A Standardised Method for Assessment of Soil Degradation and Soil Conservation: the WOCAT mapping methodology

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Summary

The World Overview of Conservation Approaches and Technologies (WOCAT) has developed a set of standardised tools to document, monitor and evaluate soil and water conservation (SWC) know-how world-wide, and to disseminate it around the globe in order to facilitate exchange of experience and better decision making and planning.

A set of three comprehensive questionnaires and corresponding databases has been developed to document all relevant aspects of SWC technologies and approaches, and the mapping of their area coverage. The collection of information on SWC technologies and approaches focuses on case studies that describe the technology and its human and natural environment, where it is used, and which approach was used for its implementation. The questionnaire and database on the SWC map aims at providing a spatial overview of soil degradation and conservation. It can be applied at different scales, from local to national and international level.

This paper will discuss the map methodology, which covers an assessment of land use, soil degradation, SWC technologies and soil productivity aspects. Data is collected through a "Participatory Expert Assessment". The map methodology comprises an interactive mapping tool for data entry and map viewing. The resulting maps help planners, coordinators and decision-makers to make appropriate plans and set priorities for future investments. They also help in identifying knowledge gaps and research priorities.

A. Introduction to WOCAT methodology

WOCAT (World Overview of Conservation Approaches and Technologies) has the mission of providing tools that allow SWC specialists to share their valuable knowledge in soil and water management, assist them in their search for appropriate SWC technologies and approaches, and support them in making decisions in the field and at the planning level. (For further information about WOCAT see Liniger et al. 2002a and Liniger at al. 2002b, papers provided in these proceedings)

Soil and Water Conservation (SWC) in the context of WOCAT is defined as activities at the local level which maintain or enhance the productive capacity of the soil in erosion-prone areas through: prevention or reduction of erosion, conservation of soil moisture, and maintenance or improvement of soil fertility.

WOCAT has developed three comprehensive questionnaires and a database system to document all relevant aspects of SWC technologies and approaches, including area coverage. The methodology for mapping soil degradation and conservation, and its use for better decision-making is presented in this paper.

B. The WOCAT Map Questionnaire

The WOCAT Map Questionnaire constitutes the geographical component of WOCAT. It evaluates what is happening where, by linking the information obtained through this questionnaire to a Geographical Information System (GIS), which permits the production of maps as well as area calculations on various aspects of SWC. The map Questionnaire (QM) should be considered complementary to the Questionnaires on Technologies (QT) and on Approaches (QA). It can be linked to the case studies on SWC describing SWC technologies and approaches (see separate paper). Linkage of these three questionnaires provides a powerful overview of SWC activities in a country, a region, or world-wide.

Base Map

For the WOCAT mapping exercise in principle any base map can be used, provided it consists of closed polygons, e.g. administrative or physiographic units. The criteria for the selection and definition of the

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units are: they should easily be identifiable in the field, information should be easily available and the size (i.e. number) should be defined according the scale of the map. Wherever possible it is recommended to use physiographic map units, delineated according to the SOTER[3] methodology (van Engelen and Wen, 1995), to provide the mapping basis for WOCAT. Linking WOCAT to SOTER produces a comprehensive database, that contains information on terrain and soils, but ideally also on soil degradation, land use and climate (optional) and SWC activities. SOTER already provides some of the information needed in the QT and QA.

Alternatively, other units (e.g administrative) can be selected. The experiences made so far indicated that several countries showed a preference for administrative units since data was more easily available and the boundaries were easier identifiable than for physiographic units. It was pointed out that the information collected for administrative units can later be overlaid with other spatial data such as SOTER, land cover, land use or satellite imagery to produce more accurate maps.

Data collection

Data are collected through a "Participatory Expert Assessment" method (PEA), which includes both expert knowledge and existing documents, and which reflects the current state of knowledge. It amalgamates dispersed knowledge and identifies data gaps. Ideally several experts knowing the status of the land sit together and fill in the data in a process of negotiation and consultation of existing documents. For each delineated unit (polygon) of the base map in a country or region, information on land use, soil degradation, soil and water conservation and productivity issues needs to be entered in a matrix table. For each mapped technology that has also been described in a separate Technology Questionnaire (QT), a link is provided to the Technology database, which contains much more detailed information.

1. Land use

Land use is defined (by UNEP/FAO, 1994 and ISRIC, 1995) as: "human activities which are directly related to land, making use of its resources or having an impact upon it". Land use is an important parameter related to soil degradation and SWC. Soil erosion on forest land, for instance, may require different SWC measures than degradation on cultivated land. The categories provided are far from comprehensive and just serve as major distinctions, since WOCAT does not intend to make a detailed land use type inventory.

a) Land use type (LUT)

The following major *Land use types* (with various subtypes) are recognized: cropland, grazing land, forest land, mixed land, other land.

b) Area percentage of the LUT

For each LUT defined under a), the relative area is assessed as a percentage of the entire polygon. The total area percentage of all LUTs within a polygon should be 100%

c) Area trend of the LUT

Changes in land use area may be an important factor in soil degradation assessment and evaluation of conservation activities. If the area for one or several LUTs is *increasing*, this will be at the expense of one or several other LUTs within the same polygon, which should show a *decreasing* trend. The increase or decrease in area is assessed over approximately the past 10 years.

d) Land use intensity trends

A change in the *intensity* of land use is another significant trend with respect to SWC. It is expressed through changes in inputs, management, or number of harvests, etc., over approximately the last 10 years. Only changes within the same LUT are considered here - not changes from one LUT to another!

[3] SOTER is an internationally endorsed and standardised methodology for storage and mapping of soil and terrain data.

2. Soil degradation by land use type

Prior to evaluating the distribution of SWC activities it is important to have an impression of the extent and degree of current degradation, which necessitates these measures. The methodology to be used for this purpose is derived from the "General Guidelines for the Assessment of Soil Degradation" (van Lynden, 1999). Although natural degradation is not excluded, emphasis is placed on degradation caused by human activities.

a) Types of soil degradation

Four main types of degradation are distinguished: water erosion, wind erosion, chemical deterioration and physical deterioration. The former two involve displacement of soil material through the action of water or wind (e.g. sheet erosion, gully formation, deflation), the two latter indicating various in-situ processes such as soil fertility decline, salinisation, pollution (chemical) or compaction, crusting, waterlogging or aridification (physical) (van Lynden, 1999).

b) Relative extent of the degradation type

For each identified degradation type, the extent should be given as percentage of the LUT affected by that degradation type. For example, if cropland occupies 20% of the polygon and 40% of the cropland is degraded, the extent indicated should be 40% - although this degraded area in fact constitutes only 8% (40% of 20%) of the entire polygon.

Different degradation types may overlap each other within a same piece of land. For instance water erosion (Wt) affects 40% of the cropland in a polygon, fertility decline (Cn) covers 35%, but another 10% is affected by a combination of both Wt and Cn. This is indicated as a separate type! The other degradation factors are then also given for this combination as a whole.

c) Degree of soil degradation

Degree is defined here as the intensity of the soil degradation process, e.g. in the case of erosion: the amount of soil washed or blown away. Indicators of soil degradation are: the percentage of the total topsoil lost, the percentage of total nutrients and organic matter lost, the relative decrease in soil moisture holding capacity, etc. For the assessment of the degree of degradation qualitative indicators are used.

d) Impact of soil degradation on productivity

The same *degree* of degradation can have different *impacts* in different places: e.g. removal of a 5 cm layer of soil may have a greater impact on a poor shallow soil than on a deep fertile soil. The main impact to be assessed here is the effect of soil degradation on soil productivity.

The effects of degradation can be partially hidden by various measures, such as use of fertilizers. Part of these inputs is in fact used to compensate for the productivity loss caused by soil erosion and nutrient loss. The impact of soil degradation needs to be assessed in consideration of these compensating measures. 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.

Degradation can also have a positive (off-site) impact. Degradation in one place can lead to higher soil productivity elsewhere, e.g. through the accumulation of sediments and water downslope. However, we consider the on-site impacts here which by definition cannot be positive.

e) Rate of degradation

Whereas the *degree* (and impact) of degradation indicates the current static situation, the *rate* indicates the trend of degradation over a certain 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 areas where the situation is improving (through soil conservation measures, for instance) can be revealed. The average development over approximately the last 10 years is assessed to level out irregular developments.

f) Causes of degradation

Various types of human activities and natural *causes* may lead to soil degradation, e.g. agricultural mismanagement, deforestation, overgrazing, industrial and mining activities, infrastructure development and urbanisation. The emphasis in the degradation inventory is on human-induced degradation, but sometimes natural degradation also necessitates measures to be taken. More than one cause at the time may be responsible for degradation.

3. Soil and Water Conservation

While the questionnaires on SWC technologies (QT) and on SWC approaches (QA) collect detailed information on SWC activities, the map questionnaire (QM) aims at obtaining a geographical display of some important SWC data.

a) Name of the Technology

A commonly used name (preferably not a local name) is given for the most widespread - not necessarily the most effective! - technologies within each LUT for the polygon being described.

b) SWC Categories

The technologies identified under a) are categorised according to a categoriation system presented in another paper at this conference (W341 - Liniger et al.). Where several measures are combined in one and the same technology for a certain LUT the categories for these measures are listed according to their importance up to a maximum of three categories.

If more than one SWC technology (consisting of one or more categories each) is indicated for the same LUT, they are considered to be covering different areas i.e. not to be mutually overlapping.

c) SWC: Percentage of LUT area

The area for each of the SWC technologies listed under a) is expressed as a percentage of the LUT area. As with degradation, overlapping combinations are considered separately.

d) Period of implementation

It may be important to know when the technology has been implemented, in combination with a trend in effectiveness. Some recently installed measures may not yet have reached their optimal effectiveness.

e) Effectiveness of implemented SWC measures

The "effectiveness" of SWC measures is defined here in terms of reducing (the degree of) degradation addressed by the technology. Four qualitative classes from very high to low are distinguished.

f) Effectiveness trend of SWC

SWC measures may become increasingly or decreasingly effective over time for various reasons: changes in land use or farming systems, changes in population density, ecological changes, etc. To assess whether a given SWC practice is (still) appropriate under certain conditions, the trend in SWC effectiveness over the last 5-10 years is one suitable indicator. Three classes are distinguished: increase, no change or decrease in effectiveness.

g) Reference to QT

The information provided here on SWC technologies is limited and mainly restricted to geographical information. Since much more background information may be given in the Technology Database, it is important to refer to the QT code describing the technology that is indicated under a) in this section.

4. Soil productivity

Often the main concern of the land user is not erosion control as such but the eventual decrease in productivity due to degradation, or increase in productivity as a result of SWC. Therefore some general data on production trends are collected for every SWC technology per LUT.

a) Productivity trend

Although changes in productivity (and certainly in production value!) can be attributed to a wide variety of causes, they may also be an indication of soil degradation or, if positive, of effective soil conservation and appropriate land management. Only a rough indication of trends in productivity over the last 10 year is required.

b) Impact of SWC on productivity trends

The role of soil and water conservation measures on productivity increase (or *decrease*, e.g. due to reduced cropping area!) is expressed according to four classes from great influence to none at all.

C. The WOCAT Map Database

The layout of the map database conforms as much as possible to the paper version of the map questionnaire (QM). Data can be entered on the hard copy matrix tables first or directly into the database. The database consists of two main parts: Data Management and Map Data.

The **Data Management** module enables users to enter or edit data. A Master Record containing information about the contributing specialist must be completed before any data can be entered in the Map Questionnaire (data) form. When the Browse or Edit option is selected, a digital form is opened that looks similar to the hard copy matrix table in the questionnaire (Figure 1). Data can thus be added, edited or browsed for individual polygons.

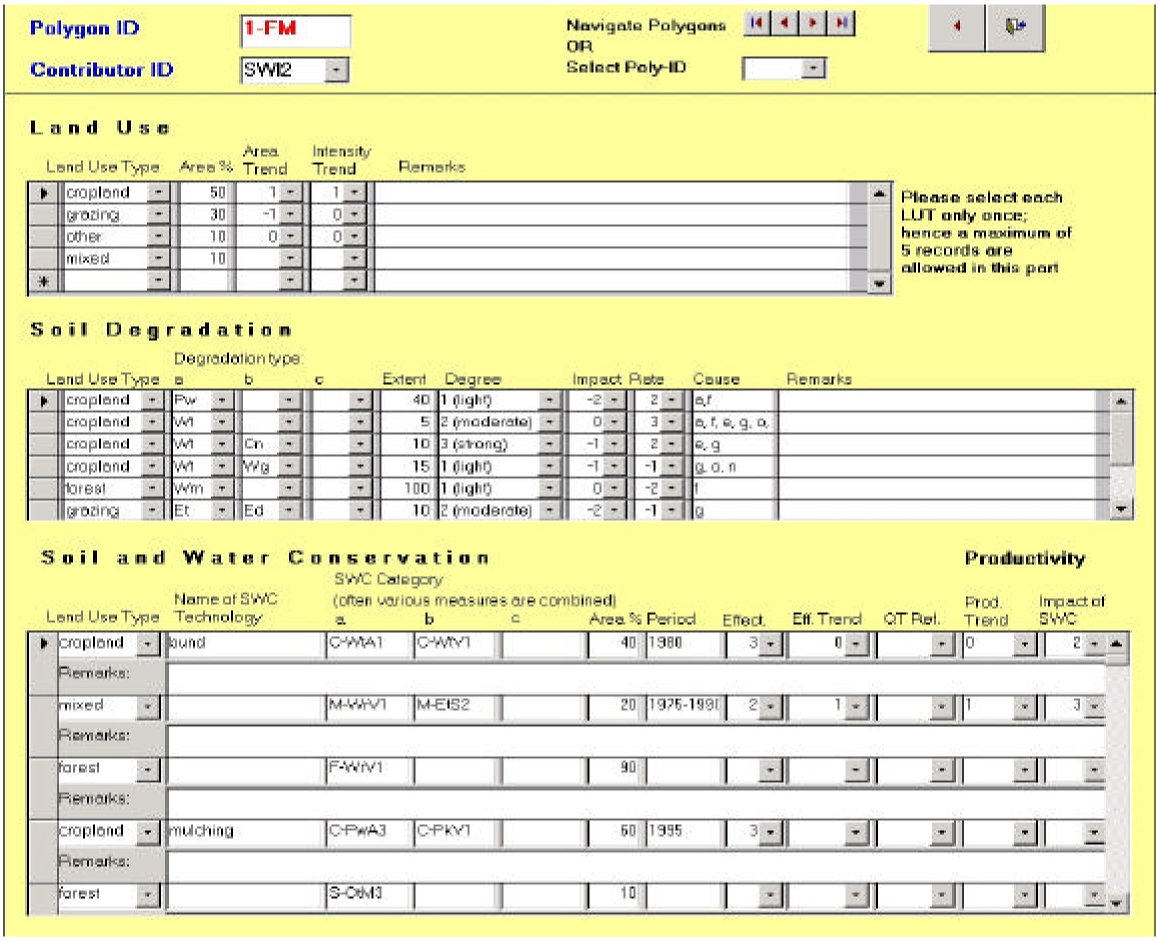

Figure 1: Map data entry form

In the Map Questionnaire Data Entry Form, a polygon has to be selected for which data are being entered. For many fields in the database list boxes are provided from which an item can be selected.
The **Map Data** option opens an interactive map viewer (see Figure 2). Pre-selected thematic maps can be displayed, but there is also a possibility to browse or edit polygon data by clicking on a specific polygon. This will again open the map questionnaire form (Figure 1), and enables the user to have a direct visual feedback of the data entered. Besides the predefined maps there is an option for a free search and displaying single value maps for the result. A search can be made for instance on all occurrences of grass strips on a slopes of >15% in sub-humid conditions. The result will then be displayed in a single colour.
This map viewer offers various features of a GIS without the user being required to have GIS software and knowledge. Only for more specific data calculations advanced database and GIS software and expertise is needed.

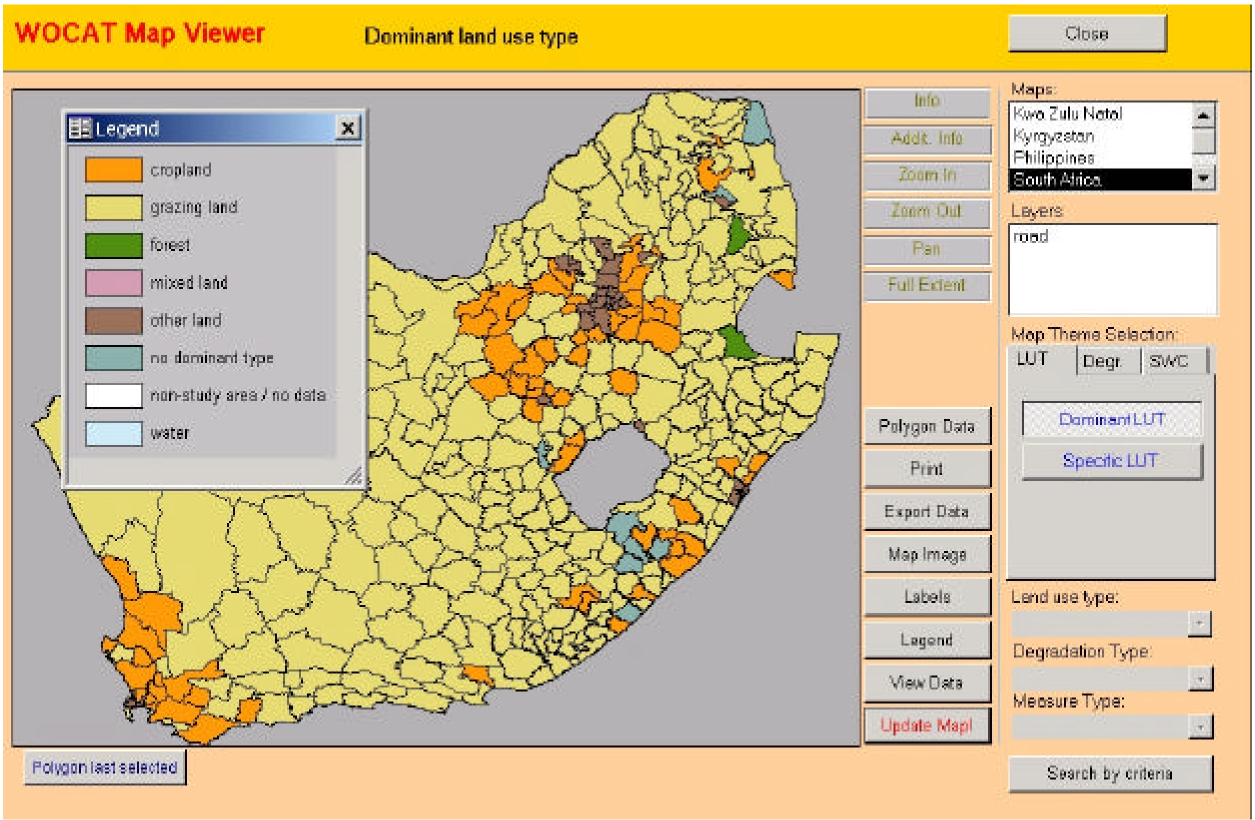

Figure 1 WOCAT Interactive Map viewer

The WOCAT map database is developed in MS Access97, with the Map Viewer in ESRI Map Objects Light. A run-time version is being developed for users who do not have Access or Map Objects.

D. The use(fullness) of the WOCAT mapping tool

A first global mapping of degradation was done in 1990 through the GLASOD (GLobal Assessment of SOil Degradation), followed by a few regional assessments of soil degradation. At the national level the documentation of degradation is scarce or needs updating. However, no global or national map of soil and water conservation exists showing the achievements made so far in terms of combating or preventing soil degradation. Thus there is no systematic documentation and monitoring of degradation problems and achievements towards sustainable land management. Therefore, decisions on additional investments cannot sufficiently take previous experiences and achievements into considerations nor can they be based on a proper assessment of the current problems and existing options for solutions.

WOCAT offers a method for both the mapping of degradation and improved sustainable land management technologies. This is most urgently needed at the national and regional level in order to (a) document the current state (of land degradation and SWC) and (b) monitor SWC activities and their impacts.

Both steps are needed in order to allow better planning and decision making for further SWC activities and for setting priorities for prevention or for combating degradation.

Through its "participatory expert assessment" the WOCAT mapping method capitalizes on the experiences of SWC specialists and on existing documents and data. It facilitates the compilation of scattered knowledge and helps to identify knowledge gaps to be addressed by surveys or applied research.

The mapping tool can best be used at national, sub-national or even village or local level, since it is scale independent. The use depends on the scale of operation of implementing agencies. The main users identified so far are the national, sub-national and local implementing programmes (either government, non-government or bilateral development projects).

The results of the mapping exercise are most useful to planners, decision makers and donors in order to support them in making the difficult decisions on where and how to invest limited available resources (funds, labour, etc.) in a most efficient way (i.e. showing a great positive impact). The ultimate target group and beneficiaries are the land users, who are expected to receive more focussed and better support.

So far the mapping tool has been presented, tested and further developed in several countries. However, due to the recent development of the tool, no national overview has been completed to date. In South Africa the mapping of the degradation has been accomplished but the conservation part is still missing, except for Gauteng Province and part of Kwazulu Natal. Several other countries are involved in mapping SWC (e.g. Philippines, Thailand) or have indicated interest to do so.

Next steps are planned to complete a few maps at different scales in order to further assess the usefulness and the feasibility of the mapping method, the inputs needed as well as the use for decision-making. Since the methodology and the product are targeted to suit the needs of the countries and implementing agencies, suggestions for improvement and better use of the method are welcome in order to assist WOCAT in developing the tool.

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Further reading & contact: www.wocat.net ; wocat@giub.unibe.ch