LAND DEGRADATION ASSESSMENT IN DRYLANDS

LADA

LADA PROJECT

QUESTIONNAIRE FOR MAPPING LAND DEGRADATION AND SUSTAINABLE LAND MANAGEMENT (QM)

Version 2

Cover photos:
above: Ch. Errath
below: ©FAO/Giulio Napolitano / FAO

Cover design:
Simone Morini

LAND DEGRADATION ASSESSMENT IN DRYLANDS

QUESTIONNAIRE FOR MAPPING LAND DEGRADATION AND SUSTAINABLE LAND MANAGEMENT (QM)

Version 2

general coordinators
Freddy Nachtergaele and **Riccardo Biancalani**
FAO, Rome, Italy

authors
Hanspeter Liniger
Godert van Lynden
Freddy Nachtergaele
Gudrun Schwilch
Riccardo Biancalani

editor
Anne Woodfine

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2013

This work was originally published online by the
Food and Agriculture Organization of the United Nations in 2011.

ISBN 978-92-5-107564-7 (print)
E-ISBN 978-92-5-107565-4 (PDF)

CONTENTS

Acknowledgements

This questionnaire has been developed in a joint effort between the WOCAT, LADA and DESIRE projects. The authors and editor would like to acknowledge the numerous people that have contributed to the development of this questionnaire. Special thanks goes to the donor agencies: Swiss Agency for Development and Cooperation (SDC), FAO, UNEP, UNDP and GEF.

Contact:

WOCAT Secretariat:
CDE, Hallerstrasse 10, 3012 Bern, Switzerland
Tel +41 31 631 88 22, Fax +41 31 631 85 44
E-mail: wocat@cde.unibe.ch; hanspeter.liniger@cde.unibe.ch
http://www.wocat.net

LADA Secretariat
FAO, Food and Agriculture Organization of the United Nations
Viale delle Terme di Caracalla, 00153 Rome, Italy
Tel +39 06 57054888, Fax +39 06 57056275
E-mail: dominique.lantieri@fao.org
http://www.fao.org/nr/lada

ISRIC- World Soil Information
PO Box 353, 6700 Wageningen, Netherlands
Tel +31 317 47 17 35, Fax +31 317 47 17 00
E-mail: godert.vanlynden@wur.nl
http://www.isric.org

Acronyms and abbreviations

A	adaptation
DPSIR	Drivers-Pressure-State-Impact-Response
ES	ecosystem services
FAO	Food and Agriculture Organization of the United Nations
GEF	Global Environment Facility
GIS	geographical information system
LADA	Land Degradation Assessment in Drylands
LADA-L	LADA Local
LUS	land use system
M	mitigation
MDG	Millennium Development Goal
N-LUS	national-land use system
P	prevention
QA	conservation approach
QT	conservation technology
R	rehabilitation
SDC	Swiss Agency for Development and Cooperation
SLM	sustainable land management
UNCBD	United Nations Convention on Biological Diversity
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WOCAT	World Overview of Conservation Approaches and Technologies

Introduction

In spite of some progress made toward the Millennium Development Goals, hunger, poverty and food insecurity persist, while the key ecosystems that underpin and service the natural resource base continue to be depleted and degraded. These development challenges and the related pressures on the natural resource base are now recognised at the global level and as a global issue. While driven primarily by population and economic growth, the pressures are exacerbated by a rapidly changing environmental context that includes, *inter alia*, land degradation, climate change, loss of biodiversity, water scarcity, liberalised trade regimes and demands for bio-energy production. These factors, furthermore, are linked and often self-reinforcing.

Sustainable management of the natural resource base is one of a very few, truly fundamental issues that the international community will be obliged to address effectively over the next two decades. The last twenty years have seen an emphasis on global and national economic management; the next twenty will need to address environmental management effectively.

This needs to follow a globally structured approach, based on adequate, reliable, up-to-date data and knowledge, also governed by appropriate international strategies and agreements. One key product sorely lacking to reach this goal is an overview of *where* land degradation takes place at *what* intensity and *how* land users are addressing this problem through sustainable land management. In order to fill this knowledge gap, three projects have come together to establish the current status, while mapping out a route forward.

The **Land Degradation Assessment in Drylands** (LADA) project aims to establish and implement a comprehensive methodology for the assessment and mapping of land degradation. The LADA assessment is carried out at three spatial scales (local, national and global) and considers land degradation status, drivers and impacts within land use systems (LUS). The results of LADA provide a better understanding of the degradation phenomena and gives indications for appropriate responses at all levels of scale.

The **World Overview of Conservation Approaches and Technologies** (WOCAT) has as its mission to support innovation and decision making processes in sustainable land management (SLM). The main objective of SLM is to promote long-lasting human coexistence with nature, in order that the provisioning, regulating, cultural and supporting services of ecosystems are assured for future generations. Sustainable land management is defined as the use of land resources (including soils, water, animals and plants) for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions. SLM is an essential prerequisite for sustainable development.

The **DESIRE** project aims to establish promising alternative land use and management conservation strategies, based on the close participation of scientists with stakeholder groups in the degradation and desertification hotspots around the world. This integrative participatory approach ensures both the acceptability and feasibility of conservation techniques, also a sound scientific basis for the effectiveness at various scales.

The three projects' aims and missions are complementary. In order to enhance their synergy, these guidelines have been prepared to streamline methods to map and document land degradation and land improvement at a national scale in a unique, yet common, way.

Practical notes

- The ultimate goal of this exercise is to obtain a picture of the distribution and characteristics of land degradation and conservation / SLM activities for a district, a province, a country, a region, or ultimately world-wide. The final output will be maps of land degradation status, causes and impacts, also conversely the conservation status and impacts for major land use systems in the area.
- This questionnaire should be used as an evaluation tool for land degradation and the conservation activities undertaken in a country or provinces / regions within a country.
- It is important to note that units to be evaluated will inevitably be large in area. This requires considerable capacity to combine information amongst the evaluators. The risk to be avoided is that an example of a particular gully or a particular conservation technology applied by a few farmers will be given undue attention and its importance correspondingly over-estimated.
- It is necessary to document and map not only so-called "**successful**" examples, but also those that may be considered – at least partially – **failures**. The reasons behind failure are equally important for the analysis. The map will display information on the dominant land degradation and conservation technologies for each important land use system in each country.
- It is important to evaluate the current situation, taking into account a historical perspective of the last ten years. Information should not reflect the expected, recommended, or modelled situation.
- It is recommended that the questionnaire be filled in by a **team of land degradation and conservation specialists** with different backgrounds and experiences, **in consultation with the land users**. These specialists must be familiar with degradation and conservation / SLM as well as the land use practices on croplands, grazing lands, in forests and on other land within the region or country being mapped.

- As much as possible, use should be made of existing documents (maps, GIS layers, high resolution satellite images etc.) and advice from other specialists and land users, in order to improve the quality and reliability of the data. It is important to remember that the quality of the results entirely depends on the quality of the answers. In some places, the information will be simple to obtain; but in others there may be no hard data available. In this latter case, we ask you to provide a best estimate, based on your professional judgement.
- A separate matrix table must be completed for each mapping unit. Completing all the information for each mapping unit using the matrix table and transferring the data to the database is one way of compiling the information and producing maps as a result. However, the information may not be readily available for all mapping units. In an interactive and participatory process, involving several experts/ knowledgeable resource persons, the state of degradation and conservation can be assessed, corrections can be made based on their judgements and the results can be viewed immediately. This process helps to compare neighbouring units and adjust the "values" according to the best knowledge and judgement. It might also highlight for which areas a field survey is needed, if information is not available or there is disagreement between the resource persons.
- The lists with selectable items aim to be as comprehensive as possible, but if a specific item is not mentioned it can be catered for by adding it in comments within the database. As the manual covers national, sub-national and local assessments and mapping, it may be advisable not to use all the details possible but to focus on the major categories, particularly for work at the national level.
- If a SLM Technology or a SLM Approach used for the implementation of the technology is to be described in more detail, please download separate questionnaires on SLM Technologies and/or Approaches from the internet (www.wocat.net). More information on how to evaluate land degradation at local level is available by consulting the LADA links to local assessment.
- Note that the questionnaire is a working document and users are welcome to amend it during their assessments to fit their specific needs. Feedback and improvements are highly appreciated and should be sent to the addresses below.
- Feedback for the improvement of these guidelines would be much appreciated and should be sent to one of the addresses on page iv of this document.

CHAPTER 1

User's guide

Background

The WOCAT-LADA-DESIRE mapping tool is based on the original WOCAT mapping questionnaire (WOCAT, 2007). It has been expanded to pay more attention to issues such as biological and water degradation, it also places more emphasis on direct and socio-economic causes of these phenomena, including their impacts on ecosystem services. It evaluates 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, region, or world-wide.

Base Map

For the WOCAT-LADA-DESIRE mapping exercise, the land use system (LUS) is considered as the basic unit of evaluation (FAO, 2011a). A global map of land use systems is available, but this map needs to be refined and adjusted at national level in order to provide appropriate national units in which land degradation and conservation can be described and evaluated. The basic LUS units contain a wealth of information (biophysical as well as socio-economical) related to land use and land use practices which are the major causes of land degradation.

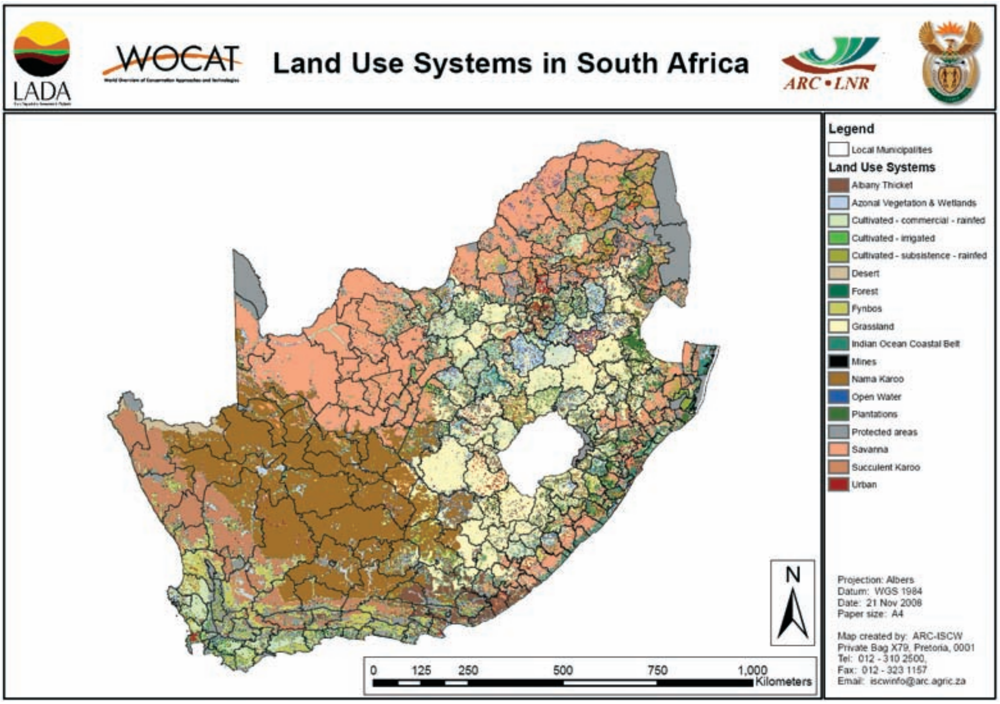


FIGURE 1 **Example of a base map with land use systems and administrative units from South Africa**

Using the methodology described below, the LUS units in combination with administrative units pemit the user to evaluate trends and changes in time of the land degradation and conservation practices applied. An example of the LUS units combined with administrative[1] units is presented in Figure 1. Each LUS within an administrative unit constitutes a unique **mapping unit** (see Figure 2) for which information on degradation and conservation should be provided in the matrix tables (one table per mapping unit, see pp. 29-31). Note that each mapping unit has one clearly defined LUS, but the same LUS may occur in other administrative1 units and hence form additional mapping units.

The basic unit of evaluation: the land use system (LUS)

For the delineation of the LUS the following criteria have been established:

LUS delineation criteria (compulsory):

- Land cover type (cropland, grassland, forest, wetlands, open water, bare areas and urban land);
- Land use type: no use, protected use, urban, large scale irrigated areas, combination of cropland and livestock (agro-pastoralism), if available livestock density class (no, low, moderate, high);

1 Could also be a watershed / basin.

LUS delineation criteria and attributes (additional/ optional):

- Land use attributes: e.g. dominant crop type/group, livestock type, small scale irrigation, input level;
- Biophysical attributes: e.g. slope, soil type, moisture availability (infiltration, runoff), altitude, temperature regime, highland and mountain ecosystems and climatically determined ecosystems;
- Socio economic attributes: e.g. population density, poverty indicator.

Specific national LUS delineation criteria and attributes that may be added (if available):

- Farm size, tenure and organization (commercial or subsistence);
- Fertilizer use and mechanization (if known);
- Water resources (if known);
- Forest management (if known).

(See to Annex 1 for the LUS table)

[The LADA project provides (free of charge) the various GIS layers for the LUS delineation criteria mentioned above at a resolution of 5 arc minutes, which can be adapted, refined and expanded nationally. Please contact: LADA-Secretariat@fao.org]

Land use systems and their attributes include many important parameters related directly to land degradation and soil and water conservation.

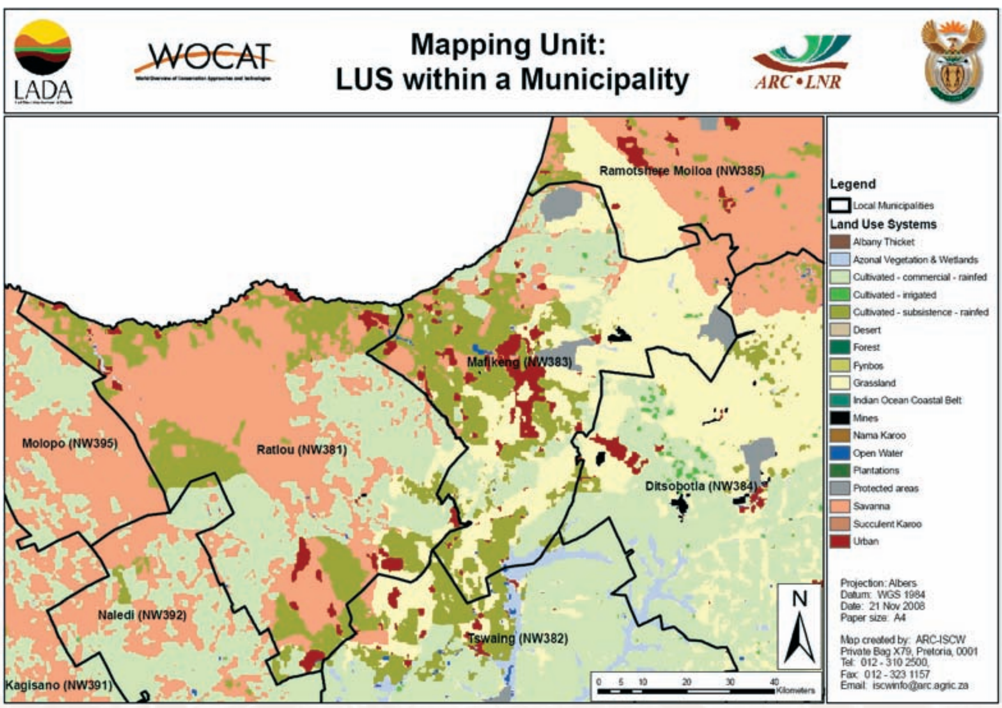


FIGURE 2 **A mapping unit consists of a LUS within a municipality e.g. the pink coloured area called savanna (LUS) in Ratlou Municipality (administrative unit)** (example from South Africa)

Soil erosion on forest land, for instance, is likely to require different soil and water conservation measures than degradation on cultivated land.

Detailed explanations for constructing LUS globally are published separately (FAO, 2006 and FAO, 2011d). An example of the national LUS creation is published for South Africa (Pretorius *et al.*, 2007).

[Where no LUS map is available or it is not at the appropriate scale for a study site, any other land use map can be used as a base map.]

Steps in data collection

The following steps will guide you through the process of collecting the necessary data. Each step first lists what needs to be done, followed by detailed explanations. Data may be entered in two ways: either directly in the database by clicking on a unit or as hard copy on the attached matrix tables, which then can be entered in the interactive map database, allowing visualization and easy adjustments of the results. In any case, for harmonization and quality assurance sake, the assessment needs to be done in teams of experts. It is recommended to complete each step for **all** mapping units before moving to the next step. Alternatively you can complete the whole questionnaire for **one** mapping unit before moving to the next.

Step 1: Contributing specialists

Data collection, harmonization and quality assurance should be done in a team of specialists. National specialists involved in this exercise should cover an array of subjects related to land degradation, land management, land use, also soil and water conservation in the country.

What needs to be done?

Fill out the information on page 28 or enter it directly in the database.

Step 2: Land use system (LUS)

What needs to be done?

a) Estimate the increase or decrease in **area** over the past 10 years for each LUS within the administrative unit concerned.

b) Similarly, give your best estimate of decrease or increase in the **intensity** of each land use system. (See Table 1 for example.)

Explanations concerning step 2:
Select the LUS mapping unit for which the information on land degradation and conservation is to be filled in. (For definition of a mapping unit refer to p. 2).

[Note: Information that is contained in that specific unit will be displayed in the database system and contains the unit delineation (the boundaries of the system) and an optional number of attributes consisting of ecosystem and socio-economic parameters.]

a) Area trend of the LUS (direct driver[2])
Changes in land use area may be an important factor in soil degradation assessment and evaluation of conservation activities. Note that if the area for one or several LUS is **increasing**, this will be at the expense of one or several other LUS, which should show a **decreasing** area trend. Consider the increase or decrease in area over approximately the past 10 years.

2 Refers to indicators within DPSIR framework for degradation and conservation in Annex 3.

The *changes in area extent* of the LUS are represented by the following five classes:

- **2**: area coverage is rapidly increasing in size (i.e. > 10% of the LUS area / 10 years);
- **1**: area coverage is slowly increasing in size (i.e. < 10% of the LUS area / 10 years);
- **0**: area coverage remains stable
- **-1**: area coverage is slowly decreasing in size (i.e. < 10% of the LUS area / 10 years);
- **-2**: area coverage is rapidly decreasing in size (i.e. > 10% of that specific LUS area / 10 years).

b) Land use intensity trends (direct driver)
A change in the intensity of land use is another significant trend with respect to land degradation and conservation. It is expressed through changes in inputs, management, and / or number of harvests in crop based systems, the introduction of rotational grazing and fencing for instance in grazing lands or the introduction of paved roads in urban systems. The estimate required is to cover the period of approximately the last 10 years.

Only changes within the same land use system are to be considered here – not changes from one land use system to another.

- **2**: Major increase (e.g. from manual labour to mechanisation, from low external inputs to high external inputs etc.);
- **1**: Moderate increase (e.g. a switch from no or low external inputs to some fertilizers/ pesticides; switch from manual labour to animal traction);
- **0**: No major changes in inputs, management level etc.;
- **-1**: A moderate decrease in land use intensity (e.g. a slight reduction of external inputs);
- **-2**: A major decrease in land use intensity (e.g. from mechanisation to manual labour, or a large reduction of external inputs).

c) Remarks
Indicate relevant information related to land use, its area and intensity change. Of special importance are reasons for intensity trend.

Step 3: Land degradation per land use system

What needs to be done?

a) Determine the major **types** of land degradation (including overlaps of degradation types) present now under each land use system.

b) Give the current **extent** of the identified land degradation types or overlaps as a percentage of the land use system area.

c) Indicate the current **degree** of land degradation for the types or overlaps identified.

TABLE 1 **Land use system (example)**

Name: *First name and Last name* **Country:** *South Africa*
Mapping Unit Id (LUS + admin. unit): 113 *(Savanna + Ratlou municipality)*

Land Use System (Step2)		
a) LUS area trend	b) LUS intensity trend	c) Remarks (e.g. reasons for trend)
2	*1*	*Increased grazing pressure due to growing numbers of livestock*

d) Estimate the **rate** of land degradation over the past 10 years.

e) Indicate the **direct** causes of land degradation.

f) Indicate the **indirect** causes of land degradation.

g) Estimate the **impact on ecosystem** services for the identified degradation types or overlaps.

Explanations concerning Step 3:
Prior to evaluating the distribution of conservation activities (response indicators), it is important to have an impression of the extent and degree of current land degradation (state indicators) necessitating these measures. Although natural degradation is not excluded, emphasis is placed on degradation caused by human activities.

It is not the intention to capture **all** manifestations of degradation. It is important to focus on the major ones – in terms of their extent and/or impact. If more than one type occurs, it is important to focus on the different major types that may occur rather than on subtypes.

In the case of **different degradation types affecting the same area within a LUS**, these can be indicated as overlapping (up to a maximum of three types per overlap – indicated as i, ii, iii horizontally in example of Table 2: Ha, Pc). The other attributes such as extent, degree etc. should be indicated for the overlap as a whole, not for the individual constituting types. Degradation types occurring in different areas of the LUS should be listed vertically. (See Table 2 for example: Ha / Pc as first (overlapping) type occurring in one area of the LUS, Bs as second type occurring in another area of the LUS (also Figure 3)).

[Note: Experience in collecting data on degradation has shown that there is a tendency to overestimate the extent and the degree of degradation. Objective judgements should be made as far as possible. In general, only degradation types or groups that cover at least 10% of the mapping unit should be considered.]

a) Types of land degradation (state indicators[3])

O: *No degradation*

W: *Soil erosion by water*

Wt: Loss of topsoil / surface erosion
Loss of topsoil through water erosion is a process of more or less even removal of topsoil, generally known as surface wash or sheet / inter-rill erosion. Wt also includes tillage erosion. As nutrients are normally concentrated in the topsoil, the erosion process leads to impoverishment of the soil. Loss of topsoil itself is often preceded by compaction and/or crusting, causing a decrease in infiltration capacity of the soil and leading to accelerated runoff and soil erosion.

Wg: Gully erosion / gullying
Development of deep incisions, down to the subsoil, due to concentrated runoff.

Wm: Mass movements / landslides
Examples of this degradation type are landslides and mudflows, which occur locally but often cause serious damage.

Wr: Riverbank erosion
Lateral erosion of rivers cutting into riverbanks.

3 Refers to indicators of DPSIR framework of degradation and conservation in Annex 3.

Wc: Coastal erosion
Abrasive action of waves along sea or lake coasts.

Wo: Offsite degradation effects
Deposition of sediments, downstream flooding, siltation of reservoirs and waterways, and pollution of water bodies with eroded sediments.

E: ***Soil erosion by wind***

Et: Loss of topsoil
This degradation type is defined as the uniform displacement of topsoil by wind action. It is a widespread phenomenon in arid and semi-arid climates, but it also occurs under more humid conditions. Wind erosion is nearly always caused by a decrease in the vegetative cover of the soil. In (semi)arid climates, natural wind erosion is often difficult to distinguish from human-induced wind erosion, but natural wind erosion is often accelerated by human activities.

Ed: Deflation and deposition
Uneven removal of soil material by wind action. Leads to deflation hollows. It can be considered as an extreme form of loss of topsoil, with which it usually occurs in combination. Deposition is the opposite effect and can be equally uneven, in places damaging vegetation, buildings, roads and polluting water (*inter alia* lakes, reservoirs, rivers).

Eo: Offsite degradation effects
Covering of the terrain with windborne particles from distant sources ("overblowing"). Includes air pollution from mining activities e.g. mining dust, asbestos etc.

C: ***Chemical soil deterioration***

Cn: Fertility decline and reduced organic matter content
Apart from loss of nutrients and reduction of organic matter as a result of topsoil removal by erosion, a net decrease of available nutrients and organic matter in the soil may also occur due to "soil mining": nutrient outputs (through harvesting, burning, leaching, etc.) are not or insufficiently compensated by inputs of nutrients and organic matter (through manure/fertilizers, returned crop residues, flooding). This type of degradation also includes nutrient oxidation and volatilisation.

Ca Acidification
Lowering of the soil pH, e.g. due to acidic fertilisers or atmospheric deposition.

Cp: Soil pollution
Contamination of the soil with toxic materials. This may be from local (e.g. waste dumps) or diffuse sources (atmospheric deposition).

Cs: Salinisation / alkalinisation
A net increase of the salt content of the (top)soil leading to a productivity decline.

P: ***Physical soil deterioration***

Pc: Compaction
Deterioration of the soil structure by trampling or the weight and/or frequent use of machinery.

Pk: Sealing and crusting
Clogging of pores with fine soil material and development of a thin impervious

layer at the soil surface obstructing the infiltration of rainwater. Development of a water-repellent layer (e.g. beneath surface ash after forest fire).

Pw: Waterlogging
Effects of human induced water saturation of soils (excluding paddy fields).

Ps: Subsidence of organic soils, settling of soil
Drainage of peatlands or low lying heavy soils.

Pu: Loss of bio-productive function due to other activities
Some land use changes (e.g. construction, mining) may have implications for the biological and productive function (e.g. agricultural production) of the soil and hence a degradation effect.

H: ***Water degradation***

Ha: Aridification
Decrease in the average soil moisture content (reduced time to wilting, change in phenology, lower yield).

Hs: Change in quantity of surface water
Change of the flow regime: flood / peak flow, low flow, drying up of rivers and lakes.

Hg: Change in groundwater / aquifer level
Lowering of groundwater table due to over-exploitation or reduced recharge of groundwater; or increase of groundwater table e.g. due to excessive irrigation resulting in waterlogging and/or salinization.

Hp: Decline of surface water quality
Increased sediments and pollutants in fresh water bodies due to point pollution (direct effluents e.g. from industry, sewage and waste water in river water bodies) and land-based pollution (pollutants washed into water bodies due to land management practices e.g. sediments, fertilizers and pesticides).

Hq: Decline of groundwater quality
Due to pollutants infiltrating into the aquifers. Human induced pollution is mainly caused by inappropriate land management practices or deposition of waste.

Hw: Reduction of the buffering capacity of wetland areas
To cope with flooding, droughts and pollution.

B: ***Biological degradation***

Bc: Reduction of vegetation cover
Increase in the area of bare / unprotected soil (including duration of exposure).

Bh: Loss of habitats
Decreasing vegetation diversity (fallow land, mixed systems, field borders).

Bq: Quantity / biomass decline
Reduced vegetative production for different land use (e.g. on forest land through clear felling, secondary vegetation with reduced productivity).

Bf: Detrimental effects of fires
On forest (e.g. slash and burn), bush, grazing and cropland (burning of residues). This includes low severity

("cold") fires (only understory burns where trees survive) and high severity ("hot") fires (reach the crown of the trees and may kill them).

Bs: Quality and species composition / diversity decline
Loss of natural species, land races, palatable perennial grasses; spreading of invasive, salt-tolerant, unpalatable, species / weeds.

Bl: Loss of soil life
Decline of soil macro-organisms (earthworms and termites) and micro-organisms (bacteria and fungi etc.) in quality and quantity.

Bp: Increase of pests / diseases
Reduction of biological control (e.g. through loss or predators).

b) Extent of the degradation type: area percentage of mapping unit (state indicator)
For each identified land degradation type, the extent should be given as percentage of the LUS affected by that degradation type within the selected administrative unit. In the example below of the Ratlou municipality in South Africa, 10% of the grassland within the

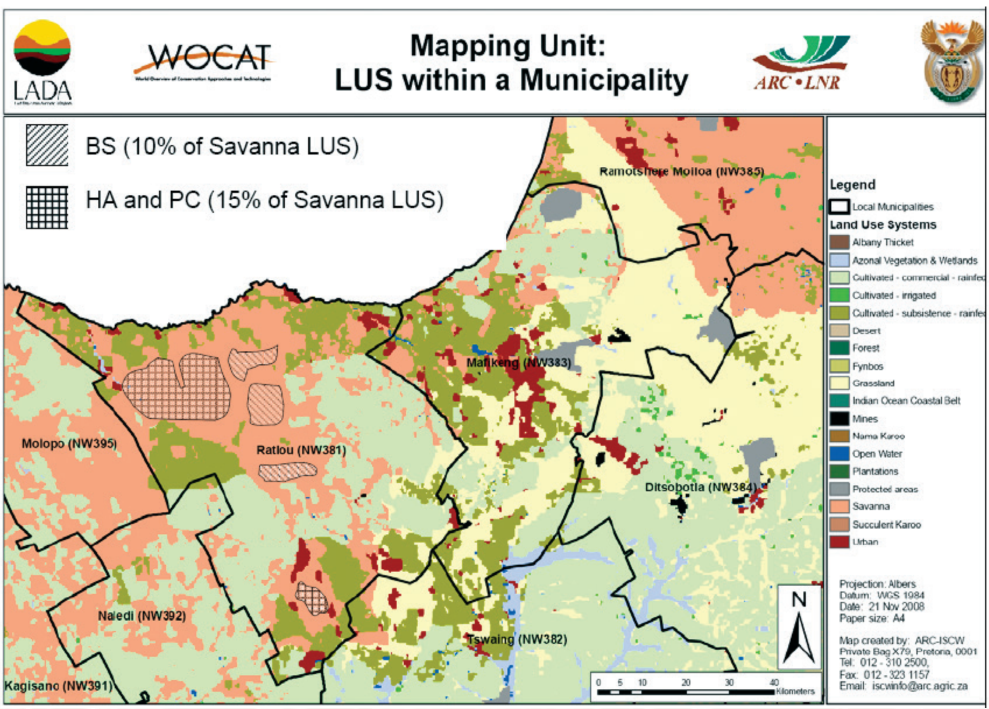


FIGURE 3 **Shows selected degradation types (shaded areas) and combinations within the LUS savanna in the Ratlou municipality (South Africa)** [In this mapping unit 10 % of the LUS is affected by bush encroachment (Bs) and 15 % by a combination (overlap) of aridification (Ha) and compaction (Pc). 25% shows no degradation (see also Table 2).]

municipality is affected by bush encroachment (Bs), and another 15% is affected by an overlap of both aridification (Ha) and compaction (Pc). The latter combination of Ha and Pc must be indicated as a separate type! The total extent indicated should be 25% (i.e. 10+15) for the entire mapping unit (see Figure 3). Note that the percentage should be rounded at the nearest 5%, and that in general only degradation types or combinations with an extent of at least 10% should be listed.

No degradation area

As the different types or groups of degradation could be overlapping, the total extent could be greater than 100%. Therefore, in order to allow the mapping of the collected data, it is necessary to indicate the extent of the mapping unit without degradation of any kind. This can be done in the first row of the form at table 2.

Note: The maps generated from this information will NOT show the real field situation as above – with degradation exactly located within the LUS – but will only reflect the percentage of that LUS that is affected by a specific degradation type.

c) Degree of land degradation (state indicator)

Degree is defined here as the intensity of the land degradation process, e.g. in the case of soil erosion: the amount of soil washed or blown away. Indicators of land degradation are used to measure the degree of degradation, e.g. the percentage of the total topsoil lost, the percentage of total nutrients and organic matter lost, the relative decrease in soil moisture holding capacity, shift in vegetation cover, decreasing ground water table etc. For the assessment of the degree of degradation, the following qualitative categories are used. In case a degradation type has different degrees of degradation within the same land use system in a mapping unit it can be split up and listed separately in two rows (e.g. Wt: extent 10% with degree 4; Wt: extent 40% with degree 1).

1. **Light:** there are some indications of degradation, but the process is still in an initial phase. It can be easily stopped and damage repaired with minor efforts.
2. **Moderate:** degradation is apparent, but its control and full rehabilitation of the land is still possible with considerable efforts.
3. **Strong:** evident signs of degradation. Changes in land properties are significant and very difficult to restore within reasonable time limits.
4. **Extreme:** degradation beyond restoration.

d) Rate of degradation (state indicator)

Whereas the **degree** of degradation indicates the current **static** situation, the **rate** indicates the **trend** of degradation over a recent period of time. A severely degraded area may be quite stable at present (i.e. low rate, hence no trend towards further degradation), whereas some areas that are now only slightly degraded may show a high rate, hence a trend towards rapid further deterioration. At the same time, an identification of the rate of degradation can reveal areas where the situation is improving (e.g. through soil and water conservation measures). The average development over approximately the last 10 years should be assessed in order to level out irregular changes. Three classes are defined that show a trend towards further deterioration and three with a trend towards decreasing degradation, either as a result of human influence or natural stabilisation; one class indicates no changes.

3: rapidly increasing degradation
2: moderately increasing degradation
1: slowly increasing degradation
0: no change in degradation
-1: slowly decreasing degradation

-**2**: moderately decreasing degradation
-**3**: rapidly decreasing degradation

e) Direct causes of land degradation (direct pressure indicators[4])

Various types of human activities and natural causes may lead to land degradation. The emphasis in the degradation inventory is on human-induced degradation, but sometimes natural degradation also necessitates measures to be taken. More than one of the following causes (direct pressure indicators) may be entered in the matrix table.

s: Soil management: improper management of the soil including:
- (s1) cultivation of highly unsuitable / vulnerable soils
- (s2) missing or insufficient soil conservation / runoff and erosion control measures
- (s3) heavy machinery (including timing of heavy machinery use)
- (s4) tillage practice (ploughing, harrowing, etc.)
- (s5) others (specify under column h - Remarks)

c: Crop and rangeland management: improper management of annual, perennial (e.g. grass), shrub and tree crops. This includes a wide variety of practices:
- (c1) reduction of plant cover and residues (including burning, use for fodder, etc.)
- (c2) inappropriate application of manure, fertilizer, herbicides, pesticides and other agro-chemicals or waste (leading to contamination and washing out (non-point pollution))
- (c3) nutrient mining: excessive removal without appropriate replacement of nutrients
- (c4) shortening of the fallow period in shifting cultivation
- (c5) inappropriate irrigation (full and supplementary): inefficient irrigation method, over-irrigation, insufficient drainage, irrigation with salty water
- (c6) inappropriate use of water in rainfed agriculture (e.g. excessive soil evaporation and runoff
- (c7) bush encroachment and bush thickening
- (c8) occurrence and spread of weeds and invader plants
- (c9) others (specify under column h - Remarks)

f: Deforestation and removal of natural vegetation: extensive removal of natural vegetation (usually primary or secondary forest), due to:
- (f1) large-scale commercial forestry
- (f2) expansion of urban / settlement areas and industry
- (f3) conversion to agriculture
- (f4) forest / grassland fires
- (f5) road and rail construction
- (f6) others (specify under column h - Remarks)

Deforestation is often followed by other activities that may cause further degradation.

e: Over-exploitation of vegetation for domestic use: in contrast to "deforestation and removal of natural vegetation", this causative factor does not necessarily involve the (nearly) complete removal of "natural" vegetation, but rather degeneration of the remaining vegetation, thus leading to insufficient protection against land

4 Refers to indicators of DPSIR framework of degradation and conservation in Annex 3.

degradation. It includes activities such as:

(e1) excessive gathering of fuel wood, (local) timber, fencing materials
(e2) removal of fodder
(e3) others (specify under column h - Remarks)

g: Overgrazing: usually leads to a decrease in plant cover, a change to lower quality fodder plant species, and / or soil compaction. This may in turn cause reduced soil productivity and water or wind erosion. It includes:

(g1) excessive numbers of livestock
(g2) trampling along animal paths
(g3) overgrazing and trampling around or near feeding, watering and shelter points
(g4) too long or extensive grazing periods in a specific area or camp, leading to over-utilization of palatable species
(g5) change in livestock composition: from large to small stock; from grazers to browsers; from livestock to game and *vice versa*
(g6) others (specify under column h - Remarks)

i: Industrial activities and mining: includes all adverse effects arising from industrialisation and extractive activities, such as loss of land resource and their functions for agriculture, water recharge, etc.. It includes land used for:

(i1) industry
(i2) mining
(i3) waste deposition
(i4) others (specify under column h - Remarks)

u: Urbanisation and infrastructure development: includes all adverse effects arising from industrialisation and extractive activities, such as loss of land resources and their functions for agriculture, water recharge. It can cause considerable run-off on neighbouring areas, causing accelerated damage like erosion, as well as other types of degradation (e.g. pollution). It includes land used for:

(u1) settlements and roads
(u2) (urban) recreation
(u3) others (specify under column h - Remarks)

p: Discharges leading to point contamination of surface and ground water resources, or excessive runoff in neighbouring areas:

(p1) sanitary sewage disposal
(p2) waste water discharge
(p3) excessive runoff
(p4) poor and insufficient infrastructure to deal with urban waste (organic and inorganic waste)
(p5) others (specify under column h - Remarks)

q: Release of airborne pollutants from industrial activities, mining and urbanisation: leading to:

(q1) contamination of vegetation/ crops and soil
(q2) contamination of surface and ground water resources:
(q3) others (specify under column h - Remarks)

w: Disturbance of the water cycle leading to accelerated changes in the water level of ground water aquifers, lakes and rivers (improper recharge of surface and ground water) due to:

(w1) lower infiltration rates / increased surface runoff
(w2) others (specify under column h - Remarks)

o: Over-abstraction / excessive withdrawal of water:
- (o1) irrigation
- (o2) industrial use
- (o3) domestic use
- (o4) mining activities
- (o5) decreasing water use efficiency
- (o6) others (specify under column h - Remarks)

n: Natural causes: many occurrences of degradation are not caused by human activities. Although this assessment places the emphasis on human-induced degradation, natural causes may be indicated as well if of major importance. They include:
- (n1) change in temperature
- (n2) change of seasonal rainfall
- (n3) heavy/extreme rainfall (intensity and amounts)
- (n4) windstorms / dust storms
- (n5) floods
- (n6) droughts
- (n7) topography
- (n8) other natural causes (avalanches, volcanic eruptions, mud flows, highly susceptible natural resources, etc.)

f) Indirect causes of land degradation (indirect pressure indicators)

Socio-economic factors are often crucial in order to understand why land degradation occurs. They are the driving forces of the direct causes of land degradation. More than one of the following indirect causes may be entered in the matrix table:

p: Population pressure: density of population can be a driving force for degradation. High population pressure may trigger or exacerbate degradation (e.g. by competing for scarce resources or ecosystem services), but a low population density may also lead to degradation, for instance where it leads to a insufficient labour force to manage land adequately.

c: Consumption pattern and individual demand: a change in the consumption pattern of the population and in the individual demand for natural resources (e.g. for agricultural goods, water, land resources etc.) leading to degradation.

t: Land tenure: poorly defined tenure security / access rights may lead to land degradation, as individual investments in maintenance and enhancement can be captured by others and land users do not feel "ownership" of their investments. Tenure systems are particular important factors when conservation practices have a long time-lag between the investment and return (e.g. terracing and tree planting).

h: Poverty: poor people cannot afford to invest in resource conserving practices, so instead they continue to use inappropriate farming practices (e.g. ploughing hillsides and overgrazing), which will exacerbate land degradation and worsen poverty. Whether poverty plays a role in land degradation needs to be assessed. It also includes situations where the need for bigger profits leads to over-exploitation and degradation of natural resources.

l: Labour availability: shortage of rural labour (e.g. through migration, prevalence of diseases) can lead to abandonment of traditional resource conservation practices such as terrace maintenance. Off-farm employment opportunities may, on the other hand, help to alleviate pressure on production resources, in the sense that land users can invest more in conservation infrastructure as income increases.

r: **Inputs and infrastructure** (roads, markets, distribution of water points, etc.): inaccessibility to, or high prices for key agricultural inputs such as fertilizers, may render it difficult or unprofitable to preserve soil fertility or water resources. Access to markets, income and good infrastructure may improve this. On the other hand, a road through a forest can lead to overexploitation and degradation.

e: **Education, awareness raising, access to knowledge and support services, also loss of knowledge:** investing in human capital is one of the keys to reducing poverty (and thus land conservation practices). Educated land users are more likely to adopt new technologies. Land users with education often have higher returns from their land. Education also provides off-farm labour opportunities.

w: **War and conflict:** both lead to reduced options to use the land and to increase pressure.

g: **Governance, institutions and politics:** laws and their enforcement, organization, collaboration and support: government induced interventions may set the scene and be indirect drivers for implementation of conservation interventions.

o: **Others** (specify under column h - Remarks).

g) Impact on ecosystem services (impact indicator[5])

The same degree of land degradation can have different impacts in different places: e.g. removal of a 5 cm layer of soil will have a greater impact on a poor shallow soil than on a deep fertile soil. Similarly, the reduction of water availability in a semi-arid environment has much greater impact on humans and livestock than a similar reduction in a humid environment. The main impact to be assessed here is the effect on ecosystem services (ES) as derived from the Millennium Ecosystem Assessment (World Resources Institute, 2005). The impact in areas with land degradation is being assessed compared to areas without land degradation (e.g. areas that are sustainably managed).

The effects of degradation can be partially hidden by various measures, such as the use of fertilizers or the treatment of polluted water. In this case, parts of these inputs are in fact used to compensate for the productivity loss caused by soil erosion and nutrient loss, or for the loss of water quality respectively. Therefore, the impact of land degradation needs to be assessed in consideration of these responses. Conversely, other factors that are not related to degradation may contribute to yield declines (e.g. pests and diseases, weather influences). When considering the impact of degradation over a longer period (e.g. 10 years) such influences will mostly be levelled out. For each mapping unit, assess the type of impact on ecosystem services (ES) according to the classes below.

P Productive services

(P1) production (livestock / plant yields (quantity and quality – including biomass for energy)) and risk

(P2) water (quantity and quality) for human, livestock and plant consumption

(P3) land availability (area of land for production per person)

(P4) others (specify under column h - Remarks)

5 Refers to indicators of DPSIR framework of degradation and conservation in Annex 3.

E Ecological services (regulating / supporting) and indicators*

a) Water services:

(E1) regulation of excessive water such as excessive rains, storms, floods (e.g. affecting infiltration, drainage, runoff, evaporation etc.)

(E2) regulation of scarce water and its availability (e.g. during dry seasons, droughts affecting water and evaporation loss etc.)

b) Soil services:

(E3) organic matter status

(E4) soil cover (vegetation, mulch etc.)

(E5) soil structure: surface (e.g. sealing and crusting) and subsoil affecting infiltration, water and nutrient holding capacity, salinity etc.

(E6) nutrient cycle (N, P, K) and the carbon cycle (C)

(E7) soil formation (including wind-deposited soils)

c) Biodiversity:

(E8) biodiversity

d) Climate services:

(E9) greenhouse gas emission (CO_2, methane, etc.)

(E10) (micro)-climate (wind, shade, temperature, humidity)

(E11) others (specify under column h - Remarks)

S Socio-cultural services / human well-being and indicators

(S1) spiritual, aesthetic, cultural landscape and heritage values, recreation and tourism

(S2) education and knowledge (including indigenous knowledge)

(S3) conflict transformation

(S4) food and livelihood security and poverty

(S5) health

(S6) net income

(S7) protection / damage of private and public infrastructure (buildings, roads, dams etc.)

(S8) marketing opportunities (access to markets etc.)

(S9) others (specify under column h - Remarks)

For each type indicate the code and add the level from 1 to -3 (e.g. P1-2: for high negative impact on production) according to the following definitions. Note that there may also be positive impacts of land degradation, e.g. erosion in one place can lead to accumulation of fertile sediments further downslope or downstream.

Level of impact:

-3 high negative impact: land degradation contributes negatively (more than 50%) to changes in ES;

-2 negative impact: land degradation contributes negatively (10-50%) to changes in ES;

-1 low negative impact: land degradation contributes negatively (0-10%) to changes in ES;

1 low positive impact: land degradation contributes positively (0-10%) to the changes in ES;

2 positive impact: land degradation contributes positively (10-50%) to the changes in ES;

3 high positive impact: land degradation contributes positively (more than 50%) to changes in ES.

h) Remarks

Indicate relevant additional information related to land degradation (e.g. if the category 'others' is indicated (e.g. under overgrazing g3), describe it further (see example in Table 2 below)).

Step 4: Land conservation (response indicators[6])

What needs to be done?

a) Give the name of the most widespread **technologies** (single or combinations) for each mapping unit.

b) Assign each technology identified under (a) to a **conservation** group described below or in Annex 2.

c) Categorize each technology according to the **conservation measure**: agronomic, vegetative, structural, management including combinations (see Figure 4).

d) Indicate whether the technology has been implemented with the purpose of **prevention, mitigation and /or rehabilitation** of land degradation.

e) Indicate the **extent** of each technology as a percentage of the area of the mapping unit (land use system area within the administrative unit).

f) Indicate **degradation addressed** by the conservation measures.

g) Estimate the **effectiveness** class for the identified technologies per land use system unit.

TABLE 2 **Land degradation (Example)**

Name: *First name and Last name* **Country:** *South Africa*

Mapping Unit Id (LUS + admin. unit): 113 *(Savanna + Ratlou municipality)*

Land degradation (Step 3)										
a) Type (state) i	ii	iii	b) Extent	c) Degree	d) Rate	e) Direct causes	f) Indirect causes	g) Impact on ecosystem services	h) Remarks
No degradation			*25%*						
Ha	*Pc*		*15%*	*2*	*1*	*g1, e1, f4,*	*p, h, t*	*P1-3, E2-2*	*Degradation is concentrated in NW communal grazing are of District*
Bs			*10%*	*2*	*-3*	*g1, g3*	*e, g*	*P1-2, S3-1*	*g3: change of livestock composition from large to small stock*

6 Refers to indicators of DPSIR framework of degradation and conservation in Annex 3.

h) Indicate any **trends** towards higher or lower effectiveness of conservation.

i) Indicate the impact on **ecosystem services** (type and level).

j) Indicate **when** each technology was installed.

k) Give a **reference** to one or more WOCAT questionnaires on SLM Technologies (QT) that describe the technologies listed under a). If no QT is available for a specific technology, give some concise details on the back of the table for the hard copy or under "Remarks" in the database. (See Table 3 for example.)

Explanations concerning step 4:
While the questionnaires on SLM Technologies (QT) and on SLM Approaches (QA) collect detailed information on conservation activities, this map questionnaire is intended to provide the information necessary to obtain a geographical display of some important conservation data. Wherever you can make a reference to relevant QTs, more background information will be available (see k below).

[Note: Experience in collecting data on SLM has shown that there is a tendency to overestimate the extent and the effectiveness of conservation. Objective judgements should be made as far as possible.]

a) Name of the technology
Provide a commonly used name (preferably not a local name) for the most widespread (not necessarily the most effective) technologies applied within each land use system unit. (N.B. only up to four possible technologies per LUS are numbered in the hard copy matrix table, but more technologies for the same polygon may be entered on the reverse side or on another sheet.

In the on-line version of the database, the number of technologies to be entered per LUS is not restricted. However, only technologies covering at least 10% of the LUS unit area should be described.

b) Conservation groups
The technologies are clustered into conservation groups:

CA: Conservation agriculture / mulching (mainly agronomic measures):
Conservation agriculture is characterised by systems incorporating three basic principles: minimum soil disturbance, a degree of permanent soil cover and crop rotation.

NM: Manuring / composting / nutrient management (mainly agronomic measures):
Organic manures, composts, green manure, mineral fertilizers / soil conditioners are intended to improve soil fertility and simultaneously most (not mineral fertilizers) enhance soil structure (against compaction and crusting) and improve water infiltration and percolation.

RO: Rotational system / shifting cultivation / fallow /slash and burn:
This system is characterized by the rotation of quite different land management such a few years of intensive crop production followed or by a period of low intensity use allowing natural regrowth (fallow) or replanting of grasses, legumes, trees etc. and then followed by re-clearing of the vegetation and intensive use.
Shifting cultivation is an agricultural system in which plots of land are cultivated temporarily, then abandoned. This system often involves clearing of a

piece of land followed by several years of wood harvesting or farming until the soil loses fertility. Once the land becomes inadequate for crop production, it is left to be reclaimed by natural vegetation, or sometimes converted to a different long term cyclical farming practice. Slash and burn refers to the cutting and burning of forests or woodlands to create fields for agriculture or pasture for livestock, or for a variety of other purposes.

VS **Vegetative strips / cover** (mainly vegetative measures):
Grasses or trees are used in various ways. In the case of strips (ideally along slopes), these often lead to the formation of bunds and terraces due to 'tillage erosion' – the downslope movement of soil during cultivation. In the other cases, the effect of dispersed vegetation cover is multiple, including increasing ground cover, improving soil structure and infiltration, also decreasing erosion by water and wind.

AF **Agroforestry** (mainly vegetative, combined with agronomic)
Agroforestry describes land use systems where trees are grown in association with agricultural crops, pastures or livestock (also known as silvopastoral systems) – and there are usually both ecological and economic interactions between components of the system. There are a wide range of systems, including shelterbelts, trees for shade with coffee and multi-storey cropping.

AP **Afforestation and forest protection**
Replanting of forests, improved forest management, protection against fires, improved management of forest use and felling of trees are part of this group.

RH **Gully control / rehabilitation** (structural combined with vegetative)
Gully control encompasses a set of measures that address this specific and severe type of erosion, where land rehabilitation is required. There are a whole range of different and complementary measures, although structural barriers dominate – often stabilised with permanent vegetation. (Includes mining rehabilitation, top soil storage, sloping and revegetation.)

TR **Terraces** (structural, but often combined with vegetative and agronomic measures)
There are a wide variety of different terrace types, from forward-sloping terraces to level or backward-sloping bench terraces, with or without drainage systems. Irrigated terraces (usually for paddy rice) are a special case in terms of water management and its implications for terrace design.

GR **Grazing land management**
(management practices with associated vegetative and agronomic measures)
Improved management of grazing land relates to changing control and regulation of grazing pressure. It is often associated with an initial reduction of the grazing intensity through fencing, followed either by rotational grazing, or 'cut-and-carry' of fodder and vegetation improvement and management change.

WH **Water harvesting** (structural, but also combined)
Water harvesting is the concentration and collection of rainfall runoff for crop production or for improving the performance of grass and trees, in dry areas where moisture deficit is the primary limiting factor.

SA: Groundwater / salinity regulation / water use efficiency
All measures that improve the regulation of the water cycle (reducing flooding, maintaining low flows, improving water infiltration into the soil and thus the recharge of the groundwater tables or in case of salinity to lower ground water tables and improve water availability and water quantity). This includes improved irrigation techniques such as the use of drip irrigation.

WQ: Water quality improvements:
(structural, management and vegetative)
Measures that primarily aim to improve water quality (e.g. through sedimentation traps, filter / purification system, infiltration ponds).

SD: Sand dune stabilization: (vegetative, structural and management)
Fixing surfaces from being blown and transported by wind (e.g. sand dunes, light structured soils such as loess). The aim can be to reduce the material from being blown and / or to stop the shifting of dunes. Also includes stabilization of mine dumps.

CB: Coastal bank protection: (vegetative, structural and management)
Measures that protect land and infrastructure from water erosion and impact of waves.

PR: Protection against natural hazards:
Floods, storms, earth quakes, stone / rock falls, avalanches, land slides and mudflows.

SC: Storm water control, road runoff:
(structural, vegetative, management)
Measure that are designed for extreme events such as flood flows and for coping with the runoff caused by sealed surfaces like roads, industrial areas, parking places etc.

WM: Waste management:
Organic and inorganic waste management, including solid waste (sewerage), rubble littering, effluent tailings, bio-waste and chemical waste.

CO: Conservation of natural biodiversity:
Conservation of natural ecosystems and processes and the conservation of rare and endangered species.

OT: Other: (specify under column l - Remarks)

c) Conservation measures

Choose the conservation measures that correspond to the technologies identified under (a). Annex 2 indicates the conservation measures and definitions. Often several measures are combined in the same technology (see Figure 4). In that case, list the categories for these measures according to their importance (the dominant one first), up to a maximum of 3 land degradation types and 4 conservation measures (see Table 3 for the example).

If more than one SLM Technology (consisting of one or more categories each) is indicated for the same land use system mapping unit, they are considered to be covering different areas, i.e. not to be mutually overlapping. If two or more conservation measures are overlapping the technology is a combination (see Table 3 for an example of a field situation for a single polygon and how to map it).

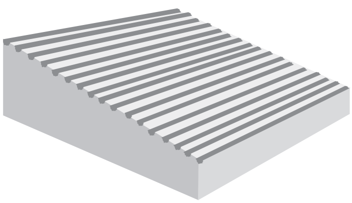
d) Purpose: prevention, mitigation and / or rehabilitation of land degradation

Indicate what purpose the SLM Technologies address most:

P **Prevention** implies the use of conservation measures that maintain natural resources and their environmental and productive functions on land that may be prone to degradation. The implication is that good land management practice is already in place: it is effectively the antithesis of human-induced land degradation.

M **Mitigation**: is intervention intended to reduce ongoing degradation. This comes in at a stage when degradation has already begun. The main aim here is to halt further degradation and to start improving resources and their functions. Mitigation impacts tend to be noticeable in the short to medium term: this then provides a strong incentive for further efforts. The word 'mitigation' is also sometimes used to describe reducing the impacts of degradation.

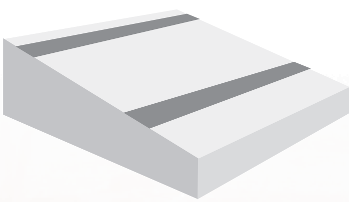
R **Rehabilitation**: is required when the land is already degraded to such an extent that the original use is no longer possible and the land has become practically unproductive. Here longer-term and often more costly investments are needed to show any impact.



A: Agronomic measures such as mixed cropping, contour cultivation, mulching, etc.

- are usually associated with annual crops
- are repeated routinely each season or in a rotational sequence
- are of short duration and not permanent
- do not lead to changes in slope profile
- are normally independent of slope

A1: Vegetation / soil cover
A2: Organic matter / soil fertility
A3: Soil surface treatment
A4: Subsurface treatment
A5: Others

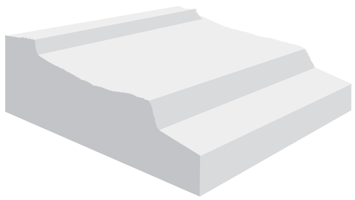


V: Vegetative measures such as grass strips, hedge barriers, windbreaks, etc.

- involve the use of perennial grasses, shrubs or trees
- are of long duration
- often lead to a change in slope profile
- are often zoned on the contour or at right angles to wind direction
- are often spaced according to slope

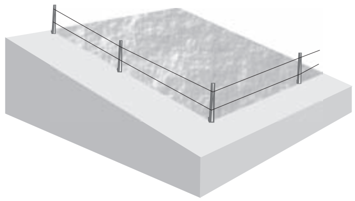
V1: Tree and shrub cover
V2: Grasses and perennial herbaceous plants
V3: Clearing of vegetation (e.g. fire breaks / reduced fuel)
V4: Others

FIGURE 4 **Categories (measures) of conservation**



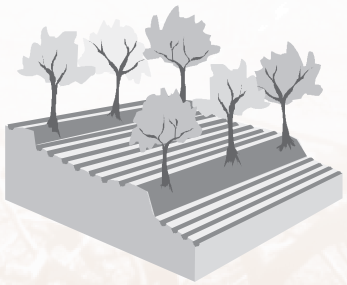
S: Structural measures such as terraces, banks, bunds, constructions, palisades, etc.
- often lead to a change in slope profile
- are of long duration or permanent
- are carried out primarily to control runoff, wind velocity and erosion
- often require substantial inputs of labour or money when first installed
- are often zoned on the contour / against wind direction
- are often spaced according to slope
- involve major earth movements and / or construction with wood, stone, concrete, etc.

S1: Bench terraces (slope of terrace bed<6%)
S2: Forward sloping terraces (slope of terrace bed>6%)
S3: Bunds / banks
S4: Graded ditches / waterways (to drain and convey water)
S5: Level ditches / pits
S6: Dams / pans: store excessive water
S7: Reshaping surface (reducing slope angle)
S8: Walls / barriers / palisades
S9: Others



M: Management measures such as land use change, area closure, rotational grazing, etc.
- involve a fundamental change in land use
- involve no agronomic and structural measures
- often result in improved vegetative cover
- often reduce the intensity of use

M1: Change of land use type
M2: Change of management / intensity level
M3: Layout according to natural and human environment
M4: Major change in timing of activities
M5: Control / change of species composition (if annually or in a rotational sequence as done e.g. on cropland -> A1)
M6: Waste Management: Any measure which includes recycling, re-use or reduce: includes both artificial and natural methods for waste management
M7: Others



Combinations in conditions where different measures are complementary and thus enhance each other's effectiveness. Any combinations of the above measures are possible, for example:
- structural: terrace, with
- vegetative: grass and trees, with
- agronomic: ridges

Example: **S1, V1, V2, A3**

FIGURE 4 **Categories (measures) of conservation** *(continued)*

e) Extent of SLM technology: percentage area of mapping unit

Specify the area of each of the SLM Technologies as a percentage of the land use system area. The total percentage area for all SLM Technologies cannot be more than 100% for one mapping unit. As with degradation, (overlapping) combinations are considered separately (see Table 3 and Figure 5).

f) Degradation addressed:

Specify the degradation type addressed by the SLM Technology. Use the degradation types listed under Step 3 a).

g) Effectiveness of implemented SLM technologies

The "effectiveness" of conservation measures is defined in terms of how much it reduces the degree of degradation, or how well it is preventing degradation.

- **4: Very high:** the measures not only control the land degradation problems appropriately, but even improve the situation compared to the situation before degradation occurred. For example, soil loss is less than the natural rate of soil formation, while the rainfall infiltration rate and / or the water retention capacity of the soil, as well as soil fertility, are increased; only maintenance of the measures is needed. Either the measures have strongly improved water availability and quality (addressing water degradation), or vegetation cover and habitats have been highly improved (addressing biological degradation).
- **3: High:** the measures control the land degradation problems appropriately. For example, soil loss does not greatly exceed the natural rate of soil formation, while the rainfall infiltration rate and the water retention capacity of the soil, as well as soil fertility, are sustained; only maintenance of the measures is needed. Concerning water and vegetation degradation, the measures are able to stop further deterioration, but improvements are slow.
- **2: Moderate:** the measures are acceptable for the given situations. However, the loss of soil, nutrients exceeds the natural or optimal and the water retention capacity is sub-optimal (as with "high") situation. Besides maintenance, additional inputs are required to reach a "high" standard. Regarding water and vegetation degradation, the measures only slow down the degradation process, but are not sufficient.
- **1: Low:** the measures need local adaptation and improvement in order to reduce land degradation to acceptable limits. Much additional effort is needed to reach a "high" standard.

h) Effectiveness trend of SLM technologies

SLM Technologies may become increasingly or decreasingly effective over time for various reasons, (e.g. changes in land use or land use systems, changes in population density, ecological changes, etc.). To assess whether a given practice is (still) appropriate under certain conditions, the trend in conservation effectiveness over the last 5-10 years is one suitable indicator.

- **1:** increase in effectiveness: the measures have a growing positive impact on the reduction of degradation
- **0:** no change in effectiveness
- **-1:** decrease in effectiveness: the measures have less and less effect in reducing degradation, (e.g. due to lack of maintenance)

i) Impact on ecosystem services

The main impact to be assessed here is the effect of SLM Technologies on ecosystem services (provisioning, regulating, supporting and cultural) as defined in the Millennium Ecosystem Assessment (World Resources Institute, 2005). It is necessary to assess the impact in areas with the listed conservation measure compared to areas without conservation (e.g. areas that are degraded).

For each mapping unit, assess the type of impact according to the classes listed below.

P Productive Services
(P1) production (of animal / plant quantity and quality including biomass for energy) and risk
(P2) water (quantity and quality) for human, animal and plant consumption
(P3) land availability (area of land for production per person)
(P4) others (specify under column h - Remarks)

E Ecological services (regulating / supporting) and indicators

a) Water services:
(E1) regulation of excessive water such as excessive rains, storms, floods (e.g. affecting infiltration, drainage, runoff, evaporation etc.);
(E2) regulation of scarce water and its availability (e.g. during dry seasons, droughts affecting water and evaporation loss etc.).

b) Soil services:
(E3) organic matter status;
(E4) soil cover (vegetation, mulch, etc.);
(E5) soil structure: surface (e.g. sealing and crusting) and subsoil affecting infiltration, water and nutrient holding capacity, salinity etc.;
(E6) nutrient cycle (N, P, K) and the carbon cycle (C);
(E7) soil formation (including wind-deposited soils).

c) Biodiversity:
(E8) biodiversity

d) Climate services:
(E9) greenhouse gas emission (CO_2, methane, etc.)
(E10) (micro)-climate (e.g. wind, shade, temperature, humidity);
(E11) others (specify under column l - Remarks)

S Socio-cultural services / human well-being and indicators
(S1) spiritual, aesthetic, cultural landscape and heritage values, recreation and tourism
(S2) education and knowledge (including indigenous knowledge)
(S3) conflict transformation
(S4) food & livelihood security and poverty
(S5) health
(S6) net income
(S7) protection/ damage of private and public infrastructure (buildings, roads, dams etc.)
(S8) marketing opportunities (access to markets etc.)
(S9) others (specify under column h - Remarks)

Level of impact
-3 high negative impact: conservation contributes negatively (more than 50%) to changes in ES
-2 negative impact: conservation contributes negatively (10-50%) to changes in ES

- **-1** low negative impact: conservation contributes negatively (0-10%) to changes in ES
- **1** low positive impact: conservation contributes positively (0-10%) to the changes in ES
- **2** positive impact: conservation contributes positively (10-50%) to the changes in ES
- **3** high positive impact: conservation contributes positively (more than 50%) to changes in ES.

For each type indicate the code and add the level from 3 to -3 (e.g. **P1+2**: for high positive impact on production) according to the following definitions. (N.B. there may also be negative impacts of conservation e.g. reduction of direct runoff upstream reducing amount for water harvesting in downstream areas.

j) Period of implementation

Indicate in what year the technology was implemented. This may be important in combination with a trend in effectiveness. If implementation has lasted several years, indicate the start and end dates (e.g. 1960-1970).

k) Reference to QT

The information provided on SLM Technologies in this questionnaire is limited and mainly restricted to geographical information. If more detailed information is available in the questionnaire of SLM Technologies (QT), please add that reference number. Otherwise, provide a short description at the back of the matrix table.

l) Remarks

Indicate relevant additional information related to land conservation.

[Note: The map generated from this information will NOT show the real field situation, but the uniformly coloured LUS unit according to the theme selected.]

TABLE 3 **Conservation (Example)**

Name: *First name and Last name* **Country:** *South Africa*

Mapping Unit Id (LUS + admin. unit): 113 *(savanna + Ratlou municipality)*

Conservation (Step 4)											
a) Name	b) Group	c) Measure	d) Purpose	e) % of area	f) Degradation addressed	g) Effectiveness	h) Eff.. trend	i) Impact on ESS	j) Period	k) Ref to QT	l) Remarks
Controlled grazing + reseeding	*VS*	*V2 M2*	*M*	*20%*	*Wt Pc Pk*	*3*	*0*	*P1+3, E3+3 E2+2, E7+1*	*1985*		*Major efforts were made in the late 80'ies and have been meintained*
Dams (with Agroforestry)	*WH*	*S6 M1*	*M*	*15%*	*Wt Cn Ha*	*2*	*1*	*P1+2, S2+1 E1+2*	*1980*	*RSA05*	*Great potential for up-scaling*

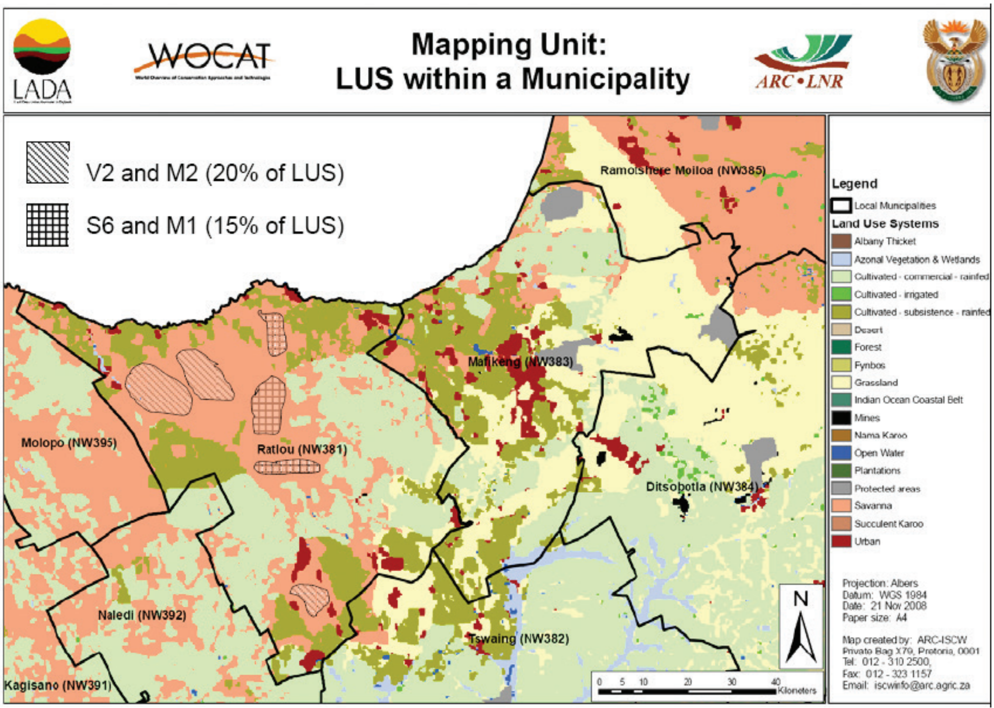


FIGURE 5 **Map showing the actual different conservation measures and combinations / overlaps (shaded areas) within the savanna LUS in the Ratlou municipality (South Africa)** (In this case, 20 % of the LUS (savanna) is covered by a combination of measures V2 (reseeding of perennial grasses) and M2 (change of the management from open to controlled grazing) and another 15% by S6 (dams / pans) and M1 (change of land use type) (also see Figure 4))

Step 5: Expert recommendation

For each mapping unit, provide an expert recommendation concerning interventions on how to address degradation (maximum 2). You first need to decide on the best intervention to deal with degradation in that specific mapping unit – *either* **adaptation**, **prevention**, **mitigation** or **rehabilitation**. In the Remarks and additional information column, provide more detail about the 'what' and 'how' of that specific intervention (see example in Table 4).

A **adaptation** to the problem: the degradation is either too serious to deal with and is accepted as a fact of life, or the causes are beyond the reach of the affected stakeholders

P **prevention** implies the use of conservation measures that maintain natural resources and their environmental and productive functions on land that may be prone to further degradation, where some has already occurred. Prevention is mostly oriented towards reducing the causes of degradation. In this, it is effectively the antithesis of human-induced land degradation.

TABLE 4 **Expert recommendation (Example)**

Name: *First name and Last name* **Country:** *South Africa*

Mapping Unit Id (LUS + admin. unit): 113 *(Savanna + Ratlou municipal)*

Expert recommendation (Step 5)	
Expert recommendation	**Remarks and additional information**
P	*Maintain good soil cover conditions through agroforestry systems*
M	*Reduce loss of water through runoff and evaporation by the soil surface through mulching and minimum tillage.*

M mitigation: is intervention intended to reduce ongoing degradation. This comes in at a stage when degradation has already begun. The main aim here is to halt further degradation and to start improving the land resources and their functions. Mitigation impacts tend to be noticeable in the short to medium term: this then provides a strong incentive for further efforts. The word 'mitigation' is also sometimes used to describe reducing the impacts of degradation.

R rehabilitation: is intervention when the land is already degraded to such an extent that the original use is only possible with extreme efforts as land has become practically unproductive. Here longer-term and often more costly investments are needed to show any impact. Careful cost effectiveness analysis should be performed when considering rehabilitation actions.

CHAPTER 2

Questionnaire

Contributing specialists (Step 1)

If several specialists are involved, write the full data of the main resource person and his/her institution below and add the name of the other person(s) with their institution(s).

Last name / surname:		First name(s):		female ☐ male ☐
Current institution and address: Name of institution:				
Address of institution:				
City:		Postal Code:		
State or District:		Country:		
Tel:	Fax:		E-mail:	
Permanent address:				
City:		Postal Code:		
State or District:		Country:		
Other resource persons involved: ……………………………… ……………………………… ………………………………		Institution: ………… ………… …………	Email …………… …………… ……………	

[Note: In cases where you wish the information to be stored in the LADA-WOCAT on line database, please refer to the following paragraph.]

Please confirm that institutions, projects, etc. referred to, have no objections to the use and dissemination of this information by WOCAT – LADA – DESIRE.

Date: ……………………………………… Signature: ………………………………………

Thank you in advance!

Please enter the information in the online database, see www.wocat.net/databs.asp or send the completed questionnaire plus any additional materials back to the respective project / programme coordinators: WOCAT: hanspeter.liniger@cde.unibe.ch; LADA: dominique.lantieri@fao.org; DESIRE WB1: godert.vanlynden@wur.nl

DATA ENTRY TABLE

Please fill out one table for each mapping unit. Make copies of this table as required to fill in information for other mapping units.

Name: ______________________________ Country: ______________________

Mapping Unit Id (LUS + admin. unit): _____________________________

Land Use System (Step 2)		
a) LUS area trend	b) LUS intensity trend	c) Remarks (e.g. reasons for trend)

Land degradation (Step 3)										
a) Type			b) Extent	c) Degree	d) Rate	e) Direct causes	f) Indirect causes	g) Impact on ecosystem services	h) Remarks
i	*ii*	*iii*							

Name: ____________________ Country: ____________________

Mapping Unit ID (LUS + admin. unit): ____________________

Conservation (Step 4)

a) Name	b) Group	c) Measure			d) Purpose	e) % of area	f) Degradation addressed			g) Effectiveness	h) Eff.. trend	i) Impact on ESS	j) Period	k) Ref to QT	l) Remarks

Name: ______________________________ Country: ______________________

Mapping Unit ID (LUS + admin. unit):______________________________

Expert recommendation (Step 5)	
Expert recommendation	Remarks and additional information

ANNEX 1

Land Use Systems (LUS)

[Note: This is an example, taken from South Africa, to illustrate the possible definitions of LUS. For information concerning the delineation criteria for LUS refer to p. 1 and to the LUS guidelines.]

	Land Use System class	Class description
1.	**Urban**	Essentially compromising all formal build up areas in which people reside on a permanent or near-permanent basis, identifiable by the high density of residential and associated infrastructure, includes cities, towns, villages and were applicable, the central nucleus of more open rural clusters. Urban areas also include permanent, semi-permanent and non-permanent shack type dwellings, typically established on an informal, ad-hoc basis, on non-serviced sites.
2.	**Cultivated Commercial Rainfed**	Cultivated areas characterised by large, uniform, well managed field units (i.e. +/- 50 ha) with the aim of supplying both regional, national and export markets. Often highly mechanised. Include fallow and 'old fields'. It includes all non-timber based plantations such as tea, sisal, citrus, nut crops etc. and planted pastures.
3.	**Cultivated Subsistence Rainfed**	Characterised by numerous small field units (less than +/- 10 ha) in close proximity to rural population centres. Field units can either be grouped intensive or widely spaced, depending on the extent of the area under cultivation and the proximity to rural dwellings and grazing areas. Subsistence includes both rainfed and irrigated (i.e. mechanical or gravity-fed), multi-cropping of annuals, for either individual or local (i.e. village) markets. May include fallow and 'old fields' and some inter-field grazing areas.

	Land Use System class	Class description
4.	Cultivated Irrigated	Permanent irrigation of most agricultural crops and major irrigation schemes (i.e. areas supplied with water for agricultural purposes by means of boreholes, ditches, rivers, streams or dams). Different methods of irrigation are used on cultivated irrigated areas (inter alia flood, drip or centre pivot irrigation systems).
5.	Plantations	All areas of systematically planted, managed tree resources, primarily composed of exotic species (including hybrids). Category includes both young and mature plantations that have been established for commercial timber production, seeding trials and woodlots / windbreaks of sufficient size to be identifiable on satellite imagery. Excludes all non-timber based plantations such as tea, sisal, citrus, nut crops etc.
6.	Mines	Active or non-active underground, sub-surface and surface based mining activities. Includes both hard rock or sand quarrying / extraction sites, opencast mining sites (e.g. coal). Category includes all associated surface infrastructure etc.. Primarily non-vegetated, exposed mining (and heavy industry) extraction or waste material are also included in this category.
7.	Protected Areas	National Parks, Provincial Nature Reserves, Bird Sanctuaries, Botanical Gardens, Conservation Areas, DWAF Forest Areas, Mountain Catchment Areas, National Heritage Sites. Excludes private game farms, private nature reserves and state land. They are included in the related natural vegetation biomes.
8.	Open Water	Areas of (generally permanent) open water. The category includes both natural and man-made waterbodies, which are either static or flowing, including fresh, brackish and salt-water conditions. This category includes features such as rivers, major reservoirs, farm-level irrigation and stock watering dams, permanent pans, lakes and lagoons.
9.	Succulent Karoo	The succulent Karoo is restricted to the year-round and winter rainfall areas and have the greatest summer aridity. This biome occurs mostly west of the western escarpment through the western belt of the Western Cape and inland towards the Little Karoo in South Africa. This is the land of many spring flowers. Succulent plant species with thick, fleshy leaves are plentiful here, the diversity of which is unparalleled anywhere else in the world. This, together with many geophytes (plants that survive by means of bulbs, tubers, etc. in times of unfavourable climatic conditions) and annual plants, makes the succulent Karoo unique and of international importance in terms of conservation.
10.	Savannas	Savannas are the wooded grasslands of the tropics and subtropics that account for 46% of the South African landscape. They are second only to tropical forests in terms of their contribution to terrestrial primary production. They are the basis of the livestock industry and the wildlife in these areas make them a key tourist attraction. Savannas also include valley bushveld, the veld type containing the greatest range of rainfall seasonality in South Africa. Fire is a crucial factor in the ecology of all savannas and is therefore a regular natural feature of this environment.

	Land Use System class	Class description
11.	**Fynbos**	Fynbos occupies 5,3 % of South Africa, occurring almost exclusively in the south-western and southern parts of the Western Cape Province. Fynbos comprises evergreen heathlands and shrublands in which fine-leafed low shrubs and leafless tufted grass-like plants are typical. Trees are rare and grasses comprise a relatively small part of the biomass. Fire is a very important component in fynbos. Most fynbos is highly flammable due to the common presence of flammable oils. Finely wooded fynbos plants are obligate seeders, which means that the whole plant dies after fire and can only reproduce through seed. This distinguishes fynbos from the other ecosystems where fire is common. Many plant species are dependent for pollination on small mammals or birds such as the Cape sugarbird (*Promerops cafer*).
12.	**Grasslands**	The grasslands cover the high central plateau of South Africa, inland areas of Kwazulu-Natal and the mountain areas of the Eastern Cape Province. Grasslands are defined as those areas where grasses dominate the vegetation and where woody plants are absent or rare. They occupy 24,1% of the country's surface area. Most grassland occurs in high rainfall areas, where thunderstorms and hail are common in summer and frost is common in winter. The grassland biome is regarded as the third-richest area in terms of plant species diversity, with a total number of 3 788 species. The most noteworthy species with a wide distribution is *Themeda triandra*, more commonly referred to as 'rooigras'. In the past, the ungulate fauna (hoofed animals) of the Highveld grasslands included vast herds of blesbok (*Damaliscus dorcas phillipsi*), black wildebeest (*Connochaetes gnou*) and the springbok (*Antidorcas marsupialis*). A surprisingly rich variety of birds are found in the grasslands, including the blue crane (*Anthropoides paradiseus*), black korhaan (*Eupodotis afra*) and helmeted guineafowl (*Numida meleagris*).
13.	**Forests**	The forests of South Africa include the indigenous evergreen and semi-deciduous closed forests of the coastal lowlands and escarpment slopes and cover only about 0.25% of the land area. With a few exceptions such as the forests of the Knysna area and the KwaZulu-Natal coastal dune systems, forests are small, usually occupying less than 1 000 ha. These forests amount to little more than patches scattered through the higher rainfall areas. The total area of forests in South Africa is probably less than 2 000 km². The forest structure results in reduced light levels in the area beneath the canopy where species such as tree ferns are common. Typical mammals include the bushbuck (*Tragelaphus scriptus*), bush pig (*Potamochoerus porcus*) and blue duiker (*Philantomba monticola*). Birds found in forests include the Knysna lourie (*Tauraco corythaix*) and rameron pigeon (*Columba arquatrix*). Despite the small land surface area that they occupy, forests have relatively high species richness. Only fynbos exceeds the species richness found in forests.

	Land Use System class	Class description
14.	**Nama Karoo**	The Nama-Karoo covers most of the vast central plateau region of the Western and Northern Cape Provinces. The area forms an ecotone or transition between the Cape flora to the south and the tropical savanna in the north. Many of the plant species of the Nama-Karoo also occur in the savanna, grassland, succulent Karoo and fynbos biomes. Species that occur in the Nama-Karoo include the sweet-thorn (*Acacia karroo*), stone plant (*Lithops ruschiorum*) and blue Karoo daisy (*Felicia australis*). The former vast migratory herds of springbok (*Antidorcas marsupialis*) have been replaced by domestic stock, particularly sheep and goats. A rich variety of rodents and reptiles, also occurs in the Nama-Karoo. The few, endemic or near-endemic bird species include the Sclaters lark (*Spizocorys sclateri*). Sheep-farming is the main agricultural activity in this region.
15.	**Marine and coastal ecosystems**	The South African coastline covers a distance of over 3 000 km, more than 80% of which consists of sandy beaches and sand dunes. Other ecosystems include rocky shores, coral reefs, kelp beds and the open sea. Two hundred and seventy of the world's 325 fish families occur in South African waters. The east coast waters are characterised by the warm waters of the southward flowing Agulhas Current, while those of the west coast are characterised by the upwelling of cold, nutrient-rich waters of the Benguela Current. Along the southwest and south coast, there is an extensive mixing of water masses. The currents influence the composition of the animal and plant communities along this coastline.
16.	**Wetland (Azonal vegetation)**	The term "wetlands" groups together a wide range of inland and coastal habitats – from mountain sponges and midland marshes to swamp forests and estuaries – linked by rivers and streams. These wetlands share common and important functions in river catchments by providing a regular water supply, by filtering the water naturally, by reducing the effects of floods and droughts, also by providing a vital wildlife habitat and superb recreational areas for people. Most wetlands are characterised by a high water table, water-retentive soil and hydrophytes (water-loving plants), but in semi-arid Southern Africa there are numerous pans that support few if any hydrophytes and that may contain shallow water only once in five or more years.

Source for South African land use system class descriptions: CSIR & ARC (2005) and Mucina & Rutherford (eds.) (2006).

2

ANNEX

Conservation measures

(as defined in QM p. 19)

Main types and subtypes

A: Agronomic / soil management

A1: Vegetation / soil cover

- better soil cover by vegetation (selection of species, higher plant density)
- early planting (cropland)
- relay cropping
- mixed cropping / intercropping
- contour planting / strip cropping
- cover cropping
- retaining more vegetation cover (removing less vegetation cover)
- mulching (actively adding vegetative / non-vegetative material or leaving it on the surface)
- temporary trash lines (and in A2 as "mobile compost strips")
- others

A2: Organic matter / soil fertility

- legume inter-planting (crop and grazing land; induced fertility)
- green manure (cropland)
- applying manure / compost / residues (organic fertilisers), including "mobile compost strips" (trash lines)
- applying mineral fertilisers (inorganic fertilisers)
- applying soil conditioners (e.g. use of lime or gypsum)
- rotations / fallows (associated with M)
- others

A3: Soil surface treatment
- conservation tillage: zero tillage, minimum tillage and other tillage with reduced disturbance of the top soil
- contour tillage
- contour ridging (crop and grazing land), done annually or in rotational sequence
- breaking compacted top soil: ripping, hoeing, ploughing, harrowing
- pits, redone annually or in rotational sequence
- others

A4: Subsurface treatment
- breaking compacted subsoil (hard pans): deep ripping, "subsoiling", ...
- deep tillage / double digging
- others

A5: Others

V: Vegetative

V1: Tree and shrub cover
- dispersed (in annual crops or grazing land) (e.g. *Faidherbia*, *Grevillea Sesbania* spp.)
- aligned (in annual crops or grazing land) (e.g. live fences, hedges, barrier hedgerows, alley cropping)
  Subcategories:
  - on contour
  - graded
  - along boundary
  - linear
  - against wind
- in blocks
  Subcategories:
  - woodlots
  - perennial crops (tea, sugar cane, coffee, banana)
  - perennial fodder and browse species

  Further subcategories for dispersed, aligned and in blocks:
  - natural reseeding
  - reseeding
  - planting

V2: Grasses and perennial herbaceous plants
- dispersed
- aligned (grass strips)
  Subcategories:
  - on contour
  - graded
  - along boundary
  - linear
  - against wind
  - in blocks

  Further subcategories for dispersed, aligned and in blocks:
  - natural reseeding
  - reseeding
  - planting

V3: Clearing of vegetation

V4: Others

S: Structural

Structures constructed with soil or soil enforced with other materials (S1-S7) or entirely from other materials such as stone, wood, cement, others (S-8)

S1: Bench terraces (<6%)
- level (incl. rice paddies)
- forward sloping /outward sloping
- backward sloping / back-sloping / reverse

S2: Forward sloping terraces (>6%)

S3: Bunds / banks
- level
  - tied
  - non-tied
- graded
  - tied
  - non-tied
- semi-circular
- v-shaped
- trapezoidal
- others

S4: Graded ditches / waterways (to drain and convey water)
- cut-off drains
- waterways

S5: Level ditches / pits
- infiltration, retention
- sediment / sand traps

S6: Dams / pans: store or harvest water for irrigation, human or animal consumption

S7: Reshaping surface (reducing slope, ...) / top soil retention (e.g. in mining, storing top soil and re-spreading

S8: Walls / barriers / palisades, (constructed from wood, stone concrete, others, not combined with earth)

S9: Others

M: Management

M1: Change of land use type:
- enclosure / resting
- protection
- change from crop to grazing land, from forest to agroforestry, from grazing land to cropland, etc.

M2: Change of management / intensity level:
- from grazing to cutting (for stall feeding)
- farm enterprise selection: degree of mechanisation, inputs, commercialisation
- from mono-cropping to rotational cropping
- from continuous cropping to managed fallow
- from "laissez-faire" (unmanaged) to managed, from random (open access) to controlled access (grazing land forest land e.g. access to firewood), from herding to fencing
- adjusting stocking rates
- staged use to minimise exposure (e.g. staged excavation)

M3: Layout according to natural and human environment:
- exclusion of natural waterways and hazardous areas
- separation of grazing types
- distribution of water points, salt-licks, livestock pens, dips (grazing land)

M4: Major change in timing of activities:
- land preparation
- planting
- cutting of vegetation

M5: Control / change of species composition (not annually or in a rotational sequence: if annually or in a rotational sequence as done e.g. on cropland -> A1)
- reduction of invasive species
- selective clearing
- encouragement of desired species
- controlled burning / residue burning

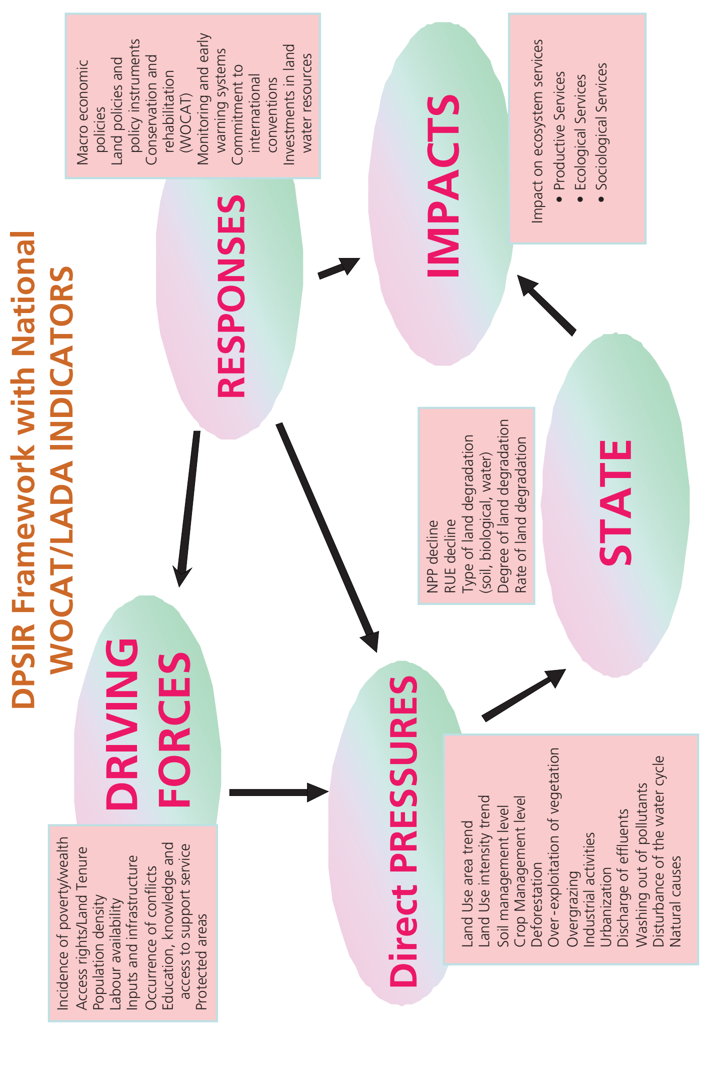
M6: Waste management: Any measures which includes recycling, re-use or reduce: includes both artificial and natural methods for waste management

M7: Others

Combinations:
Often there are combinations: list them according to importance (e.g. A3 V2).

ANNEX 3

Drivers-pressure-state-impact-response (DPSIR) diagramme



4

ANNEX

Guidelines for national assessment of land degradation and sustainable land management

These guidelines are intended to give a road map for countries that want to embark on an assessment of land degradation and sustainable land management. They are illustrated by country examples from the LADA project. An approximate budget which an "average" country would need should it proceed in this way is included for guidance.

Objectives

The overall objectives of carrying out a national assessment of land degradation and sustainable land management are manifold and can be summarized as follows:

1) To obtain a reliable picture of the state of natural resources and their use in the country;
2) To prepare the way to establishing a monitoring system on land use, land degradation and land management;
3) To prepare the way and identify areas of greatest interest for more local and detailed assessments;
4) To provide information (the results) to inform decision makers on the wisest uses of natural resources, in particular land and water;
5) To provide a reliable basis to report to the different UN conventions in particular UNCCD, UNCBD and UNFCCC.

Preparatory phase

Firstly, a national workshop should be organized to explain the objectives (above) of the making of the inventory and baseline involving multiple disciplines (agriculture, livestock, forests, statistics, natural resources and environment). The workshop should give an overview of the state of the art of actual inventories available within the ministries and institutions of data on land resources (soil, climate, land cover, topography), land use (what is cultivated, levels of inputs, management levels? what livestock figures are available sub-nationally? what is the extent and intensity of irrigation?) and specific information on particularly good practices applied in agriculture, rangeland and forestry management. Availability of information should also be discussed on social and economic factors, in particular on population and poverty sub-nationally. It is important to note that this first workshop should set the basis for the involvement of the national technical and scientific community in the assessment exercise, in order to obtain a widely accepted product and create the conditions for establishing better collaboration among the concerned institutions.

The outcome of this first national workshop should be a binding agreement on:

1) The lead institution that will coordinate the work;
2) The institutions and ministries that will cooperate by making available data and personnel to carry out the baseline study;
3) Financial arrangements.

Phase 1: Preparation of an endorsed National Land Use map

The preparation of the base materials

The underlying major principle of the LADA approach is that land use and management largely explain the state of the land and the land degradation that takes place. This degradation in turn is exacerbated directly by climatic, soil and terrain pressures, also indirectly by population and institutional issues. Therefore the national level assessment of LADA is based on such a map and uses its mapping units as the basis for the assessment, as these units represent areas with similar pressures and processes of land degradation. Also, land management interventions as inventoried by the WOCAT tool (QM) are often specific for a particular land use system.

Base materials to prepare a land use systems map include a range of products in digital format (if not they should be digitized before use), in particular national maps of soils, climate and land cover, possibly also of specific land uses such as irrigated land and protected lands. Digital databases of altitude and topography are also required. These maps and databases often are only available at different resolutions and scales. Therefore the information needs to be changed to a common resolution and scale, in order to safeguard the positional accuracy (including precision, correctness, integrity and completeness) of original data. The aim should be to enhance the homogeneity between datasets and avoid over-exaggerating accuracy (e.g. presenting small scale maps at a larger scale. For most countries, a 1 km resolution or maps at 1:500 000 scales are best suited for this purpose, but higher resolution and largest scale maps may be used, particularly in small countries.

Another source of information is national statistics on a number of socio economic factors such as sub-national (by administrative unit) data on population density, poverty levels, the use of inputs (tractors, fertilizers), average yields for specific crops, land tenure arrangements, livestock density classes and dominant livestock species. As these data are often only available by administrative unit, they can generally not be further broken down in a geo-referenced way (e.g. to land systems within administrative units), although some may well be redistributed (livestock in grazing lands or fertilizers / tractors on cropland only).

A third source of data is regional and global datasets that sometimes are collected and available at sufficiently high resolution to be used in national studies.

The preparation of the base map

The base map is the National Land Use System (N-LUS) map, which should be prepared and documented by the lead institute in collaboration with its team in the other Ministries and national institutions. [The general technical specifications for building the N-LUS map are given in LADA Technical Report # 8.]

The National Land Use System map: delineating units

The starting point of preparing of an N-LUS map is land cover information, freely available for the year 2005 (ESA *et al.*, 2005) for the whole world at a 300 m resolution. This database, although generally reliable and of high resolution contains areas with lower confidence levels and the results of this database should be verified with the best national maps on land cover and expert knowledge. Use of the Globcover database is

TABLE 4.1 **Example of a Land Use System classification**

Land cover	Land manangement
Forests	Pristine non protected Pristine protected Managed
Urban	
Grasslands	High livestock density Moderate livestock non protected Moderate livestock protected Low livestock protected Low livestock not protected
Marginal grazing lands	High livestock density Moderate livestock non protected Moderate livestock protected Low livestock protected Low livestock not protected
Wetlands	Protected Not protected
(Nearly) bare Land	Low livestock Moderate or high livestock Pristine Oasis
Cropped agriculture	Irrigated with moderate or high livestock commercial Irrigated with no livestock commercial Rainfed with moderate or high livestock Rainfed without livestock subsistence Rainfed without livestock commercial Paddy Rice

highly recommended to avoid significant errors in mapping of land that is for instance nationally classified as " Forest land" while in reality no trees occur any longer in the area. The Globcover database has an extensive legend that for national purposes should be simplified in order to cover the following major classes of interest: urban land, forests, good grazing lands, marginal grazing lands, agricultural cropland, wetlands, (nearly) bare lands and open water. Certain of these classes can be further subdivided: for instance forests can be divided into pristine and managed, grazing lands can be subdivided by livestock density, agricultural cropped areas can be divided on the basis of irrigation or rainfed and commercial or subsistence while the importance of livestock is an additional factor that can be used to further subdivide cropped land use systems. In order to avoid a very pixelized map, the information can be aggregated in 1km pixels. A theoretical example of such a legend is given in Table 4.1 and a practical one prepared by LADA- Tunisia in Table 4.2.

The National Land Use System map: attributes of the delineated units

Although for mapping purposes the procedure above is sufficient to start the next phase, it is advisable to attach the collected ancillary data to the N-LUS socio economical data (population, income, land tenure regime) to each pixel, with the land use data (dominant crops, crop management, livestock dominant species if available) and biophysical information (*inter alia* slope, dominant soil and climate, dominant species of crops and livestock etc.). This information can be spatially-related in a geo-referenced base if available, or according to cadastral or administrative units, as appropriate. Doing so sets up a national information system on natural resources that is easily queried and can be used to produce thematic maps on request. Moreover, this information can be used in the subsequent analysis of the data.

TABLE 4.2 **National Land Use Systems in Tunisia**

1.	Zones urbaines
2.	Parc naturel ou réserve naturelle
3.	Site Ramsar
4.	Grandes cultures en irrigué
5.	Arboricultures en irrigué
6.	Palmier en irrigué
7.	Cultures maraîchères en irrigué
8.	Agrumes en irriguée
9.	Grandes cultures en sec
10.	Olivier
11.	Verger (principalement amandier) en sec
12.	Vigne en sec
13.	Palmier en sec
14.	Agrume en sec
15.	Cultures maraîchères
16.	Agro Pastoralisme en irrigué élevage intensif
17.	Agro Pastoralisme – élevage intensif
18.	Agro pastoralisme en irrigué, élevage Modérément Intensif
19.	Agro pastoralisme en irrigué extensif
20.	Agro pastoralisme élevage Modérément Intensif
21.	Agro pastoralisme élevage extensif
22.	Pastoralisme en sol nu (couloir de transhumance) intensif
23.	Pastoralisme en sol nu (couloir de transhumance) modérément intensif
24.	Pastoralisme en sol nu (couloir de transhumance) extensif
25.	Pastoralisme dans des aires d'arbustes intensif
26.	Pastoralisme dans des aires d'arbustes modérément intensif
27.	Pastoralisme dans des aires d'arbustes modérément extensif
28.	Forêt
29.	Arbustes et herbacées éparses
30.	Sols nus
31.	Eau

Validation of the National Land Use map

The validation of the N-LUS map is very important for its acceptance by the users and the correct development of the subsequent land degradation assessment exercise. The validation is done through a national workshop, involving the same institutions and Ministries involved in the first workshop, with an additional presence of representatives from farmer / ranger organizations and extension workers from each (higher) administrative unit in the country. In this meeting, the draft N-LUS map (based on existing maps and databases) should be opened to any challenges from experts with the ground level expertise and changes made where required. It is of utmost importance that the principles on which the map is built are accepted by all. Once this is acquired, changes can be freely discussed to refine and correct the prepared draft N-LUS Map. It is important however that the eventual changes are made following the principles of the stratification mapping (land cover-land use-livestock density). These changes are often minor, but agreement on them is essential in order to avoid problems down the line.

The final outcome of this phase is threefold:

1) A central digital information system has been established that contains maps, data and information on natural resources in the country and is accessible by all contributors;
2) A unique national land use system map has been produced that can be used as a basis to assess and map land degradation and sustainable management;

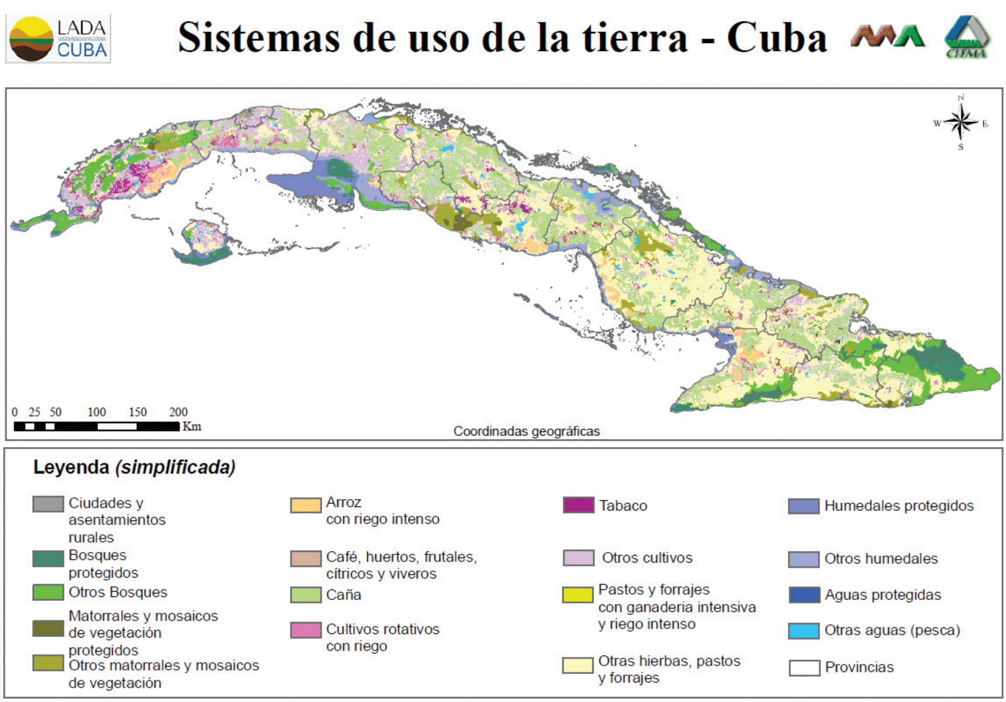


FIGURE 4.1 **National Land Use Systems in Cuba**

3) Agreement has been reached and the map has been endorsed by the national assessment team.

An example for Cuba is given in Figure 4.1.

Phase 2: Assessment of Land Degradation and Sustainable Land Management

During this phase, the team applies the LADA/WOCAT Questionnaire (ibid.) to assess each mapping unit. This exercise involves: (1) organization of the assessment; (2) training of the assessment team; (3) desk assessments using the national land use map and the questionnaire in each of the administrative units in the country. Importing the data and associating them with the map; (4) Quality control.

The land degradation and sustainable land management questionnaire and software

This LADA/WOCAT Questionnaire (QM) was produced based on an original WOCAT (2003) document that was significantly expanded to cover all issues of land degradation and ecosystem services in close collaboration with the six LADA country teams, who tested and amended the questionnaire in various regions of the world. The questionnaire is available as a LADA Technical Report and has been translated in 6 languages (available at LADA). Parallel with the development of the questionnaire, data-entry software has been developed that guides national teams in land degradation and SLM assessment and stores all the information gathered during the assessment. The database, supported by the consultation of the land use database (possibly projected to a screen with possibility to query attributes, or made available in printed form), can be queried on the spot and data exported to a GIS compatible format. The software is available at the LADA homepage.

Organization of the assessment

To assure an acceptable level of detail and accuracy, the assessment should take place in each administrative unit or groups of administrative units, not as a single national exercise and should be realized by sub-national teams (for further details go to LADA). These sub-national teams should be composed of people who live and work in the areas to be assess, thus having a direct knowledge of the on-going issues and easier access to existing data and information upon which the expert evaluation can be based. This includes land users, extension officers and district officers.

However, assessments within a country by numerous sub-national teams increase the risk that a certain variability of judgment slips in, with inconsistent non-harmonized results when viewed nationally. Three precautions should be taken to minimize these discrepancies:

- Firstly, after the decision is made as to how many and which parts of the country will share the assessment task, a selected group of people who will take part in the assessment has to be trained together by the national LADA team.
- Secondly, a core group from the national team should participate in all the assessment workshops.
- Thirdly, at the end of the exercise, the national team should revise and harmonize the various outputs from the districts.

Preparation of the assessment team

Before starting the actual assessment, it is recommended to share the questionnaire with a number of experts that can facilitate the process in the areas that will be investigated. Therefore a briefing workshop should be organized by the lead institution to introduce experts from the different areas in the use of the WOCAT/LADA questionnaire. At the same time, the administrative hurdles and the selection of local experts should be discussed. This process is usually very country-specific. Examples from the LADA pilot countries can however be found in the LADA website.

The participatory assessment

It is of utmost importance that the assessment makes use of the "hard" measurable data that are available in the administrative units. The lead institution should assure that all maps and background information collected while preparing the national land use map are available. The local team may complement that with more detailed material available for the administrative unit. Google Earth maps, images and larger scale local printed maps can often be of great assistance. The composition of the team doing the assessment should include one or more extension officers and one or two land users. Depending on the dominant land uses, adequate specialists on crops, livestock and forestry should be associated with the assessment. A natural resources specialist, sociologist and economist are valuable additions in a team. Lindeque (2010) describes the process in detail for South Africa. The lead trainer should assure that all questions are answered and entered in the database. The data can then be transformed with GIS or with a viewer system such as Dynamic Atlas to provide visual outputs of land degradation and land management characteristics typical for certain land use systems.

Quality control

Various checks are built into the questionnaire that allows users to verify if any gross errors were made. Additionally, once results of

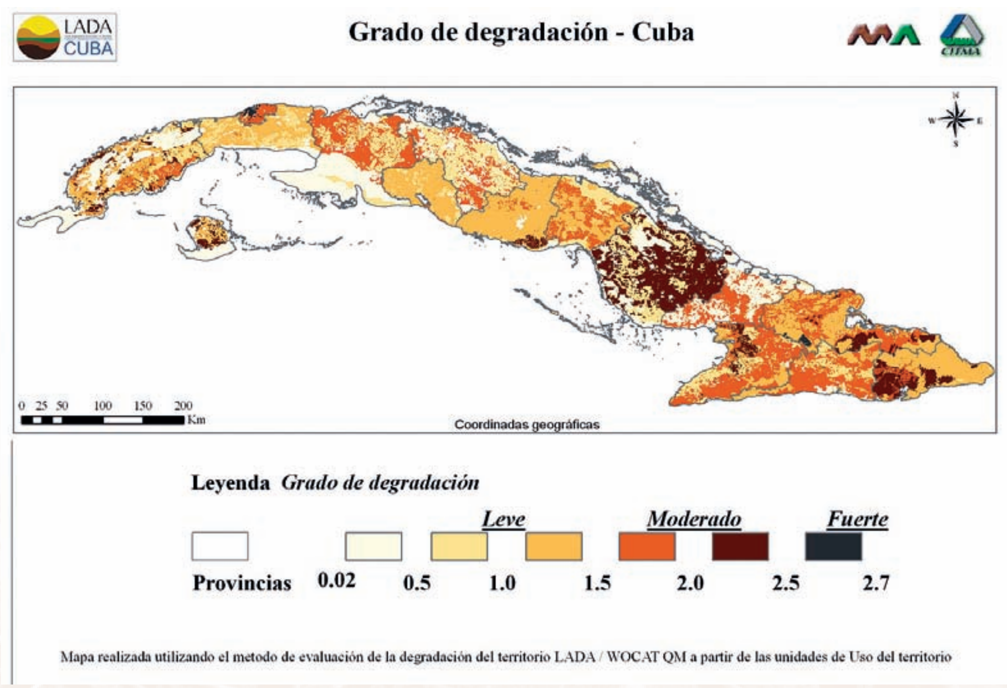


FIGURE 4.2 **Degree of land degradation in Cuba**

bordering administrative units are input, these can be checked across-boundaries. Finally, more sophisticated controls have been developed by the Free University of Amsterdam in collaboration with the LADA Senegal team available as a working paper from the LADA homepage.

The final responsibility of this quality control lies with the national team.

Phase 3: Consolidation in a single national product with related outputs, maps and analysis

Mapping of individual degradation or management characteristics

This is a straightforward GIS exercise, as it simply translates individual aspects contained in the national QM-database into a map. Examples are given for different parameters in Cuba, China and Argentina in Figures 4.2, 4.3 and 4.4 respectively. More detailed instructions are contained in Annex V.

Combined mapping of land degradation types

The extent of the dominant unit can be combined with the degree and could be used in 4 combinations of writing the legend : HA (very severe) ha (severe) (ha) (moderate) [ha] (light). Associated types could be indicated with specific number combinations [see Soil Map of the World Figure 1.9, in Annex 1 of Land Use Systems Guidelines (FAO, 2011a) as an example] in this way HA-34 could stand for a dominant Ha type at very severe degree with lesser extents of Pc and Bs (combination

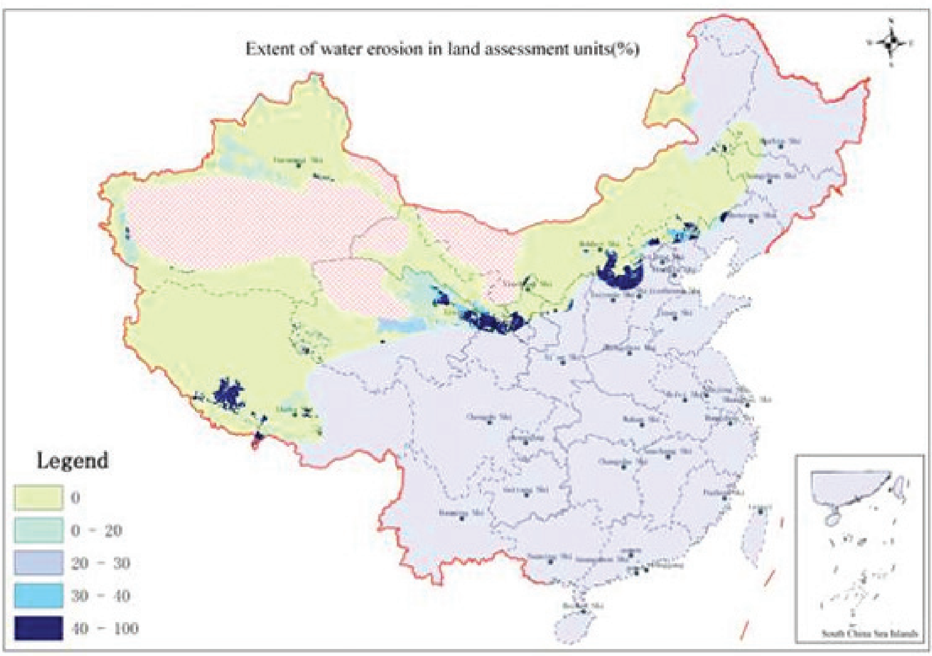


FIGURE 4.3 **Extent of Water erosion in China**

34). An alternative is the GLASOD legend, which combines degree and extent in classes from 1.1 to 4.4 and groups the classes in colour variants to indicate the range from low extent and low degree to high extent and high degree of the dominant degradation type. As there are considerably more types in QM than in GLASOD this may not result in very understandable maps, although at country levels the combinations would be limited in number.

Mapping the individual types and characteristics could also be improved by this approach, because each type is now associated with its degree cause and impact, individual maps can be produced without ambiguity (which was not the case when using overlapping types) (illustrated in Figures 4.2 and 4.3).

National mapping of sustainable land management

Thematic maps can be prepared in a similar way as for the degradation types provided each combination is considered a unique SLM type and inventoried as such. Although these types are more numerous than the degradation types, limiting them to 5 and focusing from high to low extent should capture most of them (see Figures 4.2 – 4.4 above).

QM analysis and interpretation

The amount of information collected through the National Land Use System and the QM inventory associated with it is extremely rich and can be used to construct maps that illustrate the various characteristics, pressures, causes and impacts of each degradation type or of each land use system within an administrative unit or, (after simplification), nationally. It also allows the construction of Driving Forces-Pressures-State-Impacts-Responses (DPSIR) indicators for each of the LUS / admin unit combinations and finally it allows statistical correlations to be determined between, for example, the extent of land degradation and the poverty level or land tenure security. The latter techniques can also be applied to verify the accuracy of the answers to the questionnaire. For instance, if poverty is mentioned as a driver in QM, this should correspond to a similar range in the poverty levels attached to the administrative unit.

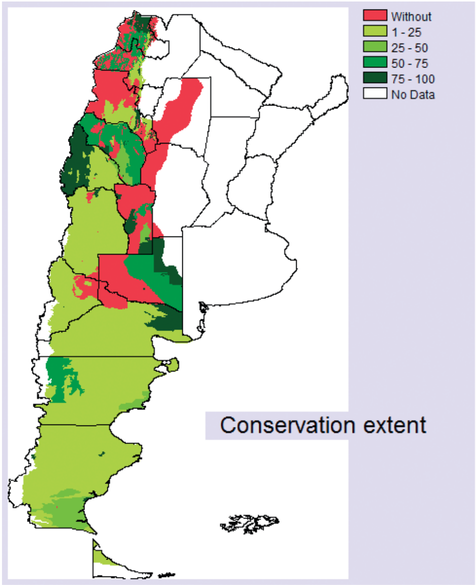


FIGURE 4.4 **Conservation extent by Land Use System in Argentina**

Phase 4: Feedback to users

A final workshop should be organized bringing together the original contributors involved in the first workshop, to discuss the results and evaluate the implications for land use and environmental planning. The authorities and contributors in the administrative units should also be involved in this final workshop. Agreement should be reached how to package the results for reporting.

Plans should be made to repeat the exercise within 5-10 years to monitor the results.

TABLE 4.3 **Information contained in the National Land Resources Information system**

Land Use System	LD & LM mapping questionnaire
S: Land cover type (national classes)	Extent of degradation (per unit)
S/P: Livestock density class (national classes)	Land degradation types & subtypes (per unit)
S: Land use practice (national classes)	Degree of degradation (per type and per unit)
P: Dominant slope (subnational)	Cause of degradation (per type and per unit)
D: Aridity index trend (subnational or per admin unit)	Impact of degradation (per type and per unit)
D: Population density (subnational or per admin unit)	Drivers of degradation
D: Poverty level (per admin unit)	Type and extent of SLM practices
S/P: Crop management index class (subnational)	Purpose of SLM practices
P: Dominant soil type (subnational)	Effectiveness of SLM practices
S: Dominant crop (subnational)	Effectiveness trend of SLM practices
S: Dominant livestock species (subnational)	Impact of SLM on ecosystem services
D: Land tenure/access information? subnational?	Cause of SLM adoption?

Provisional Budget (in US dollars)

The budget includes the extra expenditure required for national staff, workshops, reporting and international staff, but does not include costings for an equivalent input in kind from the Government concerned. (Ultimately the cost depends on the size of the country and the number of LUS / admin units; this example is for a medium-sized country.)

	Unit cost	pm	Total
National Experts			
Land Resources Specialist	2 000	12	24 000
Land Management Expert	2 000	12	24 000
GIS expert	2 000	12	24 000
Secretary/Accountant	1 000	12	12 000
Workshops			
National	20 000	2	40 000
Sub-national	5 000	15*	75 000
Reporting	**10 000**		**10 000**
International Consultants	15 000	1	15 000
International Travel	20 000	1	20 000
Total			**244 000**

* The costs of sub-national workshops depends on the unity of measurements (LUS x administrative units) used in a country, and influence strongly the total land degradation mapping cost.

5

ANNEX

Converting LADA / WOCAT QM software results to GIS format

The LADA / WOCAT QM Questionnaire for land degradation and sustainable land management mapping exports data in formats that are compatible with geographical information systems.

This Annex gives information about exporting and using QM data in a GIS. A complete explanation of those steps is available within the software manual from LADA.

The software allows the participatory panel to complete the entire set of QM questions. At any point during the assessment, data can be exported and converted to maps.

Export and conversion to GIS

After exporting data from the QM, the user has a set of Excel files including trends, degradation, conservation, also recommendations. These data need to be joined to GIS layers / coverages. To join data to a GIS, user needs to both prepare the GIS layers and the Excel files exported from the software. In Excel, creating a unique code that combines the LUS code and the administrative codes can be easily performed by "concatenating" the two codes (LUS and administrative code). Certain combination cannot be distinguished by simply concatenating (ex. LUS 1 / admin 11 and LUS 11 / admin 1 would both be 111). To differentiate those combinations is necessary to insert a 0 between the LUS and admin. The same procedure can be applied in the Access database which is linked to the software.

In GIS, a concatenation between the two codes is also necessary. In ESRI software, the user will probably start this exercise with two GRIDs (LUS and administrative units). An attribute table containing both codes can be implemented by a "combination" of the two coverages. Within the table, a "concatenation" can be performed similarly to that done in Excel.

In general terms, the datasets are now "joinable" in GIS software by using the concatenate code as univocal.

Map preparation

An extensive set of maps can be prepared by users, as the database allows different operation to be performed either in Excel or in Access. Even if the datasets are now joinable, there are several typologies of maps that can be prepared, including:

1. direct maps;
2. calculated maps;
3. indirect or query maps;
4. DPSIR maps.

Direct maps are prepared by a simple join between GIS and QM results. This is the case of data that have a "one to one" relation with the GIS layer "LUS per administrative units", i.e. area or intensity trend, % of area degraded or under conservation measures, complete list of degradation types or purpose of conservation measures, start or end year of conservation measures, recommendation. Those data can be

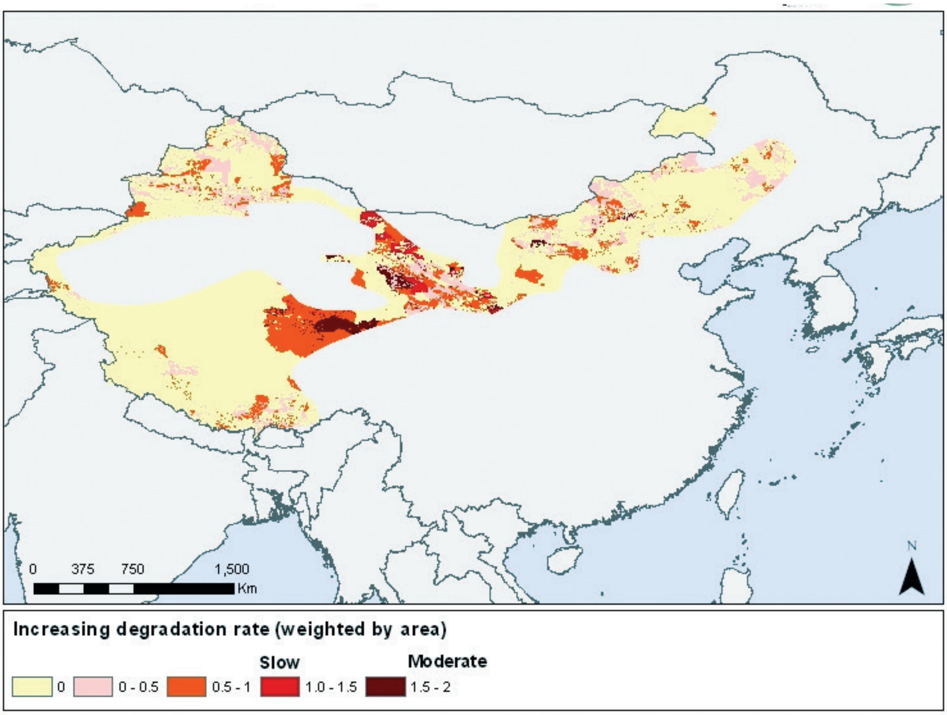


FIGURE 5.1 **Increasing degradation rate of China** (obtained by the summation of the extent (%) and degree of the three degradation levels)

used as simple indicators and after the join to the GIS layer, a map can be prepared without any additional input, except eventual reclassification for numerical data (see Figures 4.2 and 4.4 in Annex 4).

Calculated maps are those maps that use more than one input to produce an indicator, they are based on a mathematical operation. This type of map include important indicators such as the degree or rate of degradation, as those data are available in the questionnaire for each degradation level (3 levels for each unit of assessment) and need to be weighted before being presented as a single indicator. As an example of this sort of map, the variation of degradation, obtained by multiplying extent and degree of the three degradation levels, and later summing then together (usually presented as decreasing or increasing degradation rate, weighted by the area) can be considered as one of the valid syntheses of land degradation results. These maps can be calculated in Excel or directly within the GIS. An example map showing the increasing degradation rate for China is presented in Figure 5.1. Similar maps could be prepared by calculating the levels of impact of degradation or conservation measures in ecosystems services. Anyway users may find any complex calculation options in order to manage their data so to be able to better present typical land degradation and conservation issues.

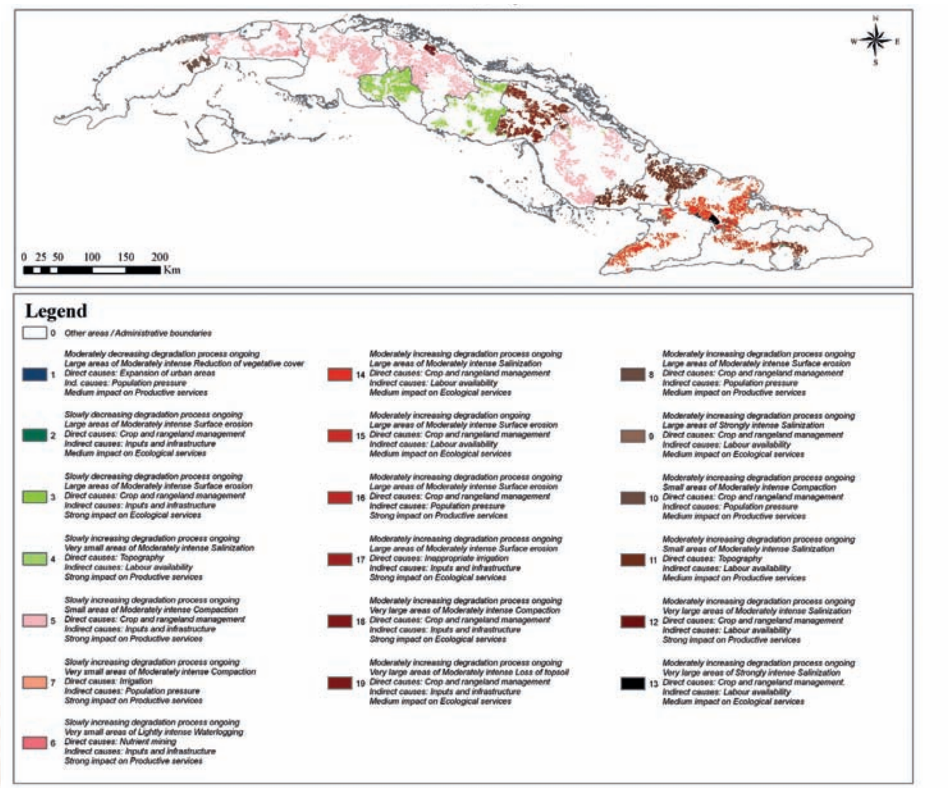


FIGURE 5.2 **DSPIR Framework – sugar cane in Cuba**

Indirect or query maps are the maps that present the result of either a query on a single indicator or a simplification of several indicators, or a query between indicators. As an example of a single indicator map users can present only one degradation type (i.e. water erosion) giving its extent per pixel. This simplified presentation can be an option to simplify visualization in many causes such as a single option for the following indicators: direct or indirect cause, impact of degradation or conservation on ecosystem services, degradation addressed by conservation measures. More complex queries in Excel, Access, or GIS may be useful in the definition of particular issues and can answer by more complex questions (e.g. are there rehabilitation measures using terraces in areas with water erosion effective? Is there a soil cover measure addressing biomass decline? etc.) An example is given in Figure 4.4 (in Annex4), mapping extent of water erosion in China.

The **DPSIR** map aims to entirely describe the land degradation and sustainable land management of a certain areas by listing Driving forces, Pressures, States, Impacts, and Responses. An example is presented in Figure 5.2, although without Responses (DPSI only).

References

CSIR & ARC. 2005. *National Land-Cover Database 2000*. Council for Scientific and Industrial Research and the Agricultural Research Council.

ESA *et al.* 2005. *Globcover*. Available from: http://www.esa.int/esaEO/SEMGSY2IU7E_index_0.html [Accessed 27/07/11]

FAO. 2006. *The rapid characterization and mapping of agricultural land-use: A methodological framework approach for the LADA project*. Eds: George and Petri. LADA internal document. Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO. 2007. *Mapping Land Degradation and Sustainable Land Management (QM)*. Eds: Liniger, H., van Lynden, G. and Nachtergaele, F. LADA Project Publication. Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO. 2008. *Mapping Land Use Systems at global and regional scales for Land Degradation Assessment Analysis Version 1.1*. LADA Technical Report 8. Food and Agriculture Organization of the United Nations, Rome, Italy. Available from http://www.fao.org/nr/lada/index.php?option=com_docman&task=cat_view&gid=18&Itemid=165&lang=en&limitstart=20

FAO. 2009. *Guidelines for the identification, selection and description of nationally based indicators of land degradation and Improvement*. LADA Report. Food and Agriculture Organization of the United Nations, Rome, Italy. Available from: http://www.fao.org/nr/lada/index.php?option=com_docman&task=cat_view&gid=26&Itemid=165&lang=en

FAO. 2010a. *Global Land Degradation Information System (GLADIS) Beta Version: An Information database for Land Degradation Assessment at Global Level*. Eds: Nachtergaele, Petri, Biancalani, van Lynden and van Velthuizen. LADA Technical Report 17. Food and Agriculture Organization of the United Nations, Rome, Italy. Available from: http://www.fao.org/nr/lada/index.php?option=com_docman&task=cat_view&gid=26&Itemid=165&lang=en

FAO. 2010b. *Training Manual for the Assessment of Land Degradation and Sustainable Land Management*, based on the LADA / WOCAT Mapping Methodology (QM). LADA Paper. Food and Agriculture Organization of the United Nations, Rome, Italy. Available from: http://www.fao.org/nr/lada/index.php?option=com_docman&task=cat_view&gid=54&Itemid=165&lang=en

FAO. 2011a. L*and Degradation Assessment in Drylands: Manual for Local Level Assessment of Land Degradation and Sustainable Land Management. Part 1: Planning and Methodological Approach, Analysis and Reporting*. Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO. 2011b. *Land Degradation Assessment in Drylands: Manual for Local Level Assessment of Land Degradation and Sustainable Land Management. Part 2: Field Methodology and Tools*. Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO. 2011c. *LADA Working paper: National Land Degradation Assessment Analysis for Senegal with SOW-VU*. Food and Agriculture Organization of the United Nations, Rome, Italy. Available from: http://www.fao.org/nr/lada/index.php?option=com_docman&task=search_result&Itemid=165&lang=en

FAO. 2011d. *Land Degradation Assessment in Drylands: Mapping Land Use Systems at Global and Regional Scales for Land Degradation Assessment Analysis v1.1*. Food and Agriculture Organization of the United Nations, Rome, Italy.

Lindeque, L. 2010. *Training manual for the assessment of land degradation and sustainable land management*, based on the LADA/WOCAT mapping methodology. LADA field paper. Available at: http://www.fao.org/nr/lada/index.php?option=com_docman&task=doc_download&gid=583&Itemid=165&lang=en

Mucina, L. & Rutherford, M.C. (eds.) 2006. *The vegetation of South Africa, Lesotho and Swaziland*. Strelitzia 19. South African National Biodiversity Institute, Pretoria.

Pretorius, D. 2007. *GLADA stratification: South Africa. Response. Part 1: evaluation of GLADA procedure and of the GLADA stratification – South Africa, version 1.0*, prepared by the LADA stratification task force of the FAO. Available from: http://www.fao.org/nr/lada

Oldeman, L.R. & van Lynden, G.W.J. 1997. *Revisiting the GLASOD methodology*. Methods for assessment of soil degradation. (Lal, R., Blum, W. H., Valentin, C. and Stewart, B. A. Eds). CRC Press. Publisher Place, Boca Raton, Fla. (USA).

WOCAT. 2003. *A Framework for Documentation and Evaluation of Soil and Water Conservation – Mapping*. WOCAT, Bern, Switzerland.

WOCAT. 2007. *Where the land is greener*. Case stdies and analysis of soil and water conservation initiatives worldwide. Liniger, H and Critchley, W. Eds.) CTA, FAO, UNEP and CDE, Bern, Switzerland.

World Resources Institute. 2005. *Millennium Ecosystem Assessment – Living Beyond Our Means: Natural Assets and Human Well-Being*. Available from: http://www.millenniumassessment.org/en/Index-2.html

LADA Secretariat
Food and Agriculture Organization
of the United Nations

Viale delle Terme di Caracalla
00153 Rome, Italy
Tel.: +39 06570 54888
Fax: +39 06570 56275
LADA-Secretariat@fao.org
http://www.fao.org/nr/lada

ISBN 978-92-5-107564-7

9 789251 075647
I3240E/1/03.13