 19) are gully, ravine, landslide and tunnel – all of which fall into the severe and extreme classes, as the erosion features are >0.1 m deep. So, not only do these erosion types score "4" for type, they also immediately score "3" or "4" for severity (rate).
- If several types of erosion are found in the area under investigation, the current system scores each type separately,then sums the individual scores to give a composite score. The basis for this summation approach is both that each of the types of land degradation is inter-related, and their presence in one area has an additive, negative effect on land productivity. This composite scoring system may change in the future with time and wider use of this system.

TABLE 20
Scores for the individual descriptors

State	Score	Extent	Score	Severity	Score
				Extreme	4
Active	3	Widespread	3	Severe	3
Partly stabilized	2	Moderate	2	High	3
Stable	1	Localised	1	Moderate	2
Decreasing	0	Negligible	0	Low	1

TABLE 21
Erosion Classes

Erosion Class	Negligible or Decreasing	Low/Weak	Moderate	Severe	Very severe
Score	0-1	2-5	7-10	10-12	13+

Table 21 gives the final erosion class for any one erosion type in a study area, arrived at by summing the score value of each of the four categories of type, state, extent and severity. Where more than one erosion type exists in one area, the class values of Table 28 are added together for each erosion type–to give a composite score. It is evident that in situations where two or more erosion types are present in an area, the erosion class will almost always be «severe » (i.e. a score of >13).

The erosion classes are derived by adding - up the individual scores for each of type, state, extent and severity of Tables 19 and 20.

Worked examples of scoring erosion features Five examples will be given, based on the descriptors in section 4.4.1, the individual scores in Table 2 and the classes of the summed scores in Table 3.

- Example 1 presents the scores for the incidence of gully erosion (score 4) that is active (score 3), widespread in extent (score 3) with extreme severity as the soil loss in eroding areas is over 1 m deep (score 4). The total (summed) score = 14. So, the overall erosion class is very severe.
- Example 2 is one of rill erosion (score 2) that is partly stabilized (score 2), localized in extent (score 1) with moderate severity (score 2). The total (summed) score = 7. So, the overall erosion class is moderate.
- Example 3 is one of ravine erosion (score 4) that is decreasing in state (score 0), moderate in extent (score 2) with severe severity (score 3). The total (summed) score = 9. So, the overall erosion class is moderate.
- Example 4 scores an area that has two erosion types: (i) splash (score 1) that is active (score 3) localized in extent (score1) with low severity (score 1); Total score = 6; and (ii) *landslide* (score 4) that is stable (score 1), localised in extent (score 1) with extreme severity (score 4); total =10; The total (summed) score = 16. So, the overall erosion class is very severe.
- Example 5 scores an area that has three erosion types: (i) *sheet wash* (score 2) that is active (score 3) localized in extent (score 1) with moderate severity (score 2); Total score = 8; (ii) *terracettes* (score 2) that are active (score 3), localised in extent (score 1) with moderate severity (score 2); total = 8; and *gullies* (4) that are partly stabilized (2), localized (1) and extreme (4); total = 11. The total (summed) score = 27. So, the overall erosion class is very severe.

Note that, though the between-examples scoring gives some basis for comparisons of the impact of the erosion features, it is complex to definitively compare scores between such physically different types of erosion, as rills and gullies. A whole landscape may be covered in rills, and the resulting soil loss may be very large with important implications on soil depth and fertility, but a few large ravines in the same unit area would give quite different management problems (e.g. access for timber removal, thinning of stands and the cutting of roads that impair general access) and will require major, expensive interventions to repair and conserve.

Additionally, although generally scored low the cumulative effects of sheet and rill erosion should not be underestimated, particularly as they strip away the all important surface soil layers that are generally richer in organic matter and nutrients from plant residues, litter accumulation and vegetative growth.

Tool 5.3.3 Coastal Erosion

In SIDS, coastal erosion whether natural or anthropogenic is a concern. This can be assessed in the same manner as above using the indicators in Table 19 under coastal erosion. Scoring can be done in the same manner as well.

FIELD MEASUREMENTS OF EROSION FEATURES TO QUANTIFY RATES AND AMOUNT OF SOIL LOSS

This section provides field techniques to measure soil erosion features with the aim of gaining more quantified data on rates of soil erosion. 13 Such quantification would be valuable if soil erosion is identified as being a major degradation process in the study area and to understand the implications in terms of rate and quantity of soil loss, effects on productivity and off site implications in terms of nutrient and sediment load of water resources, siltation of valley bottoms/floodplains and wetlands, etc. However, it is an optional tool for the local level assessment according to the importance of erosion and the time and budget of the assessment team.

Of the 13 erosion types in Table 1, only 3 erosion types-rill, gully and ravine-lend themselves to a direct, rapid and simple method of field determination of amount of soil loss. Rates and quantities of soil loss from the other erosion types listed in Table 26 can be estimated indirectly by measuring the effects of erosion (Tool 4.4).

Tool 5.3.4 Direct measurement of erosion

1. Measurement of rill erosion

The estimate of the soil loss through rill erosion is based on measuring the space volume from which the soil has been eroded, to arrive at the mass of soil now missing from the rill. The measurement of soil loss from rills assumes that the depression forms a regular geometric shape that is estimated to be triangular, semi-circular or rectangular in cross-sections, as determined by field observation.

To calculate the quantity of soil lost, measurement is made of the depth, width and length of the rill. It is important to collect a number of measurements of both the width and depth of any one rill and of many rills in the study area to get an average cross-sectional area. The average catchment area for the rills in any one area must also be estimated, i.e. the area of land that contributes material to the rill. If it is known how long it has taken for the rill to form (if, for example the land was last cultivated two months or two years ago, or has only recently been cleared of forest) then an annual rate of soil loss can be estimated. Note, that the combination of the averaging of many field measurements, and the estimation of the cross- sectional shape of the rills (in any one area) to be predominantly triangular, semicircular or rectangular causes the soil loss calculation to be only an estimate of the actual soil loss.

Method: Using the average measurements of width and depth, calculate the average cross- sectional area of the rill, using the formula for the appropriate cross-section:

- triangle = ½ horizontal width x depth
- semi-circle (1.57 x width x depth)
- rectangle (width x depth).

Worked example:
a. For an area where the average dimensions of many measured rills is: **width = 0.12 m, depth = 0.042 m,**

b. The average cross-sectional area of the rills in a study area, assuming a triangular cross-section is:
½ * 0.12 * 0.042 = 0.00252 m^2

c. Assuming the average rill length in the study area was 2.5 m, the volume of soil lost from an average rill is:
0.00252 * 2.5 m = 0.0063 m^3

d. The volume of soil lost, from the estimated catchment area (here 12 m^2) is converted to a volume per square metre:
0.0063/12 = 0.000525 m^3/m^2

e. The volume per square metre is converted to tonnes per hectare, using an estimatedsoil bulk **2** density value of 1.3 t/m^3:
0.000525 * 1.3 * 10 000 = 6.9 t/ha

Hence in this worked example, 6.9 tonnes/ha have been lost in rill erosion, alone.

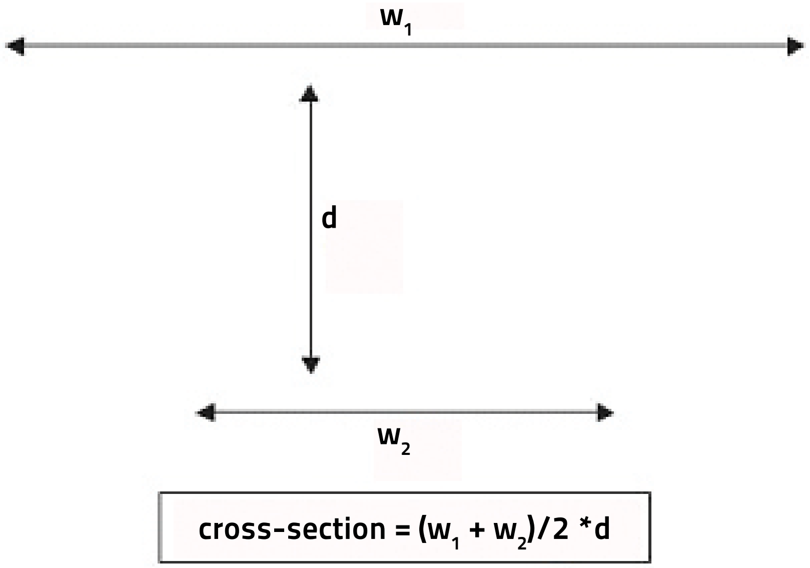
2. Measurement of gully and ravine erosion

Gullies and ravines have the same, general shape of a flat floor and sloping sides, hence the bottom of these features (the floor) is less wide than the top (parallel to the soil surface). Such a shape is best estimated as that of a trapezium 14 (Figure 13). Calculation of soil loss, therefore, is generally similar to rills, except with a different cross- sectional shape. As with rills, the measurement of the dimensions of the gullies and ravines gives an estimate of the amount of soil displaced from the area.

PHOTO 15
GULLY EROSION IN THE CARICOU AREA OF GRENADA

To calculate the quantity of soil lost from a gully or ravine, measurement is made of the depth, width at lip (the top of the feature) and base, as well as the length of the feature. Equipment used to collect these measurements will vary between operators, but could be a laser-based rangefinder (expensive) for large gullies and ravines, or a 30 to 100 m tape for smaller features. It is important to collect a number of measurements of both the width and depth along any one feature and also of many gullies in the study area to achieve a representative sample. An annual rate of soil loss from gullies and ravines is more feasible than from rills, as the former are more or less permanent features of the landscape.

FIGURE 16
MEASURING GULLY EROSION



Information on soil loss over time can be achieved in various ways, including repeated visits (particularly if permanent monitoring stakes can be installed as reference points), and time series of aerial photographs and/or satellite imagery. Even with such methods over a known time period, the annual rate of soil loss is "at best' an estimate due to such factors as:

(i) Different rates of soil loss will occur as the gully/ravine deepens and different layers of soil are exposed;
(ii) rainfall totals and periodicity will vary annually, particularly the incidence of rain with vegetative state around the gully or ravine;
(iii) change in forest density with time (both growth and thinning/clearing phases) will influence erosion rates;
(iv) tunneling may also occur on the sides of the gullies and ravines, greatly exacerbating soil loss in some years.

Method: Using the average measurements of width at lip and width at base, and depth, calculate the average cross-sectional area of the gully or ravine (considering the cross-sectional shape is trapezoid; Figure 4), using the formula:
(width at lip (m) + width at base (m)/2) * depth (m)

Worked example:

a. For an area where the average dimensions of many measured gullies or ravines is :
width at lip = 10.2 m, width at base = 4.8 m, depth = 2.0

b. The average cross-sectional area of the rills in a study area, assuming a trapezoidal cross-section (Figure 17) is: ((10.2 + 4.8)/2) * 2.0 = 15 m^2

c. Assuming the average gully or ravine length in the study area is 200 m, the volume of soil lost from an average gully or ravine is: 15 * 200 m = 3000 m^3

d. The volume of soil lost, from the estimated catchment area (here 1 km^2) is converted to a volume per square meter : 3 000/1 000 000 = 0.003 m^3/m^2

e. The volume per square meter is converted to tonnes per hectare, using an estimated soil bulk density value of 1.3 t/m^3:0.003 * 1.3 * 10 000 = 39 t/ha

Hence, in this worked example, 39 tonnes/ha have been lost in gully or ravine erosion.

At the simplest level, a "community map" could be sketched rapidly for short time time intervals, then the time sequence of sketches compared to investigate the more active or widespread areas and types of erosion features, for closer investigation.

The next level is to solely describe and class the erosion features present in an area of interest, using Tables 19, 20 and 21.

Lastly, the measurements of soil loss take the longest time, so tend to be used less often and less intensively.

Intensity of observations is also governed by the types of erosion features that occur in a study area. For example, if there are only 5 to 10 gullies in a given LUT, then the tendency would be to describe and measure all of these in some detail, even installing fixed measuring posts to exactly measure soil loss and gully encroachment. At the other end of the scale, in a heavily degraded, recently cleared, steeply sloping land in the monsoon season there may be all of sheet wash, rills, gullies and landslides. Most often human resources are inadequate to comprehensively describe and record so many types that are changing so rapidly. Photography and community sketches would be the best approach as these can be subsequently analysed to capture the rapidly changing situation.

Date:	Sketch		
Site:			
Conditions:			
Characteristics	Description	Additional observation	Score (0-4)
Erosion type:			
Erosion state:			
Erosion extent:			
Erosion severity:			
Sum of all scores			

6. Water resources

INTRODUCTION

Water resources, their management and any degradation are important to land resource components in most dryland assessment sites. Water resources degradation and effects of land degradation on water quantity and quality should be assessed in more depth in areas where this is reported to be a critical issue. Of particular concern are:

- the effective use of rainwater for direct consumption, for productive purposes and for recharging surface and ground-water supplies;
- the reduced water quality through pollution, salinization and over-exploitation (by domestic, agricultural, forest and industrial uses);
- the reduced water quantity/availability for consumption (human and animals) and other uses because of drought or over-exploitation of water sources;
- the maintenance of the hydrological regime (i.e. recharge of groundwater, flood control–in catchments and watersheds) an important ecosystem service;
- the extent and performance of water resources management alongside soil, land use and vegetation management for mitigating effects of desertification, drought, and climate change.

TOOL 6.1 LAND USER AND KEY INFORMANT INTEERVIEW ON LD/SLM

The key informants for this exercise should be members of the community who are knowledgeable of the water resources in the local area. A small group (male and female) should be selected following the community focus group discussion (Tool 1.1). The interview focus is on changes in water resources quality, quantity, and availability. It should cover on-site information (water sources, watering points, evidence of runoff etc.) and wider off-site or ecosystem effects of land use/management practices (e.g. impacts of losses from surface runoff and evaporation from bare ground); the effects on the hydrological regime (e.g. change in water flow and availability, depth of water table, drought periods and peak flood levels etc.). The information needs to reflect:

- the status and trends (S) of the water resources in terms of water quality, quantity and the hydrological regime (S);
- change in demand or pressures on water resources (P) and related drivers (D);
- the impacts (I) of changes in water quality and availability on productivity, livelihoods and the environment;
- some actual and possible policy or management responses (R) to conserve and/ or manage water resources.

The focus group discussion with the community members and the reconnaissance visit/transect walks (Chapters 1 and 2) should answer questions on the general state and trends of the water resources in the study area. However, with accompanying land users and key informants, the team should complete their assessment by visiting most water sources in the study area(s) and answer some of the following questions.

[Note: as with all questionnaires, the questions have to be reviewed by the team prior to the field assessment, in order for them to be adapted and specific to the local context.]

In the study area, discuss the following issues with land users and key informants:

1. Changes in hydrological regime and water supply

1.1 Changes in the hydrological regime and sediment-related processes such as:

- surface runoff;
- peak flow/floods;
- base flow/dry season flow ;
- ground water recharge;
- soil moisture recharge;
- erosion and sediment load.

(For example, high runoff could influence the size and severity of gullying and the quantity of sand deposited in reservoirs);

1.2 Drought/flood risk and incidence:

- Do serious droughts/floods occur in the area? How frequent are the drought/ flood events? Have they become more or less common in the last 10 years? Why do local people think this is happening (i.e. such as bare, compacted or crusted soils increasing runoff and hindering infiltration, the use of less drought resilient crop species, the deviation of streams etc.
- What is the period of drying up/flooding (months and interval)?
- What are the main impacts they have on the different livelihoods activities?

1.3 Changes in water quality of the different water sources and their causes: Pathogens;

- Nutrients and organic matter;
- Pesticides and other persistent organic pollutants;
- Salinity.

(For example, lower, stable or increasing pollution or salinity.)

1.4 Changes in water availability:

Types of surface and ground water sources, their number, their uses (e.g. human consumption, livestock, agriculture, industry), their size/capacity and any trends (e.g. decreasing, stable, increasing surface and/or ground water levels).

[Note: here it is important to understand causes of any changes in depth and quality of the ground water table. For example, in a pilot area in China, the water table had fallen some 2 metres over a number of years but local experts did not know the impact/ relative importance of pumping for irrigation and household use or tree planting. The extent of land use changes need to be monitored and linked to water information (available from water authorities etc.)].

1.5 Distance and access to water:

- What is the approximate distance (km) and time (min) taken to reach water for: i) domestic consumption in the dry and wet seasons and for ii) livestock watering in the dry and wet seasons? Any changes in the last 10 years?
- How far (km) are the main grazing areas from nearest potable water source in: i) the dry season and i) the wet season? Has this changed over the last 10 years?

2. Water resources management and changes in demand

2.1 Demand on water:

Water use, water withdrawal, and water infrastructure:

- What changes have there been in demand on water and water withdrawals in the last decade for the different water uses (e.g. number of dried-up wells/ boreholes)?
- How is the water supply managed and by whom? Is the management sustainable and equitable?
- Do all people in the community/area have equal rights to use water resource? If not what are the differences?

2.2 Water resources management

Have there been changes in the last 10 years in water conservation, water harvesting activities and irrigation:

a. Soil and water conservation: What techniques are used to optimize moisture and water capture, retention, infiltration and groundwater recharge? Have they been effective in enhancing productivity/reducing degradation by wind and water erosion/ maintaining surface and ground water supply? The answers could include one of more of the following:

- Bench terraces (level, forward or backward sloping);
- Contour bunds/banks (level, graded, semi-circular, v-shaped, trapezoidal etc.);
- Graded ditches, waterways and cut-off drains;
- Level ditches/pits (infiltration, retention, sediment and sand traps);
- Soil cover and mulching.

b. Water harvesting:

What are the water harvesting techniques present? Is the water collected used for agriculture, domestic use and/or livestock watering ? How common is this harvesting (i.e. common, present, negligible)? The answers could include one of more of the following:

- Dams, tanks, reservoirs and pans to store excessive water;
- Roof catchment and cisterns;
- Negarim, half moon, zai etc.

c. Irrigation:

What are the types of irrigation systems are operational? What is the proportion of each type? The answers could include one of more of the following:

- Flood (percent);
- Sprinkler (percent);
- Drip (percent);
- Pressure hose (percent).

[It would also be useful to note any systems which are no longer operational and why.]

d. Are these measures effective in ensuring water use efficiency (high, moderate, low)?

In terms of:

- Water capture and retention;
- Meeting plant water requirement;
- Drainage and leaching;
- Losses such as pipe/canal leakages;
- Losses through runoff;
- Standing water and evaporation from bare soil.

e. Constraints:

What are the constraints to more productive/effective use of water? in regard to:

- salinity;
- shortage/access;
- conflicts;
- cost.

f. What are the impacts of the measures?

In terms of:

- productivity;
- income;
- health;
- reduced risk (crop failure, livestock mortality).

g. What is the percent of people applying these different water management techniques in the study area/community territory?

2.3 Water policy, legislation and institutional aspects

What are the arrangements for water allocation/water rights and water conflict resolution/byelaws on water resources use and their application? Have there been significant changes in the last 10 years and why?

3. Off-site/on-site impacts on water resources:

Land use management in the study area may affect the water resources outside of the study area; as well as land use management outside of the study area may affect the water resources in the study area.

It is important to consider wider on-site-off-site causes of water resources degradation during the assessment, such as:

- increasing pressure/demand on the water sources, removal of natural vegetation, overgrazing , or inappropriate cultivation in the vital "sponge" areas of wetlands;
- drainage or permanent alteration of the water levels and flows to accommodate other use(s) of the water body (e.g. for building or irrigation purposes). This change can be caused by direct human interventions (e.g. drainage) or by a natural change such as change of a river course due to floods leading to sedimentation or deepening of the river channel or erosion of the banks.
- inflow of nutrients in run-off from fertilized farmland (causing rapid growth of algae in the water which depletes the oxygen supply in the water and may kill plant, fish and animal life);
- inflow of non-selective pesticides or herbicides in run-off from adjacent or upstream farm land-that effect water quality and impacts on animal and plant populations, also aquatic functions;
- changes in the water regime leading to increased floods, or reduced low flows (e.g. change of perennial to seasonal flow, perhaps attributable to draining of wetlands);
- human activity such as damming for water storage, irrigation or recreation and pollution in or close to the water body.

1. Does local land use and management (vegetation, soil and water) in the study area affect water resources in off-site/neighbouring areas? (Select impacts from Table 22 below or note additional impacts).
2. Does land use and management outside the study area affect the water resources in the study area? (Select impacts from list Table 23 or note additional impacts).
3. What are the human and natural causes of off-site impacts? (Identify the relevant causes from Table 23 and rank them in order of importance starting with the most important)

TABLE 22
Onsite/Offsite impacts on water resources caused by landuse management

On/off-site impacts on water resources of land use and management
▪ Changes in water flow (peak, base) ▪ Floods during extreme events or the rainy season ▪ Sediment deposition/accumulation and dust storm ▪ Contamination by airborne pollutants (e.g. from industry, mining, urbanization) affecting vegetation, soil and water resources) ▪ Change in surface water availability during dry seasons/spells, droughts (e.g. river flows, lake levels, dams, ponds, etc.) ▪ Changes in the water course of a stream or 'oued"* ▪ Change in ground water/subsurface water availability ▪ Change in water constraints (water-logging, water salinity) ▪ Change in water quality (for drinking, for agricultural or industrial use) ▪ Change in water retention capacity of dams and upstream lakes (water storage and regulation) ▪ Road damage due to intense rainfall, runoff and uncontrolled flow in Oueds ▪ Active erosion gullies (unstabilised) ▪ Increase in water extraction from increased numbers of private or illegal wells/ boreholes ▪ Other (specify)

TABLE 23
Causes of impacts on water resources

Human induced causes	Natural causes
▪ Soil management (inappropriate/good) ▪ Crop and rangeland management (inappropriate/good) ▪ Deforestation and removal of natural vegetation (including forest fires) ▪ Over-exploitation of vegetation for domestic use ▪ Overgrazing ▪ Industrial activities and mining ▪ Urbanisation and infrastructure development ▪ Discharges (point contamination of surface and ground water sources, or excessive runoff) ▪ Release of airborne pollutants (urban/industrial activities) ▪ Disturbance of the water cycle/change in water level of ground water aquifers, lakes and rivers ▪ Over-abstraction/excessive withdrawal of water ▪ Other (specify)	▪ Change of seasonal rainfall ▪ Heavy/extreme rainfall (intensity and amounts) ▪ Windstorms/dust storms ▪ Floods ▪ Droughts ▪ Topography and effects on runoff, river flow regimes) ▪ Other natural causes (landslides, volcanic eru ptions,earthquakes,highlyfragile/susceptible natural resources, etc.) ▪ Other (specify)

TOOL 6.2 DETAILED BIOPHYSICAL ASSESSMENT (STATE/ TREND) OF SPECIFIC WATER RESOURCES.

Visit each important water source and conduct the following assessment with local key informants:

For each study area record the water source (type), the GPS coordinates, LUS/LUT, and the Season.

Water Quality

For each indicator, select the most appropriate answer from those provided below and give a short explanation.

1. Water level:

- Only a small fraction of the capacity of the water body e.g. a very small flow of water in a large riverbed;
- Below to half of the capacity (average to limiting water conditions);
- Above half of the capacity up to the upper limit of the capacity of the water body.

2. Water depth:

- Height of water in wells and boreholes (water table depth).

3. Potential loss of rainwater by soil evaporation:

- High- Soil uncovered and bare during long periods of time;
- Moderate- Soil partly and seasonally not covered;
- Low- Soil permanently covered (litter/live plants).

4. Loss of rainwater by runoff:

- Clear signs of water loss by runoff and soil erosion: Rills or gullies, due to inadequate soil cover and/or lack of or ineffective soil and water conservation;
- Signs of surface water runoff and some soil movement (sheet erosion)-moderate cover and/or some soil and water conservation;
- No signs of surface water runoff due to good soil cover and soil and water conservation measures.

Ask key informants:

5. Does it hold water just during the wet season or throughout the year? How reliable is it (does it dries out)?

6. What is the demand on the water source for different uses (human consumption, livestock watering , agricultural irrigation or industry) (heavy, moderate, light, none)? Has the pattern of use changed over the last 10 years?

7. What percent of the total amount of water used (withdrawn) is permitted (legal, regulated) and what percent is illegal? Indicate any changes in the last 10 years.

Water quality: *for each indicator, select the most appropriate answer with a short explanation*

8. Colour and Turbidity:

- Green and opaque from eutrophication or sewage;
- Brown and opaque from sediment;

- Transparent/normal colour.

9. Pollution by:

- Water smelling or of unnatural colour;
- Signs of animal faeces;
- Presence of discharge pipes/canals, drainage inlets with substantial inflow of sewage and other effluents;
- No visual sign of water pollution;
- Coliforms/BOD/bacteria using field microbiological water kit;
- Other chemicals and heavy metals (lab test).

10. Salinity:

- Whitish salt deposits around the water point (Y/N);
- Water conductivity value (EC)–salinity of both surface and groundwater.

11. What is the water quality? If polluted, what are the causes (e.g. increase use of fertilizer, sewage discharge, increase pesticide use, industrial pollution)?

12. Has there been a noticeable change in the quality of this water source over the last 10 years (describe the changes in amount, seasonality or quality of the water)?

The visual observations of local informants can be backed up by a water testing kit that can usually be obtained from local water authorities.

Ecosystem and living aquatic resources: *(for each indicator, select the most appropriate answer with a short explanation)*

13. Aquatic life (fish, insect) and diversity:

- Absence or very limited visible life;
- Presence of only aquatic species known to be tolerant to some pollution;
- Presence of diverse aquatic species indicating good water quality (sensitive to pollution).

14. Algae and/or invasive aquatic plants:

- Abundance of algae and/or invasive aquatic species;
- Presence of algae and/or invasive aquatic species;
- No algae or invasive aquatic species.

15. Fish stocks/productivity:

- Abundant
- Moderate
- Few
- None

Additional measurements of water quantity and quality

These additional measurements can be made where there is a particular need to generate quantitative data on water resources perhaps to complement existing data sets/activities in the country or region concerned. Only limited detail on these methods is given here.

Water quantity measurements:
Water point width

To estimated water point width, in meters. This can be measured with a rangefinder or a measuring tape. In case of a lakes, ponds, dams and reservoirs then it is the average between the wider and narrower parts.

Water point depth

This can be measured using a measuring stick or pole or a chain with a weight attached to the end. Manual measurement of depth is limited to 5-6 meters, so if the water point is deeper than 5-6 m then indicate >6 m.

Water flow
To estimate flow of rivers, streams and springs only (not ponds, dams or lakes), in litres/ minute (l/min).

This is estimated by recording the time taken (T) for a twig/stick to move a certain distance (L) (e.g. 20 m) along the water surface. For a U shape channel water flow = (average Width x average Depth x L)/T. For a V shaped channel water flow = (average width/2 x Depth x L)/2.

Water quality measurements:
Chemical and nutrient characteristics

There are a variety of water quality variables, including temperature, electrical conductivity (a measure of the total dissolved salts), pH (an indicator of the water's acidity or alkalinity), chlorophyll A, total phosphorous, total nitrogen, dissolved oxygen, and water transparency (Secchi depth). These parameters can be measured with individual instruments or with one combination instrument that includes several types of probes.

Changes to water quality often occur over long periods of time, making it difficult to determine the role of human activity as distinct from natural processes, for example, the impact of climate change. The use of long term data sets on water resources may assist to determine cause and effects.

Turbidity

Estimation of the degree of transparency or opaqueness of the water due to suspended particles and sediments. Usually measured using test/turbidity column/secchi disc, in meters.

pH

pH value of water (to be measured using pH meter or pH paper).

Biological Oxygen Demand (BOD)

Measure of the Biological Oxygen Demand (BOD an indication of oxygen availability and hence degree of contamination). To measure, use a BOD test kit.

Sources of contamination

The main sources of contamination of the water point.

Aquatic species

The presence or absence of certain chemical or biological indicators can reflect environmental conditions. Taxonomic groups, individual species, groups of species, or entire communities can be used as indicators. It is possible to use species presence/absence, and in some instances abundances and habitat characteristics to assess the condition of inland water ecosystems

TOOL 6.3 ASSESSING DEGRADATION OF RIVER/STREAM BANKS AND LAKE SHORES

Degradation of the river/stream banks may be caused by removing riverine (gallery) forests, by another change in land use nearby, or planting of inappropriate species. It has implications on the stability of the watercourse, also increasing risk of erosion, landslides and sedimentation which may undercut road bridges or influence downstream infrastructure such as dams or settlements.

By walking along a river or lake with local land users and/or key informants, assess the following indicators within 10-50 m from the bank/shore (depending on the size of the water body):

1. What is the extent and severity (severe, moderate, low, none) of the bank degradation?
2. What is the status of the river bank/lake shore vegetation? (select)

    - tree and bush vegetation is missing , the riverbank shows signs of cultivation, and is unstable or undercut with signs of active riverbank erosion;
    - vegetation partly disturbed, cultivated land within less than 10 m of the river or lake shore;
    - Stabilized by vegetation (mainly trees and bushes) and not cultivated or intensively used within 50 to 100 m.

3. Are there signs of animal trampling on river/streams banks/lake shores? (select)
    - many entry points where animals have access to the water;
    - a few entry points where animals have access to water;
    - no signs of animals entering into the water.

4. What are the other causes of degradation (e.g. landslip, erosion, undercutting) observed?
5. Is there any danger of serious changes in the water course, landslips, etc. threatening : i) productive land, ii) settlements or human life or iii) infrastructures?

6. What land management /restoration practices are in place on the adjacent land next to the river/streambank/lakeshore? To what extent are they being applied/ respected (high, medium, low) and what is their effectiveness (poor, moderate, good)?
7. What legislation and bylaws exist on river/stream bank protection and to what extent are they being respected/applied and if not why?

7. Assessing mangroove forests in SIDS

INTRODUCTION

The term "mangrove" refers to an assemblage of tropical trees and shrubs that grows in the intertidal zone. Mangroves include approximately 16 families and 40 to 50 species (depending on classification). According to Tomlinson (1986), the following criteria are required for a species to be designated a "true or strict mangrove":

1. Complete fidelity to the mangrove environment.
2. Plays a major role in the structure of the community and has the ability to form pure stands.
3. Morphological specialization for adaptation to the habitat.
4. Physiological specialization for adaptation to their habitat.
5. Taxonomic isolation from terrestrial relatives.

Thus, mangrove is a non-taxonomic term used to describe a diverse group of plants that are all adapted to a wet, saline habitat. Mangrove may typically refer to an individual species. Terms such as mangrove community, mangrove ecosystem, mangrove forest, mangrove swamp, and mangal are used interchangeably to describe the entire mangrove community.

In the Caribbean region there are three major types of mangrove red mangrove (*Rhisophora mangle*), black mangrove (*Aviennia germinas*), and white mangrove, (*Laguncularia racemosa*). Within most mangrove communities' buttonwood (*Conocarpus erectus*) can also be found especially in upland transitional zones.

Red mangrove (*Rhisophora mangle*)

- Found in areas where conditions are harshest (closest to shoreline).
- Consist of reddish prop roots or aerial roots that extend to approximately 1m above the soil.
- In optimum conditions can grow up to 25 m

Black mangrove (*Aviennia germinas*)

- Consist of pneumatophores
- Occurs on elevation that is slightly higher than red mangroves.
- Can grow up to 20 m in optimum conditions.

White mangrove, (*Laguncularia racemosa)*

- No visible aerial roots
- However when under water logged conditions for long periods can develop peg roots
- Can reach up to 15 m in optimum conditions.

The following factors are considered to be the major determinants of mangrove distribution:

Climate.

Mangroves are tropical species, with varying latitudinal limits worldwide vary depending on air and water temperatures (Tomlinson 1986; Waisel 1972; Sherrod *et al.,* 1986; Sherrod & McMillan 1985). The abundance of mangroves is also affected by aridity, and development is much greater along coasts that have high inputs of rainfall (Macnae 1968; Golley *et al.,* 1975).

Salinity.

Salt is generally not a requirement for growth, since most mangroves can grow in freshwater (Tomlinson 1986; Ball 1988). However, they do not develop in strictly freshwater habitats because of competition from freshwater species. Salinity is thus important in eliminating other vascular plant species that are not adapted for growth in a saline habitat.

Tidal fluctuation.

Tidal influence is also not a requirement, but plays an important indirect role:

- Inundation with saltwater helps exclude most other vascular plants and reduces competition.
- Tides bring saltwater up estuaries against the outflow of freshwater and extend mangrove development inland.
- Tides transport sediment, nutrients, and clean water into the mangrove environment and export organic carbon and reduced sulfur compounds.
- Where evaporation is high, tides help flush soils and decrease salinity.

The effect of this "tidal subsidy" can be seen on two landscape scales:

1) A regional or geographic scale—mangroves reach their greatest development around the world in low-lying regions with large tidal ranges (Tomlinson 1986; Macnae 1968; Golley *et al.,* 1975).

2) A local scale—trees closest to the edges of land masses, which are subject to the largest fluctuations of the tide, are obviously larger and more productive than trees in the interior (Mendelssohn & McKee 2000).

Sediment and wave energy.

Mangroves grow best in a depositional environment with low wave energy according to Tomlinson (1986). High waves prevent propagule establishment, expose the shallow root systems, and prevent accumulation of fine sediments.

TOOL 7.1 MANGROVE ASSESSMENT

Mangrove can be assessed based on the following;

Tree conditions;

Estimate the general health characteristics of the tree, average height, and leaf condition, height of aerial roots/prop roots, the average number of pneumatophores visible and overall canopy cover. This assessment will be most valid if used to assess mature forests. Table 24 below can be used to identify the nature of the forest.

TABLE 24
Mangrove assessment

Vegetation	Height	Leaf condition	Roots	Ecology	Coastal erosion
Red mangrove	• 15-25 m = 2 • 10-15 m = 1 • <10 m = 0	No sign of disease/pest/stress = 2 Moderate signs of disease/pest/stress = 1 Significant signs of disease/pest/stress = 0.	Ariel roots (Red mangrove) 0.5 -1 m = 20.25 - 0.5 m = 1 <0.25 m = 0	Highly diverse = 2 Moderately diverse = 1 Limited diversity = 0	See soil erosion section
Black mangrove	• 15-20 m = 2 • 10-15 m = 1 • <10 = 0		Pneumatophores >50 = 2 25-50 = 1 <25 = 0		
White mangrove	• 10-15 m = 2 • 7-10 m = 1 • <7 m = 0		Good = 2 Moderate = 1 Bad = 0		
Button wood	• 3-5 m = 2 • 2-3 m = 1 • <3 m = 0				

Soil colour should also be noted and using the table below determines the phase of the species. Soils are generally dark brown, ash grey or dark gray in colour.

FIGURE 17
COMPARISON OF MATURE AND PIONEER SP. AND COMMUNITIES

Table 1.1 Comparison of pioneer and mature phase species and communities with mangroves and with mangal (from Tomlinson, 1999)

Species	Pioneer	Mature	Mangrove
Seed sire	Small	Large	Usually large
Seed number	Numerous	Few	Often numerous
Dispersal agent	Often abiotic (e.g., wind)	Usually biotic	Always abiotic (water)
Dispersibility	Wide	Limited	Wide
Geographic range	Broad	Narrow	Broad
Seed production	Continuous	Discontinuous	Sometimes continuous
Seed dormancy and viability	Long	Short	Short (?)
Seedlings	Light-demanding, not dependent on seed reserves	Not Light-demanding, dependent on seed reserves	Light-demanding (?), dependent on reserves
Reproductive maturity	Early	Late	Early
Life span	Short	Long	Probably long
Leaf size	Often large	Medium or small	Medium
Leaf palatability	High	Low	Low
Wood	Soft, light	Hard, heavy	Hard, heavy
Architecture.	Model-conforming	Not model)-conforming	Model-conforming
Crown shape	Uniform	Varied	Uniform
Competitiveness	For light	For many resources	For light and other resources
Pollinators	Not specific	Highly specific	Not specific
Flowering period	Prolonged or continuous	Short	Prolonged or continuous
Breeding mechanism	Inbreeding favored	Outbreeding favored	Inbreeding favored
Community	**Pioneer**	**Mature**	**Mangal**
Floristic composition	Poor	Rich	Poor
Stratification	Absent	Well developed	Absent
Age composition	Even-aged	Uneven-aged	Even-aged(?)
Large stems	Absent	Present	Usually absent
Undergrowth	Dense	Sparse	Absent
Climbers	Few	Many	Few
Epiphytes	Few	Many	Few

Source: Budowski (1965), Gomez-Pompa and Vazquez-Yanes (1974), UNESCO (1978); see also Ewel (1980), Primack and Tomlinson (1980), Whitmore (1983).

TABLE 25
Possible Field form

Species	Soil conditions			Ecosystem condition				
	Moisture Wet = 2 Moderate wetness = 1 Dry = 0	pH 6-9 = 2 5-6 or 9-10 = 1 <5 or >10 = 0	PSD Clay = 2 Loam =1 Sand = 0	Canopy cover >75% = 2 50-75% = 1 <50% = 0	Av. Height	Leaf condition	Height of aerial roots	Average # of pneumatophores visible
Red								
Black								
White								
Buttonwood								

8. Livelihoods

INTRODUCTION

One of the objectives of this assessment is to deliver an improved understanding of how socio-economic, cultural and institutional factors influence land-users' views and management of their land resources. Particularly with poor land-users in marginal areas (common in the drylands), there are many factors relating to resource and market access, the institutional and policy environment (e.g. rights and tenure) and the characteristics of poverty itself that influence the perspective land-users have on his/her land resources. These factors can enhance or constrain their ability to practice sustainable land management, control land degradation or implement rehabilitation measures, often much more than their knowledge of land degradation processes or options for "improved" management. A good livelihoods analysis should help the team to understand the institutional and socio-economic drivers that lead to land degradation and also appropriate responses at the policy level for the different groups of land user in a community. This tool will capture livelihoods-related information that will improve countries understanding the role socio-economic and institutional factors play in affecting the ways in which people view and manage their land resources.

The analysis should be conducted with 20-30 households responsible for managing the land assessed under the detailed bio-physical assessments and more generally within the local assessment area.

TOOL 8.1 HOUSEHOLD LIVELIHOODS INTERVIEW

It is important to try to capture "trends" and for this reason many questions ask about changes in time (10-20 years). Also, a single question might lead to a line of follow-up questions and discussion that uncover the full explanation for a problem or perspective on land management. *As with any questionnaire, it is important to review the questions (modify, add, cancel as deemed necessary) to ensure they are relevant to the local context - this has to be done by the local assessment team before fieldwork.*

8.1.1 Natural capital

It will usually be necessary to ask separately about soil, vegetation and water resources as the term "land" is likely to be interpreted by land-users as soil.

1.1 Activities: What is the seasonal calendar of different activities that household members are engaged in? (Construct a table identifying what they do by month associated with rainfall and temperatures.)

1.2 Water resources: What are the main water sources (pipe, reservoir, water point, spring, well, borehole, dam)? When are they available/used? What are the water uses (drinking, livestock, irrigation)? What are the main constraints and problems linked to water resources (distances, price, safety quality and quantity)? What changes have occurred in uses, quality and access to over the last 10 years?

1.3 Land resources: How many hectares (or other measure–e.g. acre–then convert for recording) of farm land do they have? Does the household own them? If not, then on what basis is it being used (ownership, rental, share arrangement, open-access, allocation by chief or other)? How does this (ownership) situation change in time? Grazing land: Does the household own its grazing land(s)? If not then on what basis is it being used (ownership, rental, share arrangement, open-access)? How far is it from the home? Has this (ownership) situation changed in the last 10 years?

1.4 What are the uses of each crop type? (commercial/personal comsumption)

1.5 Vegetation Resources: What are the activities in which vegetation and forest resources are used? What are the main constraints and problems with vegetation resources (access, use, quality, etc)? Where there any changes in the last ten years?

1.6 Livestock: How many livestock do the household own (by type: cattle, sheep, goats,)? Have livestock numbers changed in the last 10 years?

1.7 General changes in activities and practices: Has the household made changes in his/her cultivation practices/rangeland management over the last 10 years?

8.1.2 Land Degradation

[Note: it is important to ask not just about the immediate cause, but to ask questions that get to the root cause (driving force/indirect pressure).]

2.1 What is the quality of your cropping lands, grazing lands, forested lands and water resources? What have been the recent changes/trends?

2.2 Types land degradation: soil loss by runoff or wind, gully erosion, loss of soil fertility, reduced amount of vegetation in the grazing lands, reduced quality of the grazing, loss of palatable species etc..

2.3 Why? What are the direct and indirect causes?

2.4 What specific impacts does land degradation (reduction of income, diminution of food production, less products to sell, reduction of construction materials, more time spend on farming/grazing/fetching water, need more inputs/fertilisers, out migration, etc) have on the household?

2.5 How have land degradation and its effects changed over the last 10 years?

2.6 Have attempts been made to control land degradation? If yes, for which reason? If not, why not?

2.7 Is there interest in trying land conservation approaches not currently used? If yes, which ones?

8.1.3 Financial Capital and Production

3.1 How does the household earn cash (crop and/or livestock sales, remittances, fishing, forest products, off-farm activities, business and processing food like honey/cheese)?

3.2 How much does the household rely on each one (importance of each)? Have there been significant changes in household income in the last 10 years?

3.3 What is the income used for (main things)?

3.4 Are the yields decreasing, constant or increasing over the last 10 years?

3.5 Has the use of inputs/fertilisers changed over the last 10 years?

3.6 Are the household benefiting from subsidies, extension services, payments, food aids or other support (project or government), and/or using micro-credit, cooperative bank or borrowing money from relatives? If yes, why and when? Any changes in the last 10 years?

8.1.4 Vulnerability context

4.1 What have been the main changes in the landscape and living conditions over the last 10 years (trends in livelihoods)?

4.2 In his/her opinion, what are the main problems in the area? What things would they like to change or improve?

8.1.5 Physical Capital

5.1 How is access to markets and service infrastructure (health centre, school, farming cooperative, water points) in terms of road networks and distances? Has there been any change in the last 10 years?

8.1.6 Policies, Institutions and processes

6.1 Who controls or makes decisions about how to use or access communal natural resources (water, grazing lands, forest)? Have there been any change in the last 10 years?

6.2 Are there any laws, rules and regulations (formal and informal) that affect how the household manages its land resources? Has this changed in the last 10 years?

8.1.7 Social Capital

7.1 Do any household members belong to a local association, committee, producer association, women's group, NGO, or any social group? Since when?

8.1.8 Human capital and household composition

8.1 How many members are there in the household? What are the numbers of children/ migrants?

8.2 What is the educational level of the household head and children? Has he/she/they received any training–if so, in what (e.g. SLM etc)?

8.3 What is the approximate age of the household head? (Can be estimated without asking if too sensitive) (<20, 20-30, 30-40, 40-50, 50-60, >60).

9. Analysis and reporting

INTRODUCTION

This Chapter of the manual presents some methods and a structure for analyzing the findings and for presenting the assessment in a well structured report for consideration by decision makers. The report and database will be an important record of the assessment findings and should be used to mobilise better coordinated follow-up action among the range of actors that provide support for natural resources management and development. These products also provide the baseline for subsequent monitoring of changes, to assess progress in addressing land degradation and the effectiveness of different interventions by stakeholders. The LADA local assessment methodology deserves to be widely used as a basis for supporting concerted efforts towards sustainable land management through, for example, targeted local and provincial action plans as well as future monitoring and investment planning to prevent or reverse land degradation and promote sustainable land management. A better understanding of land uses and livelihood strategies used by land users to meet their needs and cope with change, seasonality and shocks can help with the design of policies and interventions to strengthen existing coping and adaptive strategies. Interventions could include: building capacities and improving access to knowledge and education on improved land management practices; strengthening security of tenure and access rights to natural resources for sustainable cropping, grazing and forestry including sustainable gathering/harvesting of fuelwood and other goods (e.g. energy, fodder, food, crafts); providing financial and enterprise development services (not just credit for farm equipment); and promotion of diversification (land use, on- and off-farm enterprises and livelihoods).

The local level assessment findings and analysis shall be documented in the form of a concise report supported by maps, tables and diagrams.

The report should:

- explain the location of study area(s), transects and detailed assessment sites in relation to national LUS;
- present (e.g. using maps or Google earth images) the layout and distribution of land resources and land-use types;
- describe land use/management practices and their effects on the status of land resources in term of LD processes and trends (type, extent, severity) and effectiveness of conservation/improvement measures/SLM;
- present the analysis of apparent causes(drivers and pressures), impacts and policy implications on livelihoods and selected ecosystem services; and,
- propose responses for addressing land degradation or to promote sustainable land management.

Finally, it is important to bring together and synthesise findings from the LADA local and national assessments where both have beenconducted. This is expected to help highlight broader impacts of land use/management practices on ecosystem services and to draw out policy implications in relation to national action plans to combat land degradation (NAPs), natural resources management and agricultural and forestry strategies, and linkages with climate change and biodiversity.

Structure of the Assessment Report

The proposed structure of the local assessment report is as follows:

- Introduction of the Assessment
- Methodology
- Characterization of the Study Area
- State of the Land Resources (and trends)
- Driving Forces & Pressures
- Impacts on Ecosystem Services
- Impacts on People and their Livelihoods
- Responses
- Conclusions and Policy Recommendations

Then, for each chapter, the scope and content is described.

Introduction of the assessment report

The introduction should describe briefly the composition of the assessment team (covering skills and background of team members) and key elements of the pre-assessment planning.

This should be followed by an explanation of the reasons for the selection of the assessment area, notably:

- To explain the selection of the assessment area (what are the LUS under assessment and why?)
- To explain the rationale and the process by which the study areas were selected and how they represent the LUS found in the assessment area;
- To refer to significant existing interventions and projects relevant to LD/SLM in the area;
- To address specific concerns or questions concerning LD/SLM in the study area that came out of the national assessment or that the team members are interested in (e.g. an explanation of productivity decline in a once productive area).

Methodology

Summarise the approach, including the interactions with and participation of local stakeholders and highlighting where the LADA methodology was and was not followed (i.e. reasons for omissions, additions, changes; problems encountered etc.).

List the secondary information reviewed and used, also the tools/methods used in the field (by LUS).

Characterization of the study area

The study area can be characterized using available secondary information (from technical services, projects and relevant statistics) and the information collected through the community focus group discussion and mapping. This research process should include, in particular: an analysis of perceived and actual changes in climate (rainfall amount and distribution, frequency of extreme events and, as appropriate, temperature changes), population and land use trends, average farm size, livestock type and numbers, land management practices, types of crop, tree and livestock production and yields, access to resources also implications of land degradation and natural resource management interventions over the last 10 or so years.

The section will be largely descriptive and should use the following checklist of issues to be addressed:

- Location, population and settlement history (period as appropriate e.g. up to 50 years) (including cultural and socioeconomic stratification, demographic trends, etc.);
- Development activities in recent past (last 10 years), stakeholders involved and nature of their interventions and projects;
- Natural resources: brief description of the topography, soils, vegetation and biodiversity, water and hydrology, climate and wildlife;
- Main forms of land-use: grazing, crop cultivation, forest etc, land management, and income generating activities (business, processing, crafts, etc.), agricultural intensification/diversification;
- Important formal and informal institutional features: identifying changes and trends in the last 10 years, access to research, extension, credit and financial issues;
- Community organizations (e.g. commodity groups, forest or livestock committees), marketing opportunities and restrictions;
- Land tenure regime: situation, changes and trends (state land, protected areas, ownership, tenancy (security of tenure), leasehold, common property, user rights, access rights), extent of fragmentation etc.;
- Main sources of livelihood: degree of diversification, income generation within and outside agriculture and food security;
- Main/common land related problems, constraints and implications in terms of livelihood strategies (past, present and trends) identifiable at the community level;
- Identifiable gender/socio-economic differentiation in land resources management;
- Indicators of wealth/poverty (to be used for wealth ranking);
- Relevant socio-economic infrastructure (hydraulic, education, health, roads, markets, others) and their accessibility;
- Linkages/interrelationships with neighbouring communities and territories.

This section should contain a copy of the participatory community territory map(s) (Tool1.4) facilitated by support maps (topographic, soil, etc.) and/or remote sensing images (land cover, time-series NDVI etc.). These should display as much information as possible, including the locations of key resources, main areas and types of land degradation, main conservation/SLM measures, location and route of the transect/ reconnaissance visit and locations of the detailed sampling plots. The transect route can be illustrated using a Google Earth image on which the different landscape features (land use types, land units, severely degraded or restored areas) can be annotated.

The study area characterisation should also contain the transect diagram and indicators table, as well as tables/graphs and figures illustrating specific findings such as climatic and demographic trends based on secondary data.

Secondary information on the study area, for example:

- Population, income generating activities, socio-economic data;
- Climatic data (rainfalls, temperature, floods, droughts), farming calendar;
- Maps (topography, soil, bioclimatic zones, land cover and use, etc.);
- Projects/interventions of relevance to natural resources management.

Where possible, secondary data such as population, rainfall, market sales/prices and so forth, should be summarised and presented in the form of graphics.

Community focus group discussion findings are an important part of the assessment to understand land users perceptions and behavior.

- Wealth ranking and land user typologies;
- Community mapping of the study area;
- Institutional mapping of relevant local/ external organisations and their influence (access to and use of resources, capacities, etc.);
- Identification of successful/best land resources management practices in the area.

Transect findings:

- Reasons for the selection of the transects, their locations (number and length) and what they show (e.g. to compare types of land users and degraded areas with well managed or protected areas);
- Transect diagram summarizing information on each land use system/type;
- Maps (topography, aerial photographs, Google Earth images or sketches) to show transect locations, LUS and the main land use types, water sources, degraded/well managed areas, roads, markets, towns, etc.

The above tools provide a synopsis of land uses, management and land degradation issues in the selected study areas, also an understanding of how socio-economic and institutional factors influence land users' perceptions and management of land resources at farm, community and landscape level. The community focus group discussion, wealth ranking and participatory community territory mapping, guide the location and conduct of transects (1-4 per study area) and reconnaissance assessment with the land users of soil, vegetation and water resources degradation and its conservation (stability) or improvement (restoration or rehabilitation) in relation to land use. The findings provide a rational basis for the location of sampling sites and households for more detailed assessments.

State of the land resources (and trends)

This chapter should present the analysis of the state of the land resources, along with some perspective on magnitude and direction of recent historical changes. The term "recent" throughout the methodology means in approximately the last ten years, as this is a reasonable recall period to discuss with landusers and also corresponds to the time-frame used in the national level LADA assessment.

In some cases, specific events may have had significant implications on LD/SLM over a longer recall time-period and these should then also be considered.

There should be both qualitative and quantitative information available. The quantitative and semi-quantitative data from the biophysical assessments (soil, vegetation, water, ecosystem services) should be integrated and triangulated with the information from the community focus group discussion(s) and livelihoods interviews. In many cases, land-users will identify key LD/SLM features from their perspective i.e. in terms of livelihood implications that are then assessed and compared using the biophysical tools. The land-users will also provide an historical context for the LD/SLM observed.

In many cases, information on a particular land use type (e.g. fenced, managed pasture) or on land degradation process (e.g. overgrazing) will be generated by several tools. For example, the community focus group discussion, livelihoods and land user interviews, soil erosion and vegetation assessment tools will all give information on pasture condition, quality and change dynamics. Hopefully most of the results generated by these tools will point in a similar direction and suggest a similar trend in regard to pasture and overgrazing. This process of drawing from several findings (qualitative or quantitative) to improve understanding is called triangulation.

For each land use system (LUS) along the transect and at all sampling sites, qualitative visual indicators and simple field measurements should be are made comparing well managed and poorly managed land and assessing the following:

Vegetation and biodiversity: This section should present and summarise the findings of the vegetation assessments (Tools 3.1 to 3.6) that were conducted with the land users for forest land, grazing land and cropland. This will include observations from quadrats or line transects (a 1 m^2 grid quadrat for herbaceous species; 5, 10 or 20 m^2 quadrats or a line transect in shrub/tree vegetation depending on the vegetation density) (see Photo 19). These should have been repeated (up to 3 times per site) where the vegetation is less uniform, to ensure it is a representative sample. The state of vegetation and biodiversity is determined by the observations of:

- Protective cover (percent plant, litter, bare soil);
- Vegetation structure (percent trees, shrubs, annual herbaceous species);
- Plant vigour (height, diameter), biomass, regrowth;
- Habitat and species diversity (richness; abundance; useful/undesirable/invasive species and products);
- Productivity (crop, livestock, forestry, energy);
- Effectiveness of vegetative conservation measures - wind breaks, reforestation, fire control, grassed strips, etc.

Trends can be determined from the interviews with local resource persons and land users and, where available, from the use of satellite images and aerial photos to compare the current situation with the situation over the last 10 years.

In croplands, as well as assessing where possible the crop(s) (where they are in the ground), the state of the natural vegetation should be assessed, such as the maintenance of field borders, vegetated strips or bunds, shrubs/trees in fields and around homesteads. The natural vegetation provides host plants/habitats for wildlife including beneficial predators of pests (birds, retiles and insects) and pollinators. A monocrop on a single farm (repeated year after year) or a tendency for all farmers in an area to grow the same crop will both result in a greater risk of pests and disease outbreaks (information from the land users). Crop rotations or sequences and crop mixes should be recorded, as these contribute to reducing community vulnerability to crop losses drought diseases and pests.

Soil: This section should present and summarise the findings of the soil assessment that was conducted with the land users for forest land, grazing land, cropland, treecrop land and mangrove (see Part 2, Section 4). The soil is strongly influenced by vegetation and vice versa, so these findings could be usefully brought together for each land use type. The soil status and trends are determined from observations and measurements of a number of soil properties and of soil erosion:

Soil properties, including physical, biological, chemical properties, should have been assessed using the VS-Fast tools and indicators (see Part 2, Section 4) to provide a comparable score of soil health:

- soil surface and structure (cover, crusting, compaction, depth, water infiltration rate);
- soil organic matter and life–organic matter content, rooting, earthworms;
- pH, salinity, plant nutrient deficiencies.

Soil erosion should have been assessed in terms of activity (is it active, or partially or fully stabilised?) and type of erosion (raindrop splash, rill, gully, stream bank, or mass movement?) and severity (none, slight, moderate, severe?).

The summary of the status and trends of the soil should bring together the findings on soil health and soil erosion as both are related. While soil types vary in erodibility, in general a well managed soil that is rich in organic matter and with a friable structure is less vulnerable to erosion. Trends in soil erosion and runoff need to be determined from the land users and where available, from the use of historical satellite images and aerial photos (e.g. 10 years before) to compare with the current situation.

Water resources: The section on the status and trends of water resources is derived from both the key visual water indicators and from discussions with land users (availability, quality, use, access, etc.). As the assessment is conducted at one moment in time, information on seasonality and changes in water resources must be obtained from the community discussion and key informant/households interviews, also secondary data (meteorological, rainfall gauging stations if available etc). Indicators include:

- Rainfall (distribution, intensity, amount) and climate variability/change;
- Water sources (types, number, size), availability (seasonality) and waterquality;
- Water uses for human consumption, livestock, agriculture, industry;

- Water resources management (over a 10 year period) (e.g. water conservation and harvesting activities);
- Water policy and institutional aspects (water allocation, rights and conflicts).

A focus should be placed on the effects of land uses and management on water for human and livestock consumption, also the effective (or otherwise) use of rainfall or irrigation water for agricultural production. It is important to assess any off-site/ landscape impacts of water resources degradation, such as flooding, sedimentation from runoff water or dust storms, salinity due to over-abstraction/irrigation, point contamination of water by housing or industry, upstream land use effects on resources downstream (e.g. water recharge, loss of productive land etc.). It is also useful for the team to think about these impacts not only in biophysical terms but also in terms of impacts on wider communities.

SLM technologies and approaches:

The evaluation of the effects of successful SLM practices and associated approaches in croplands, grazing and forest lands in the study areas is facilitated by the use of the WOCAT questionnaires. The report should include the effects on the productive, ecological and sociocultural services provided by ecosystems. [See Part 1 Annexes 2 to 5.] It is possible to document these SLM Technologies (QT) and Approaches (QA) by uploading the assessment results as case studies in the WOCAT database to share the experiences more widely.] The questionnaires help in making the team more rigorous in the evaluation and in carrying-out additional research to collect required additional information that may not be immediately available. For example, information on required inputs and costs, constraints to adoption and effects, not only for preventing, mitigating or reversing land degradation but also the effects in terms of biodiversity conservation, sustainable use and climate change adaptation and mitigation. Such issues are of increasing value for policy makers. The WOCAT questionnaires and database are available on the WOCAT website https://www.wocat.net.

Driving forces & pressures

This section tracks back from observations made on the state and dynamics of the key landresources to the causal factors (i.e. the pressures (direct) and the driving forces (indirect)) and includes the analysis of direct and indirect causes of LD/or SLM adoption by LUS. The focus group discussion (Tool 1.1 (FAO *et al.,* 2011b)) and the key informants and households interviews (Tool 7.1) will provide information on the drivers and pressures of land degradation. In many cases, specific management practices or specific demands people are making on the resources (e.g. deforestation for fuelwood) are identified as the significant "pressures" on the land resources. Some of the driving forces may be environmental (e.g. drought, rainfall variability, climate change, pest attack) but many will be economic, social and institutional in nature (such as population growth leading to land fragmentation and over exploitation). For this reason, it is important to analyse the role and implications of the different local institutions (government agencies, NGOs, producers groups, community organizations, support groups, etc.) and how they influence land use and management practices of the various types of land users (large-and small-scale farmers including subsistence and commercial enterprises, also livestock keepers (traditional and commercial).

See part one section 7.2.5 pg 90 for the steps in Identification of direct and indirect causes of land degradation in the study area

Impacts on ecosystem services

Adopting an integrated ecosystem approach improves understanding of the biophysical and socio-economic/human interactions that determine land degradation or improvement.

Drawing on the findings of the reconnaissance visit/transect walk and during the detailed site assessments of vegetation, soil and water resources, the LD/SLM impacts on ecosystem services are assessed including impacts on:

Production and productivity:

- production of food, fibre, energy (through crops, livestock, forestry), other goods;
- water productivity, availability of land;
- risks of crop failure, livestock/tree mortality, etc.

Ecological regulation and life-support:

- nutrient cycling–break down of organic matter, soil fertility replenishment, pollution (nitrates, phosphates, etc.);
- carbon cycling-C sequestration through biomass production, organic matter management (including reduced tillage), and regulation of GHG emissions (biomass burning, methane emissions from livestock and irrigated systems, fuel emissions from mechanised farming, etc.);
- maintenance of the hydrological cycle/regime (rainwater retention, flow, protection of wetlands, purification, flood and drought severity and incidence and salinization (e.g. where evapotranspiration exceeds precipitation);
- conservation of biodiversity and associated functions (pollination, biocontrol of pests and diseases;
- climate regulation–through shade, windbreaks, water conservation etc., which also contribute to climate change adaptation.

Socio-cultural services (i.e. those provided by the environment), including;

- livelihoods (e.g. farming, forestry, fisheries, ecotourism);
- spiritual and aesthetic value (e.g. landscape or recreation value);
- vulnerability/risk aversion (conflict resolution, food security).

See manual part 1 page 97 for further details.

Impacts on people and their livelihoods

One of the objectives of a livelihoods analysis is to deliver an improved understanding of how socio-economic, cultural and institutional factors influence land-users' views and their management of their land resources. It helps analyse both the drivers and pressures leading to LD/SLM and the impacts of LD/SLM on people. Understanding these LD drivers helps to identify policy responses for the diverse land user groups.

The LADA local livelihoods (socioeconomic and institutional) analysis should be completed using information from:

Community Focus Group Discussion (Tool 1.1 (FAO *et al.*, 2011b)): This generates initial information about the range of land-users, their individual and communal land management regimes and the area history. It also informs on how the socio-economic and institutional factors influence land users' perceptions and management of land resources at landscape level. It helps in interpreting secondary information.

Household livelihoods interviews (Tool 7.1): These help identify most of the relevant issues that determine sustainable resource use and land degradation and "trends" or changes over the last 10 years or so. Based on the 20-30 households interviewed (depending on community heterogeneity), it is possible to identify the socio-economic and institutional factors influencing how land users view and manage their land resources. Moreover, the various categories of land users identified during the wealth ranking will serve as a basis for the livelihoods analysis as it will help categorise the household interviewed. The capital assets of that household which represents a given wealth group can be shown on a pentagon diagram.

Key informants and land users interviews help cross-check and further discuss specific aspects of LD problems and SLM responses, and issues less visible in the field such as water resources, use of farm inputs, livestock management, experiences of by laws and policies, and risks of current practices and or their conservation effectiveness and benefits and constraints to adoption of SLM practices.

The interpretation of assessment results should be complemented by results of the discussions with key informants and community members. It is essential to obtain community feedback on assessment findings, to complete the understanding and develop recommendations for action from community to policy levels.

The results should provide information on the pressures on land resources caused by landusers, their effects on land resources (status and trends), the consequences of LD/SLM on ecosystem services and the impacts onhousehold livelihoods (e.g. in terms of food insecurity, poverty, out-migration).

See manual part 1 pg 106 for further information regarding the aforementioned analysis.

Responses

Once the impacts, driving forces and pressures have been identified and analysed, the current responses of land users and communities and decision makers (e.g. incentives for certain crops or land uses, regulations, land registration etc.) can be better understood and contextualized.

This section of the analysis and report should present:

The actual responses (already undertaken in thestudy area);

- Type and efficacy of existing land management measures and practices;
- Support measures available;
- Constraints in their larger adoption.
- Proposed solutions by categories of land users and wealth:
- Recommendations for:
  - Land users;
  - Stakeholders and decision makers at national, provincial/local levels.

See manual part one pg 108 for further information

Conclusions and policy recommendations

This section should be addressed to decision makers and is useful to identify the priorities, aspects that need more in-depth assessment in order to help future decision making on investments and to: Show and analyse any relevant maps from the national LD/SLM assessment of

- LD type, extent, severity, causes and impacts
- Type, extent and effectiveness of SLM measures
- Describe and illustrate with photos and graphs what are the impacts of recent interventions
- Propose solutions to reinforce positive responses to mitigate land degradation and decrease short term negative responses;
- Develop scenarios or chains of explanations (e.g. link sustainable land management measures, agricultural productivity and livelihoods);
- Target responses/recommendations by decision makers and types of intervention (training, awareness, subventions, value chain development, land tenure, etc.);
- Specify spatial responses/recommendations (upstream/ downstream, LUS and LUT);
- Link agricultural policies and the assessment results with the other global issues (such climate change and food security).

The recommended responses can be discussed in this section of the report, including: support, interventions, policy change, adapted local regulations etc. These responses might target the impacts directly or the drivers of these impacts. In the case of environmental driving forces (e.g. climate change) an appropriate response might be to support adaptation, ability to cope etc. rather than trying to “manage” the driver directly. The suggestions and advice given here will be important for sustainable land management implementation at community level and policy recommendations at regional and national level.

ESTABLISHING AND MAINTAINING LADA-LOCAL DATABASE

A database should be established for the storage of quantitative and qualitative data generated by the assessments. The initial assessment will provide the baseline for monitoring future changes and trends in the selected district/province or SLM project and, where national assessments are conducted, to feed more in depth knowledge and understanding into the findings of the national assessment for the area in question.

10. Example of local assessment of two parishes in Grenada

LOCAL ASSESSMENT

Parish: St-Andrew **Study**

Area: Mirabeau down to the sea

Characterization of the study areas and recent history: Ten years ago the area was a plantation owned by a government estate, which has been divided in small holdings (1/4-3 acres). Farmers now cultivated foodcrops: vegetables, maize, pigeaon peas, and also some fruit trees around the hedges of fields (windbreakers), and there are lots of abandoned lands represented by herbaceous/shruby lands. Farmers also grow mixed tree crops composed mainly of nutmeg, banana, and cocoa. On the seashore, there is mangrove, and on top of the hill, natural forest.

Reconnaissance Visit/Transect + Interviews

Land Use Systems (LUS)	Description	Land Degradation (LD) features & processes	SLM practices or measures/ecological function	Tools selected for the detailed assessment
Food crops and underutilized/ abandoned lands (bush) This LUS shall be divided in land use types if there are differences between land uses and management (e.g. organic vegetables, vegetables with soil cover, vegetables with ploughting) and measurements shall be taken for each types for comparative purpose.	Vegetable fields, fruittrees around the edges of fields, and some maize/ peas fields, few livestock (cattle and goats), vegetable fields irrigated with overhead springlers from a upstream river, - 3 acres average farm size	Gully erosion Sheet erosion Ravins Vertical ploughing (1 farmer) Use of herbicide and burning for land clearing Bare soil on the edges of beds Little mulch Short fallow period (1 month) Deep drain (no measure to slow down water like vegetation or rocks) Pest and diseases (tomatoes) Citrus dried up Too much water use in irrigation (flooding irrigation)	Lemon grass barriers to stabilize the gullies Contour ploughing (horizontal) Rotation of crops Bamboo terraces No tillage-keep soil cover when planting (watermelon) Plant sugarcane to stabilize soil Fruit trees as windbreaks and around edges	- Soil properties (1) - Soil erosion - Vegetation in croplands - Interviews with farmers(5)

Land Use Systems (LUS)	Description	Land Degradation (LD) features & processes	SLM practices or measures/ecological function	Tools selected for the detailed assessment
Mixed tree crops Nutmeg, cocoa, banana, soursop, avocado (cocoa dominant) Different layers of crops height Also cocoa alone	Site 1: cocoa only Fertiliser used	Roots exposed close to the drains Pest and diseases (thermite, witches broom, black pods)	Ground cover, except close to drains Drain clean Trees pruned	- Soil properties - Soil erosion - Vegetation tree crops (quadrat/density, distance bw trees)
	Site 2: mixed tree crops poorly managed	Improper pruning Thick canopy, limited light penetration (black pods) Diseases and pest	Minimal disturbance of soil No use of chemical fertilisers	- Interview land with user
Mangrove Natural Forest	Stable mangrove, minimal disturbance	Limited use of wood Minimal pasture of animal in shrub areas close by Trash/litter-illegal dumping Coastal erosion-illegal sand mining small scale	Coastal lagoon Birds, lezards, and aquatic life	- Visual indicators of ecosystem health - Tool in development
Natural forest				

Analysis DPSIR

Land Use Systems (LUS)	State of Land Resources (Vegetation, soil, water) Results of tools	Causes of LD and/or SLM	Impacts on ES & people See tables	Responses to LD or more effective SLM
Food crops and underutilized/abandoned lands (bush)	**Soil properties** Texture: clay loam color: red/brown no tillage pan: score 2-good ASD: score 2-good Earthworms: 4 worms, so score of 1 Roots: score 2-good Total score: 24-good **Measurements** SD: 3 (slight) pH: 5.2 slightly acidic WI: 3-D score 1-fast Salinity: score 2-good Total score: need to do the organic carbon	Land Degradation Drivers: - heavy rainfalls - steep slope - type of soil (small particules) - Incentives for farming, but not for SLM per se (lack of SLM policy) - Fertilizer subsidised by government - No taxes on agricultural inputs, but still high - Poor capacity of pest management authority to intervene quickly and pesticide costly - Government buying manure at high price (so farmers selling and not using it on their lands) - Farmers are under lease arrangement but without paying **Pressures:** - Low adoption of good practices promoted by extension services - Inadequat e agronomic practices - High uses of fertilizers and herbicides - No cooperatio namong farmers on pest control - Improper irrigation technique SLM - Project on SLM on lemon grass barriers - Extension services on good practices	**Impacts on ES:** Provisioning - Production + 2 - Water quality -1 (to be tested) Regulating/ supporting - Water-regulated during dry season-Organic matter - 1 - Soil cover - Biodiversity 0 **Impacts on livelihoods:** - Income + 3 - Food security + 3 - Physical capital-house construction - Part time farming,also job - Electricity, tv, tel, water	- Awareness on good practices to increase adoption, and field sanitation - Farmers part of a monitoring program through visual indicators - Increase use of manure and soil cover and mulch, promote livestock - Promote land ownership through government regulation - Soil conservation structures: contour, terraces, vegbarriers - Plant biocontrol trees to control diseases and pest - National plant breeding, or more control on seed quality and vendors - Regulation of water use (how many farmers can use a stream) and irrigation type
	Soil erosion Type: gully and sheet State: G-active, S-partly stabilized (PS) Extent: G-negligeable S-localized Severity: low (area) Gully: 100 cm wide, 150 cm deep, with lemon grass			

Land Use Systems (LUS)	State of Land Resources (Vegetation, soil, water) Results of tools	Causes of LD and/or SLM	Impacts on ES & people See tables	Responses to LD or more effective SLM
	Vegetation: - 40% area cover by crops - 5%-10% of mulch cover of field during grow - Fertilize rs and some manure - 10-20 crops - 1/8 acre by block, and acre by farmer - Fallow 1 month in between crops, and crop rotation - Fruit trees and bush/abandoned lands around			
Mixed tree crops	**Vegetation:** quadrat 1: 5 trees 2: 9 trees 3: 9 trees Distance between trees: average: 4m canopy cover: 90% soil cover: litter, except along drain where roots exposed **Soil:** type: belmont clay loam structure: good no pan texture: clay loam color: brown tillage pan: no pan score 2 ASD: good score 2 Soil crust: none score 2 Earthworms: 0 score 0, but evidence of worms burrows Roots: good score 2 Total score: 22 good **Measurements:** S&D: slight score 3 pH: 6.2 WI: 3D: very fast score 1 Salinity: safe good score 2	**Drivers & pressures:** - Good price cocoa nutmeg - Age farmers (some too old, young not interested) - Lack financial resources and for management - Religious believe (rasta) - Previously estate lands with these crops - Hurricane (demotiva tion) - Thiefs so farmers invest less	**Livelihoods:** - Income +3 - Food security +3 (fruits, cocoa, nutmeg medicine) **ES:** - Diversity - Soil cover - Carbon sequestation (perennial)	- Routine maintenance system developed by extension officers and farmers - Enforcement of the legislation (thiefs) and collaboration between farmers - Maintain good price and market access (as they are)
Mangrove				
Natural Forest				

LOCAL ASSESSMENT

Parish: St-Patrick **Study Areas**: River Antoine Estate + Chambeau + Belmont Estate

Characterization of the study areas and recent history:

River Antoine: sugar cane estate producing rhum, after they tried organic bananas which failed, later pockets of vegetables, and now tree crops composed of bananas, soursop, papaya, coconut, plantain, breadfruit and goden apple. It is a joint ownership between different entities (Estate >300 acres). They still produce rhum but with imported molasse.

Chambeau: Flat lands, slight slope. Farmers cultivate vegetables and foodcrops (cassava, sweet potatos, yam). Farmers have ½ acres to 6 acres, average size 3/4 to 1 acre. Previous estate, now farmers occupied the lands, no lease and renting fees (some agents try to collect user fees). Before one man cultivate most lands, so more rotation in terms of ploughing. Now all farmers apply for tractor service to plough every year, some dont get it.

Belmont Estate: family owned estate 400 acres, and 180 acres under cultivation tree crops mainly. Some livestock (40 goats).

Analysis DPSIR: Drivers-Pressures-State-Impacts-Responses

Land Use Systems (LUS)	State (trend) of Land Resources (Vegetation, soil, water) Results of tools	Causes of LD and/or SLM	Impacts on ES & people See tables	Responses to LD or more effective SLM
Mixed tree crops (previous annual croplands)	**Site 1:** banana, soursop and papaya **Vegetation**: quadrat: 13 bananas, 1 papaya, 1 soursop Distance between trees: 2 m banana 9 m soursop Soil cover: 80% by weed and litter Canopy cover: 30% Erosion: 1 gully active after concrete drain **Soil:** type, structure: clay loam structure: good no pan color: brown tillage: no, score 2 ASD: good score 2 Crust: no, score 2 Earthworms: 0 and no evidence, score 0 Roots: good, score 2 Total score: 22 good **Measurements:** S&D: slight, score 3 pH: 6 WI: fast, score 1 Salinità: safe, no saline score 2 **Water:** - buffer between lake and fields - aquatic life - no sign of eutrophic ation - water level ok - some irrigation for the plantain, extraction of water for plot elsewhere - fertiliser used for plantain	**Drivers & pressures:** - lack of financial resources and labor to maintain the cultivation - lack of interest in farming - lease arrangement - conflict of interests	**Livelihoods:** - Jobs for people from surrounded villages - Tourism **ES:** - water quality (use of fertiliser) - water level (water extraction) could increase as in dry zone, and from estate on the other side	- monitoring irrigation, and irrigation scheduling - drip irrigation, water saving - rain harvesting - regulation on use irrigation type

Land Use Systems (LUS)	State (trend) of Land Resources (Vegetation, soil, water) Results of tools	Causes of LD and/or SLM	Impacts on ES & people See tables	Responses to LD or more effective SLM
Mangrove				
Vegetables and Foodcrops **Main problems/issues:** - poor drainage waterlogging, cut stream by road - over use of fertilisers - over ploughing - machinery (?) - need bridge	**Soil proprties:** **Bed** (wet) type: clay color: brown texture: clay structure: (wet) good ASD: good but cracked soil even if wet Crust: no crust score 2 Earthworms: 0 Roots: good score 2 SD: slight score 3 pH: 6.6 **Soil properties:** **Bed** (wet) type: clay color: brown texture: clay structure: (wet) good ASD: good but cracked soil even if wet Crust: no crust score 2 Earthworms: 0 Roots: good score 2 SD: slight score 3 pH: 6.6 WI: 3D fast score 1 5min Salinity: safe not saline **Uncultivated** Same type, color and texture Structure: good score 2	Insecurity in land tenure-short term, no investment Poor drainage system, stream cut by road Previous/actual tractor ploughing Farmers dont work together, poor collaboration on water management, road maintenance, and marketing Lack of labor, and interest by younger farmers	Waterlogging/flooding in the area Soil compaction Reduce productivity Pest and diseases Reduce income Reduce availability of water in the dry season Poor water quality in stream (deposits)	Regularisation of tenure Improve drainage system Development of water dams/water harvesting Irrigation schedule during dry season, and more efficient irrigation system Road maintenance and bridge construction Minimize ploughing-training and awareness FFS approach to make farmers work together

Land Use Systems (LUS)	State (trend) of Land Resources (Vegetation, soil, water) Results of tools	Causes of LD and/or SLM	Impacts on ES & people See tables	Responses to LD or more effective SLM
Mixed-tree crops-commercial & organic Main issues: minimal erosion drain constructed along contours pest and diseases, black pods under staff	Tree crops & quadrats (10 x 10m): 1: 3 cocoa, 2 bananas 2: 3 bananas, 3 cocoa 3: 5 cocoa, 2 bananas Growth: old trees and suckers Canopy: good 90%	Under staff Limited management (clean drain, cut vegetation) New focus on agro-tourism Old trees	Less employees on farms, but jobs as guides and in restaurant/shops Reduce production because under management	Increase labor force for improve management (drain, vegetation cut, tree regeneration, selective tree harvesting, tree planting for sustainable charcoal
	Soil cover: good litter Health: thermites, rats Management: 1 horinzontal drain not cleaned but not clear Pruning done No use of manure 200 acres + 200 acres Erosion: slight sheet erosion soil properties: type: belmont clay loam structure: good texture: clay loam color: brown tillage pan: no ASD: good Crust: no sign Earthworms: 5 Roots: good SD: slight pH: 6.7 WI: - Salinity: safe			production and furniture) Better agronomic practices appropriate for organic Ensure % of profits from agro-tourism is invested back on production Use compost and manure in fields (keep more animals) Windbreaks fruit trees (mango)
Forest - planted - natura				

Land Degradation Assessment in Small Island Developing States (SIDS)

Sustainable management of the natural resource base is a fundamental issue to support global environmental benefits provided by ecosystem services, and to ensure agricultural production and ultimately food security and livelihoods. Assessing land degradation is a major component of effective sustainable land management particularly in Small Island Developing States (SIDS).

SIDS are generally characterized by high levels of chronic poverty, largely rural based populations and dependence on traditional agriculture. At the same time, SIDS possess unique characteristics, that further exacerbates the problems associated with land degradation, given the small size of the countries and their economies, limited infrastructure, distance from large international markets, high vulnerability to natural disasters, low level of human resource development, and increasing urbanization. Small size, combined with, diverse soil types, topography, climatic variation, lack or in some cases archaic and poor land use policies limits the area available for urban settlement, agriculture, mining, commercial forestry, tourism and other infrastructure, and creates intense competition between land use options.

This manual adapts the assessment methodologies which were developed under the LADA project to the particular situation of SIDS. It is built on country experiences and is expected to enhance the capacity of the user to conduct more integrated and participatory assessments of land degradation, and to monitor impacts of interventions or changes in land management more effectively. The manual reflects a substantial shift in attention from the conventional focus on assessing degradation, to a balanced assessment that looks at both the negative and positive effects and trends of land use/ management on the natural resources and ecosystem services.

ISBN 978-92-5-109904-9

9 789251 099049

I7744EN/1/08.17