as accurate. One aspect central to the monitoring and assessment of sustainable land management is attention to land use systems at landscape scales and across borders, which captures some of these issues. Nevertheless, conscious attention to impacts from and to external ecosystems needs to be taken into account within the monitoring and assessment of sustainable land management.

7. Sustainable land management depends on interactions between many components (vegetation, soils, management etc) and therefore the monitoring and assessment of sustainable land management cannot rely on simple one-dimensional indicators. Working Group 2 feels there needs to be a balance between simple but incisive indicators and more complex but realistic indicators. The scientific literature does indicate the existence of repeating patterns of cause–effect in the realm of DLDD and sustainable land management. These patterns often reflect coupled human–environment interdependencies that could in principle be identified by indicators, adding important insights into system dynamics that have so far gone unrecognized.

8. The conservation of biodiversity *in situ* is difficult and is a battle that is being lost on many fronts. It needs to be backed up by gene banks to ensure that biodiversity is preserved. Working Group 2 agrees with this comment; *in situ* and *ex situ* genetic conservation are complementary, not alternative options.

Working Group 2 keynote presentations

Working Group 2, keynote presentation 1

Monitoring and assessment of sustainable land management: overview of issues

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Credit: IISD/Earth Negotiations Bulletin

Pedro Luiz Oliveira de Almeida Machado

Defining sustainable land management

The literature abounds with different definitions of sustainability, and there are many definitions of sustainable land management. Our Working Group 2 purpose is not to review that literature, but rather to devise a working definition that is suited to the purposes of monitoring and assessing sustainable land management in the context of the UNCCD.

Most definitions of sustainable land management emphasize the maintenance of ecosystem services for providing desired functions over a specified time horizon. But what are the 'desired functions' of the UNCCD?

The 10-Year Strategy of the UNCCD, which began in 2007, echoes the link between people's well-being and the environment. Its first two strategic objectives address these two dimensions, and the first expected impact that it lists places high hopes on sustainable land management as a way to combat DLDD. Each expected impact links environments to people:

- to improve the living conditions of affected populations
- to improve the condition of affected ecosystems and
- to generate global benefits through effective implementation of the UNCCD.

Clearly, the UNCCD wishes to emphasize combating the adverse impacts that desertification has on poor people, and a key way it envisions doing so is through sustainable land management.

The Millennium Ecosystem Assessment's desertification synthesis and dryland systems analysis (Millennium Ecosystem Assessment 2005a and 2005b) provide a relevant way to connect ecosystem services to the UNCCD's pro-poor orientation. The Millennium Ecosystem Assessment recommended monitoring and assessing "things that ecosystems provide that matter to people" which it proposed in four main categories of *ecosystem services*:

1. provisioning services – goods produced or provided by ecosystems such as food, fiber, forage, water etc
2. regulating services – benefits from regulation of ecosystem processes such as water purification, climate moderation etc
3. cultural services – cultural benefits from ecosystems such as tourism, recreation, aesthetic etc
4. supporting services – these underpin the services above such as soil, biomass production, carbon, nitrogen, nutrient cycling etc.

Despite these apparently straightforward definitions, it is apparent on subsequent reflection that different stakeholders will value such services differently. Environmental conservation groups especially value features of sustainable land management that preserve the natural heritage of landscapes and ecosystems. Farmers desire sustainable land management that ensures productive and profitable use of soil and water resources for growing crops and raising animals. Urban interests place high value on sustainable land management that protects them from floods, water shortages, landslides, reservoir siltation and dust storms. Businesses are concerned with maximizing the generation of revenues from land. Global planners desire simple macro-scale sustainable land management interventions that are amenable to international negotiation, tracking and accounting. And local interests prefer customized and contextualized sustainable land management that optimizes the benefits they receive.

In keeping with UNCCD's pro-poor focus, power relationships in such negotiations should not be allowed to disenfranchise the poor, whose very survival may depend on the land's ecosystem services. However, even that focusing instrument does not eliminate ambiguities. Do the poor all agree among themselves on what services they need? Who shall be the judge of which land uses ultimately benefit the poor most? In some cases, large-scale investments in land development could benefit the poor through higher-paying employment or more productive agriculture, for example. In other cases, the poor may be worse off.

Since a useful working definition must be simple, straightforward and practical, Working Group 2 decided that its definition needed to avoid such complexities. Working Group 2 therefore decided to parallel the World Commission on Environment and Development (1987)'s definition of sustainability, adopting a working definition of sustainable land management as "the management of land to meet present needs without compromising the ability of future generations to meet their own needs."

This definition focuses the monitoring and assessment of sustainable land management on a 'do no irreversible harm' basis, erring on the side of caution since the needs of future generations cannot be assumed in advance. Irreversible damage to major ecosystem components and services such as biodiversity, soil quality, water supplies and other 'slow' but difficult or impossible-to-reverse variables (see preceding paper by Reynolds) would violate this working definition. Therefore the monitoring and assessment of sustainable land management should be as effective as possible in identifying and measuring such trends and risks.

A reference frame for the monitoring and assessment of sustainable land management

Observations of changes in land use are consequently highly informative of sustainable land management trends that indicate shifts in ecosystem services, and often impact human well-being. Furthermore, land use change is relatively straightforward to measure in a monitoring and assessment regime. Therefore, measurements of the related parameters below are prime instruments in the toolkit for monitoring and assessment sustainable land management:

- Land *use* change: changes in major categories of human use of the land (eg conversion of pasture to cropland, forests etc)
- Land *cover* change: changes in the extent or type of vegetation covering the land surface
- Land *management* change: changes in how the land is managed within the broader land use categories (eg from ploughed to zero-till system).

Advanced scientific methods for the monitoring and assessment of sustainable land management

Ecosystem services, human well-being, and stakeholder negotiations are all complex and difficult parameters to measure, and can be expected to vary in complex ways over time and space – while interacting with and affecting the trajectories of each other. Natural resource assets that are 'invisible' to direct human observation, such as carbon and nitrogen pools and fluxes and hydrological cycles, can only be effectively assessed using advanced instrumentation, modeling and data analysis.

Remote sensing is a leading methodology with valuable applications for investigating land use and land cover change. Combined with GIS, remote sensing can aid the analysis of social and economic drivers of sustainable land management by linking spatial patterns to human processes on the ground ('socializing the pixel') and vice versa ('pixelizing the social').

Remote sensing entails the acquisition of information about the Earth's surface without actually being in physical or intimate contact with it. The science offers tremendous potential for monitoring and assessing the sustainability of land management, providing spatial, spectral and temporal perspectives that cannot be obtained from ground data. It can also provide information on the spatio-temporal dynamics of biological productivity indicators, including biomass, crop yields and net primary production. Global net primary production data have been operationally available as Moderate Resolution Imaging Spectroradiometer (MODIS) and Advanced Very High Resolution Radiometer (AVHRR) products, since 2000 and 1982 respectively.

However, ground-truthing and remote sensing must go hand in hand. Fieldwork is needed to calibrate algorithms for maps and for assessing map accuracy. Contextual knowledge acquired in the field can be used to orient the analysis, for example to determine whether a gain or loss of woody plants (eg bush encroachment, deforestation, afforestation) is viewed as an improvement or degradation in sustainable land management in the eyes of stakeholders.

Fieldwork also provides ancillary data on environmental and human conditions that cannot be derived through remote sensing. When linked with remote sensing data, such field data can be used to offer qualitative or quantitative explanations for observed land surface changes. Quantitative assessments via spatial models require field data that are associated with geographic coordinates and that were collected using a spatially meaningful sampling scheme.

Key natural resources underpinning sustainable land management

Certain natural resources, such as water, soil organic matter, structure, vegetative cover and nutrients are key assets for sustainable land management. Having insufficient quantities of these assets often constrains the functioning of ecosystem services and contributes to irreversible degradation. Thus they are strategic points for monitoring and assessing sustainable land management.

Water

Water is the defining natural resource constraint of drylands. It is a basic parameter driving ecosystem productivity and biodiversity. The effects of droughts can be effectively simulated, but the problem in using these for early warning is that it is usually not possible to predict when a drought will occur or how long it will last. Long-term rainfall records can inform decision makers about the degree of variability of rainfall over the long term in particular locations, and this can be combined with poverty and related data to produce drought vulnerability maps.

Phosphorus

Phosphorus is essential for plant growth and drought tolerance, but supplies are often inadequate in dryland soils. Applications of phosphorus fertilizer are essential for raising yields in many dryland regions, for example the West African Sahel. Global reserves of available phosphorus may be depleted in about 50–100 years, with a production peak expected around 2030. Phosphorus losses into watersheds, for example through erosion, constitute a pollution problem, causing eutrophication of water bodies. Sustainable land management practices are urgently needed that improve the uptake efficiency, recycling and availability of phosphorus. The use of cover crops (mixed or in rotation) is one of a number of strategies that can help.

Soil organic carbon

Soil organic carbon affects numerous soil functions, including nutrient release, nutrient retention, soil water holding capacity, plant available moisture, water infiltration, soil tilth, soil aggregate stability, and bulk density. Soil organic carbon is therefore one of the most important supporting services enabling soil quality and health over the longer term. The establishment of a network of benchmark sites, where management practices and changes in soil organic carbon are closely monitored, is recommended to supply the data required to enhance models that can predict carbon states and trends more widely.

Connections of monitoring and assessment of sustainable land management to climate change and biodiversity conventions

The environmental issues addressed by UNCCD and its sister conventions, the UNFCCC and the CBD, are closely intertwined, and sustainable land management is fundamental to achieving the goals of all three. While there are complementarities between the environmental goals of all three conventions, trade-offs often arise in their pursuit. Integrated action on all three objectives can optimize outcomes and could improve the efficiency of monitoring and reporting, thus reducing total costs of pursuing these goals. There is much to be gained from coordinated action on the three multilateral environmental agreements when developing policy measures to support sustainable land management, and there is a need for effective interfacing and coordination of approaches to monitor and assess each convention.

Working Group 2, keynote presentation 2

Experiences in the monitoring and assessment of sustainable land management

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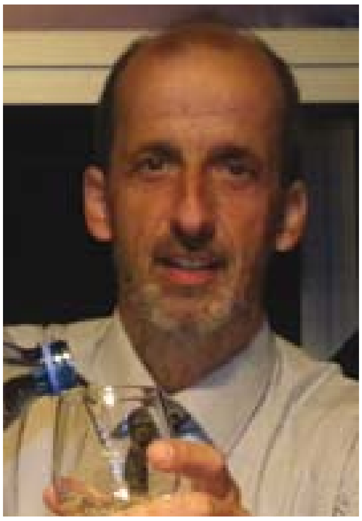
Why monitor and assess sustainable land management?

To date, most of the emphasis in monitoring and assessing desertification was placed on soil degradation and particularly on erosion. Monitoring and assessment should not only look at land degradation, but equally at the achievements made towards sustainable land management. We need to monitor and assess biological degradation such as reductions in vegetation cover and changes in the composition of plant species (eg a shift from high-value fodder to unpalatable species). We also have to include water degradation, for example reduced flows in rivers. To broaden the scope from soil to land means including soil, water, vegetation and animals – even humans. All these resources are linked.

Credit: C. Martius



Hanspeter Liniger

Monitoring and assessing sustainable land management can help us learn from experiences. There are many unrecognized sustainable land management practices that constitute a wealth of untapped knowledge that we are not using. A few examples, as documented by WOCAT[2] include:

[2] See www.wocat.net for more detailed examples