LADA

LAND DEGRADATION ASSESSMENT IN DRYLANDS

LADA
PROJECT

METHODOLOGY AND RESULTS

GLOBAL ENVIRONMENT FACILITY 20 YEARS INVESTING IN OUR PLANET

UNEP

FAO FIAT PANIS

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METHODOLOGY AND RESULTS

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Acronyms and abbreviations

COP	Conference of Parties (of UNCCD)
CST	Committee on Science and Technology (of UNCCD)
DDLD	desertification, land degradation and drought
DPSIR	Drivers, Pressures, State, Impact, Response analysis
FAO	Food and Agriculture Organisation of the United Nations
GEF	Global Environment Facility
GIS	geographical information system
GLADA	Global Land Degradation Assessment
GLADIS	Global Land Degradation Information System
GLASOD	Global Assessment of Human Induced Soil Degradation
ISRIC	World Soil Information
LADA	Land Degradation Assessment in Drylands project
NAMA	Nationally Appropriate Mitigation Actions (of UNFCCC)
NAP	National Action Plan (of UNCCD)
NAPA	National Adaptation Plan of Action (of UNFCCC)
NBSAP	National Biodiversity Strategies and Action Plan (of UNCBD)
NDVI	Normalized Difference Vegetation Index
NGO	Non-Governmental Organisation
NPP	net primary productivity
QA	SLM Approaches
QM	Mapping Questionnaire
QT	SLM Technologies
RUE	rainwater use efficiency
SLM	sustainable land management
SOLAW	State of Land and Water (FAO flagship report, 2011)
SWOT	Strengths, Weaknesses, Opportunities, Threats analysis
UNCCD	United Nations Convention to Combat Desertification
UNEP	United Nations Environment Programme
UNU	United Nations University
WOCAT	World Overview of Conservation Approaches and Technologies

LADA in a nutshell

LADA (Land Degradation Assessment in Drylands project) is a scientifically-based approach to assessing and mapping land degradation at different spatial scales – small to large – and at various levels – local to global. It was initiated in drylands, but the methods and tools have been developed so as to be widely applicable in other ecosystems and diverse contexts with minimal required adaptation.

To avoid a negative bias due to a focus only on land degradation, LADA also assesses and maps land improvement or sustainable land management (SLM) using World Overview of Conservation Approaches and Technologies (WOCAT) tools. The LADA-WOCAT set of tools and approaches provides balanced information and mapping capabilities on land resources status and trends in any given area, as well as on their causes, impacts and the actual and potential future responses.

LADA's main objective, using its mapping and assessment tools, is to identify and understand the causes of land degradation and the impacts of land use, including the effectiveness of current/recent responses, thereby enabling adequate and sustainable land management solutions to be devised. LADA provides a global monitoring and assessment system and an interlinked national and local level assessment and decision-support system on land degradation and improvement that enables stakeholders (national multisectoral teams) and agencies with land users at local level to identify and prioritize required national planning and policy interventions and actions on the ground for promoting the wide adoption of sustainable land management (SLM).

LADA's products have been tested, adapted and validated by the six participating countries for the cost effective and scientifically robust assessment and monitoring of the status and trends of their land resources and ecosystems. It provides a sound basis for the preparation of future planning and investment frameworks for land resources (soil, water, vegetation/ biodiversity, ecosystems) management and planning. Adopting the LADA approach can assist the development of national action plans, strategies and policies for combating desertification, improving food security and alleviating rural poverty, especially in response to climate change. LADA surveys forms reliable base-lines for monitoring and evaluation of SLM programmes.

The LADA programme has been financed by the Global Environment Facility (GEF), implemented by the United Nations Environment Programme (UNEP) and executed by the Food and Agriculture Organisation (FAO) in close cooperation with national institutions in Argentina, China, Cuba, Senegal, South Africa and Tunisia. It has been

FIGURE 1
LADA steps and corresponding outputs

supported by the UNCCD, the United Nations University and a number of international partners including the World Overview of Conservation Approaches and Technologies (WOCAT), hosted by the Centre for Development at the University of Berne, (Switzerland); ISRIC – the World Soil Information (The Netherlands); the Universities of East Anglia (Norwich, UK), Amsterdam (The Netherlands) and Sassari (Italy); the Global Land Cover Network (GLCN) and the International Institute for Applied Systems Analysis (IIASA), Laxenburg (Austria).

The main steps and outputs in the LADA process, at the various scales and levels (local to global) are shown in Figure 1.

Why LADA?

The LADA project was a response to a worldwide shortage of information about global land degradation – what it is, where it occurs, and on what scale. The resulting LADA approach, tools and methods enable the classification and provision of data on the locations of different types of land degradation, their extent and severity, their causes and their impacts on ecosystems and livelihoods. LADA also assesses the types and extent of the various SLM measures that have been implemented (on the ground responses), also their effectiveness and trends in addressing land degradation. The local level assessment, through its land user-livelihood and key informant questionnaires, also captures the effects of land user, institutional and policy responses, such as management practices and investment plans for sustainable, productive land and water resources and ecosystems, also interventions to secure land tenure and access rights. The results can thereby be used also to empower land users.

The annual global cost of land degradation is estimated to be at least US$40 billion, not including certain hidden costs such as the loss of ecosystem services essential for food production, water provision and for regulating the global carbon cycle.

Prior to LADA, the only comprehensive source of information on land degradation was the Global Assessment of Human Induced Soil Degradation (GLASOD – carried out during the 1980's by UNEP and ISRIC). The GLASOD inventory remains a unique first global assessment of the widespread extent and impact of the problem of land degradation. However, as the title implies, GLASOD was limited to an evaluation of soil quality, and being based on expert judgment by single experts in a country or a region, it generated (soil) evaluation results for different regions which were inconsistent, difficult to compare and difficult to harmonise. The GLASOD exercise pointed to the need for a more rigorous and comprehensive study, based on consistent and comparable data definitions and measures.

Likewise no global assessment of conservation or sustainable land management exists and it is very hard to find data on the national or global extent of various improved practices.

At the national level, most countries possess GIS with layers of basic natural resources and socioeconomic information, but these may be a combination of raster and vector files at different scales, about which there is varied confidence in the quality of each piece of information. Moreover, often this data is hosted in a range of institutions and lack a comprehensive information system.

The World Overview of Conservation Approaches and Technologies (WOCAT) programme has over the past 20 years developed a standardized and harmonized methodology for (sub) national and local-level assessment of soil and water conservation. It has built up a global database of over 200 SLM technologies and over 100 so-called "approaches" (the ways and means to successfully implement a technology on the ground). It is the only data base which provides substantive, harmonised technical assessment of conservation / management technologies and approaches. However, the coverage to-date is far from global.

In view of their common goals and mutual interests, in 2007 LADA and WOCAT entered a partnership to implement a joint methodology in 6 countries – Argentina, China, Cuba, Senegal, South Africa and Tunisia. Several of these pilot countries have expressed strong interest in following–up the pilot and around 15 more countries have expressed interest in applying LADA/WOCAT tools for land degradation assessment, SLM decision-making and land management planning. Overall, LADA/WOCAT tools have been applied in at least 20 countries, as per September 2011.

LADA, in partnership with WOCAT, has provided robust data, a harmonized methodology, practical guidelines, capacity building and cost-effective catalytic support to national and international processes, notably:

1 Provision of robust data

A key principle applied throughout LADA is that land use is the main driver of land degradation, rather than soil, terrain or climate. Physical limitations determine different types of land use, but within these, human use of the land critically influences the status and trends of land qualities over time. Therefore, a central activity of the project has been to prepare guidelines for compiling maps of national land use systems, which then serves as the basis for the national assessment.

Moreover, at global level LADA has developed a Global Land Degradation Information System (GLADIS), which facilitates analysis of the change in the provision of ecosystem goods and services resulting from land management practices. The main components analysed are: biomass, soil health, water quantity, biodiversity, economic benefit and social benefit.

2 Harmonized methods and practical guidelines

One of the priority tasks of LADA was to provide tighter definitions of key basic concepts, in order to ensure comparability of datasets within and across different geographical areas. This applies to the definitions of land, land degradation, the baseline time period, the extent of degradation and the relationships between land use management practices, degradation and their impacts on ecosystem services. In order to achieve this, the programme has had to resolve a number of methodological issues, including of aggregation, causality, impact and outcomes (Box 1).

LADA –WOCAT provides:

- a multidisciplinary approach involving the range of concerned institutions and other stakeholders at national level and also in a few pilot areas at local level;
- a specific methodology for each scale / level for making an inventory, an assessment and a mapping of land degradation, conservation and improvement;
- a framework for linking the various scales and levels;
- guidelines for the use of indicators;
- capacity building nodes in most regions (except Central Asia and Pacific);
- a functional and well-maintained LADA knowledge base and website.

BOX 1 **Clarifying key concepts in land degradation**

LAND
After GLASOD, the concept of "land" has been extended to include soil, biological and water resources. LADA has pushed the boundary further, to include the degradation of the entire human-environment ecosystem, including social benefits and losses.

LAND DEGRADATION
This is defined by by the UNCCD (1994) in terms of reduction or loss of the biological or economic productivity. LADA has further developed this definition as "the reduction in the capacity of the land to provide ecosystem goods and services, over a period of time, for its beneficiaries". "Ecosystem *goods*" are products of land which have an economic and/or social value: they include land availability, animal and plant production, soil health and water quantity and quality. "Ecosystem *services*" include biodiversity and the maintenance of hydrological, nutrient and carbon cycles. Land degradation is not necessarily confined to biophysical effects, nor is it limited to human-induced phenomena, but also includes natural impacts and effects.

PROBLEMS OF MEASUREMENT AND AGGREGATION
None of these concepts can be measured easily. Producing an overall assessment of degradation is difficult where ecosystem goods and services are not all affected in the same direction, giving rise to trade-offs between "winners" and "losers". Nor do the impacted land users or populations necessarily agree on what constitutes a benefit or a loss, or their relative importance. Furthermore, their views and preferences may also change over time.

CAUSALITY, IMPACT AND OUTCOMES
GLASOD did not contain a conceptual model of the causes and drivers of land degradation, such as slope (a direct cause) or access to inputs (an indirect pressure). Nor did GLASOD catalogue the impact of land degradation on the population concerned. Thus it had no means of evaluating possible policy interventions, such as land management practices or institutional measures to combat degradation. However, in 1995, the publication of the Drivers, Pressures, Status, Impact and Responses (DPSIR) framework, offered a solution: the national DPSIR framework adopted by LADA is set out in Annex II and the global DPSIR in Annex III of this paper.

LAND DEGRADATION AS A PROCESS
The introduction of the time component and of the causal relationships allows LADA to consider land degradation as a process, providing a better insight into the phenomenon and its relations with human livelihood, while also allowing for a better support to decision making.

BASELINE TIME PERIOD
In order to make comparable assessments, a baseline time period has to be established. The length of this period depends on available data series, but geo-referenced data on economic goods rarely go back further than fifty years, while land cover and vegetation data have similar time limitations. Moreover, human memory of change in land use and quality is reasonably reliable for maybe 10 years if triangulated with other information, but not much beyond. It is proposed that LADA assesses trends over the last 5 to 10 years, while taking a wider timeline of up to 50 years to understand the broader historical context of changes (settlement and migration patterns, conflicts, extreme climatic events etc.).

MAPPING CONSERVATION AND IMPROVEMENT EFFORTS
Land degradation is the negative trend in terms of land resources condition and health. LADA would provide an incomplete assessment unless it is complemented by the assessment of where land conditions are stable (being conserved) and where they are being improved (restored or rehabilitated). LADA has partnered with WOCAT to integrate these dimensions.

National LADA assessments have been conducted at the level of districts and provinces (or groups of these), for example in South Africa, Tunisia and Senegal. As part of the LADA-WOCAT cooperation, a common approach was devised towards drawing up inventories of land degradation and land improvement characteristics in these sub-national units. A questionnaire for mapping (QM) was developed in consultation with each of the LADA countries (CDE / WOCAT *et al.*, 2011). In each country, the completed questionnaires were processed and fed into a completed QM database that could be transformed into a standard Excel spreadsheet with results for each unit in the country. An off-line software for filling the questionnaire and preparing the Excel sheets is available from the LADA website (www.fao.org/nr/lada). An on-line facility for input and storage of data is also available (http://cdewocat.unibe.ch/wocatQM/) The questionnaire is available from the LADA website and the WOCAT home page in six languages – Chinese, French, English, Russian, Spanish and Vietnamese. The software is available in English, French and Spanish.

The National LADA-WOCAT Manuals are intended for use by task forces to be established in each sub-national unit, comprising technical and extension officers and representatives of local government from agriculture and environment, as well as land users and NGOs or CSOs. Following the development of land use systems maps by GIS experts with FAO support; these task forces evaluate land use systems in each administrative unit. Finding the right balance of detail is important; because every additional unit multiplies the number of times the Questionnaire needs to be completed. In large countries such as China and South Africa, hundreds of administrative units have to be evaluated, while in smaller countries such as Cuba, Senegal and Tunisia, many fewer units were considered. Tunisia has used the provincial (*Gouvernorat*) level, though reflecting on the national results it proposes that a finer assessment using a smaller administrative unit with less variation would be very useful.

There are many ways of mapping and interrogating the results, ranging from straightforward mapping of basic information in the database (e.g. by degradation or SLM type) to more complicated combinations or interpretations requiring spatial analysis within the GIS, such as a land degradation index or comparing land degradation severity with SLM effectiveness.

3 Capacity building

One of the major barriers to reversing land degradation and implementing SLM responses is the lack of institutional and human capacity at national and regional levels for monitoring and assessing land degradation and improvement / SLM, also for using

FIGURE 2
LADA Manuals

results for learning, knowledge sharing and planning effective interventions. Many field practitioners have limited information about the range of either traditional or innovative SLM approaches and technologies that could be promoted and up-scaled in a given context. There is also poor information about the costs and benefits of SLM practices and likewise of the value of SLM in terms of sustaining ecosystem services.

These capacity constraints are often coupled with weak harmonization and coordination of policy, legal and regulatory frameworks between sectors competing for land and natural resources. Also there are often weak institutions in charge of coordinating land issues, including those tasked with implementing National Action Plans of the desertification convention (NAPs) and related climate change (NAMA, NAPA) and biodiversity (NBSAP) conventions. There is a need for synergies among these strategies, including agriculture strategies and action plans.

National and sub-national LADA approaches were designed to strengthen national and local capacity by encouraging national and decentralized assessment and decision-making.

National LADA programmes have followed the following sequence of activities:

Identify "champion" institutes

One or more national LADA "champion" institutes were identified to organize stakeholder consultations and user surveys, in order to inform and mobilize the other relevant ministries (environment, land and agriculture, water, statistics), regional institutes and universities, NGOs etc. National workshops were then hold, in which a number of key stakeholders were identified, including relevant on-going projects within the country concerned. The process involved obtaining an overview of relevant data and information, including on past and current policies, programmes and activities related to land degradation and improvement.

Establish a national LADA taskforce

A national LADA task force was created with delegates from the institutes involved and representing all relevant expertise. This task force monitored progress on each activity and was kept abreast of developments.

Stocktaking and preliminary data analysis

The lead institute(s) proceeded with a more detailed analysis of the information and expertise available in the country. The standard LADA work plan was adapted to the needs of each country. A further national workshop was organised in each country, in which these findings were discussed and adopted, then an overall workplan prepared and made available to the participants.

Use of participatory assessments

The inclusion of stakeholders in "participatory assessments" in each administrative region being assessed (district, province etc.) was an important innovation for national and for local land resources assessments. It required a range of experts and land users to arrive at a consensus assessment of the situation for a given area at a specific point in time through the use of standardized tools. In order to achieve this, LADA conducted substantial on-the-job training with participating countries and regions at the selected level of assessment.

LADA local assessment

Ideally the local assessment should take place after, and be informed by, the (sub) national assessment – though in practice for the process of methods testing and development many local and national steps were conducted in parallel. At least three local assessment were conducted in priority areas in each countries, to assess and to understand causes and impacts of land degradation and SLM interventions.

Argentina – Soil assessment
Photo: LADA Argentina 2009

Local assessments have a triple purpose:

- to validate the sub-national assessment exercise;
- to collect additional data, in particular of a socio-economic nature, that help to clarify the causes and impacts of land degradation and sustainable land management, to assess responses and propose options to reduce degradation and promote appropriate land use and management practices;
- to provide a baseline for future monitoring.

Local assessments are more expensive than those at smaller (less detailed) scales, as they require interdisciplinary teams operating for several weeks in field work, analysis and reporting. A key task is therefore to choose carefully the areas where they will take place. LADA recommends that these areas should be representative of the major land use systems in the country and include both degraded land resources and improvements resulting from recent interventions.

The local assessments addressed a number of different elements, namely status and trends concerning:

- vegetation and biological diversity;
- soil health and specific properties;
- water resources – quantity and quality;
- impacts of land use and management on the range of ecosystem services comprising provisioning, regulating and supporting, and including also socio-cultural services;
- impacts of land use and management practices on livelihoods (assets, vulnerability).

These individual assessments require data collection, analysis and synthesis. Comparative observations of land resources status and trends between well and poorly managed areas are a key to the assessment process, in order to provide a more rigorous and reliable baseline for subsequent monitoring. The effectiveness and trends of actions and investments in arresting degradation and improved land management measures (SLM best practices for conservation; sustained productivity and restoration) is also critical information for decision makers. This information is backed-up by in-country assessments of identified SLM best practices, using WOCAT questionnaires for assessing and documenting Technologies (QT) and Approaches (QA). The resulting SLM in practice publications are valuable for subsequent mainstreaming or scaling-up.

Teams should include members skilled in the main natural science disciplines – land and water resources management, soil science, environmental monitoring, ecology, rangeland management, agricultural and animal production – as well as socio-economic, cultural and institutional specialists with experience in participatory livelihood assessments. Broader factors such as access to resources and markets, institutions and the national policies which influence land use (e.g. rights and tenure) are also addressed – encompassing both the land management practices by the poor in marginal areas and those by commercial farmers, foresters and livestock keepers.

Local assessment teams have been guided and supported by technical staff from district and provincial offices, also other projects in the study areas, in order to lend the assessment scientific rigor and produce results that are relevant and accessible to all interested parties. The findings are analysed and potential responses / options (technical, policy, organizational) are proposed for addressing degradation and promoting appropriate land use and management practices.

Responsibility for the final analysis of the results and production of the assessment falls to the LADA team leaders, who should ideally have experience of field work, team management, natural resources assessment, data collection and participatory / inter-sectoral approaches.

The local and national assessment findings and recommendations need thorough validation and endorsement by local land users and other technical specialists before being implemented. Besides the work on decision support at district level by LADA-South Africa, the complementary DESIRE project is developing relevant decision support tools.

4 Cost-effective catalytic support to international initiatives

LADA's key attribute is the production of knowledge to support better-informed decision making for dryland natural resources and ecosystems management. Its databases have received appreciation and support both from participating countries, FAO regional offices and international bodies, notably the UN Convention to Combat Desertification (UNCCD). The UN Food and Agriculture Organisation (FAO) has received requests from countries to support the expansion of LADA to countries in both humid and dryland systems. Countries that piloted the development of LADA methodologies (Argentina, China, Cuba, Senegal, South Africa and Tunisia) are now requesting support for mainstreaming and scaling-up of LADA activities. LADA is thus expected to continue contributing to international efforts in combating land degradation (in particular UNCCD), and promoting SLM for improved land productivity and food security while contributing to poverty alleviation and biodiversity conservation in interested countries worldwide. LADA will make a significant contribution to climate change adaptation, which is becoming ever more important in drylands as the impacts of increasing weather variability, frequency of extreme events and climate change are being felt more in these lands than most other ecosystems.

UNCCD has a key role in supporting global efforts to compile, manage and disseminate information from land degradation and SLM Monitoring and Assessment. The First Scientific Conference of the UNCCD (in September 2009) identified ten priorities for improving the monitoring and assessment of land degradation and SLM, including the development of:

- rigorous science-based frameworks to monitor and assess desertification, land degradation and drought (DDLD);
- integrated assessment tools that integrate biophysical knowledge with social, policy, economic and institutional knowledge;
- tools relevant to different decision-making levels;
- monitoring and assessment systems that also pay attention to SLM and the recovery of land;
- a knowledge management platform to integrate global knowledge of DDLD;
- cross-sectoral capacity building and strengthened scientific capacities;
- a DDLD/SLM monitoring system.

A further scaling-up of LADA/WOCAT at both national and also global levels would address many, if not most, of these objectives. On the basis of the outcome of this First Scientific Conference, the Conference of Partners (COP9) invited the Committee on Science and Technology (CST) to consult with LADA on the development of land degradation / impact indicators and related methodologies to support the implementation of its 10 year Strategy (Decision 19; COP9).

Other support will include:

- state-of-the-art reports on land degradation and SLM of interest to UNCCD;
- global assessment of land degradation designed for use by UNCCD and its partners;
- creating synergies between the UNCCD and other UN environment conventions through the harmonization of information on land degradation and management, biodiversity and carbon balance;
- capacity building in knowledge of interest to UNCCD Parties at global level through a networking and nodal approach using regional champions.

LADA's added value for development and decision making

The LADA project has greatly improved the state of knowledge about the incidence, severity and extent of land degradation. It provides many lessons for defining, collecting, collating and reporting on land degradation and improvement. LADA's value-added derives from its programmatic approach, moving from land resources assessment to decision support for national and global up-scaling. Countries with prior experience with LADA and WOCAT are potential regional nodes for knowledge management, information exchange and dissemination of good SLM practices. FAO will continue to coordinate the LADA programme through its Department of Natural Resources and Environment, exploiting synergies with its flagship State of Land and Water (SOLAW) Report (2011).

LADA has made enormous progress towards achieving a common and practical methodology for data collection and assessment, based on common and standardized tools and methods, which can be used flexibly and adapted to specific contexts. Specifically, LADA's scientifically-based approach:

- enables comparisons to be made of land degradation, conservation / SLM and improvement between land use systems, land use types and administrative units;
- provides a framework for assessing remedial actions to reduce / restore land degradation through implementation of sustainable land management interventions at local and sub-national levels;
- permits national and global aggregation;
- is sufficiently flexible to serve the needs of specific countries, ranging from those as large as China to those as small as Cuba, addressing the varied needs of specific stakeholders.

LADA has also demonstrated that land degradation should be considered in a holistic way, including socio-economic as well as biophysical processes.

Cuba – Gorup work on national assessment
Photo: R. Biancalani 2009

LADA's technical and scientific approach

LADA uses a basic input-output framework which identifies driving forces, proceeds through assessing current / recent responses and thereafter evaluates their impacts on ecosystems and human well-being. The choice of a specific and appropriate time- period is important, and the process of full consultation with all stakeholders is also essential, especially when assessing the trade-offs between the environmental and socio-economic services of ecosystems.

Use of scales and indicators

Indicators are essential tools for evaluating sustainable land management (SLM) interventions to arrest and reverse land degradation. LADA's sub-national assessments suggest, however, that a clear distinction needs to be made between "descriptors" (overall judgments) and "indicators" (measured parameters) of land degradation. Indicators need to reflect processes operating at different scales, but there should also be a core set of indicators of land degradation and in turn of the impacts and effectiveness of SLM. A variety of data sources are needed to construct a reliable set of indicators for monitoring - ideally these should be a combination of remotely-sensed data, ground-based scientific measurements, comparative observations and local knowledge.

Data limitations

The quality of global assessment has in the past been hampered by the paucity of reliable quantitative data, especially on the availability of water resources, but also on key economic factors. The reliability of data used in many assessments is a general concern.

Remote sensing has a clear role in monitoring land degradation, because it can provide high resolution information with repetitive coverage of continental Earth surfaces in the visible, near-infrared, short-wave, and thermal infrared regions[1]. These are also ideal for monitoring changes in land cover linked to land use, which are the major causes of land degradation. However, there is still no unique methodology for monitoring land degradation / improvement based on remote sensing that has been able to go much beyond land cover parameters.

The following information sources have been used in constructing the country and global level land use systems maps:

[1] The 30 m spatial resolution and 185 km swath of Landsat imagery fills an important scientific niche because the orbit swaths are wide enough for global coverage every season of the year, yet the images are detailed enough to characterize human-scale processes such as urban growth, agricultural irrigation, and deforestation. (Source: http://landsat.gsfc.nasa.gov/about/science.html)

- land cover (from satellite imagery) differentiating urban, bare, water, cropland, grassland, rangeland and forestry land;
- general land use aspects (from statistics and other data layers) including human population and livestock densities, occurrence of major crops, locations of protected areas and locations of irrigation systems.

Multi-scaling and multi-level integration

LADA operates at three scales (or resolutions) roughly corresponding to the three main levels of investigation:

- global level with a resolution of 5 by 5 arc minutes (9 by 9 km pixels at the equator);
- sub-National levels (LUS units combined with district or provincial delimitations) with scales ranging from 1:250 000 – 1:1 000 000;
- local levels, which are not mapped systematically but can be inventoried and these supported by more or less accurate sketch maps depending on the size and object of the investigation[2].

Global LADA – GLADA and GLADIS

Under the LADA project, the global assessment was undertaken in two phases. The Global Land Degradation Assessment (GLADA) identified trends in vegetation greenness (based on NDVI[3]) over the period 1981-2006. It defined critical areas where both the greenness and the rain-use efficiency were declining. In contrast to GLASOD (see above), the methodology used "hard" (measured) data restricted to a well-defined time period. The results indicated that the decline in greenness affected areas with a total human population of some 1 billion and results in a net loss of about 35 million tonnes of carbon per year. The areas most affected were:

- tropical Africa south of the Equator;
- Southeast Asia;
- South China;
- North-central Australia;
- drylands and steep-lands of Central America and the Caribbean;
- Southeast Brazil, the Pampas and boreal forests.

[2] The decision not to systematically map was made to avoid an undue focus in the development of methods for the mapping, to the potential detriment of the required focus on the assessment of degradation / improvement.

[3] NDVI is a numerical indicator that uses the visible and near-infrared bands of the electromagnetic spectrum, and is adopted to analyse remote sensing measurements and assess whether the target being observed contains live green vegetation or not. Currently the best data for NDVI measurements come from the Moderate Resolution Imaging Spectroradiometer (MODIS) instruments on NASA's Terra and Aqua satellites; earlier data came from the Advanced Very High Resolution Radiometer (AVHRR) instruments deployed on NOAA polar orbiting meteorological satellites.

The second step, the Global Land Degradation Information System (GLADIS), is based on an assessment of the status and trends of ecosystem goods and services, including the impacts that changes have on local populations. GLADIS summarizes findings in the form of radar diagrams aggregating broad groups of ecosystem goods and services – biomass, soil health, water quantity, biodiversity, also social and cultural impacts, considering their changes over a period of about 15-25 years. GLADIS has undergone a consultative process with the six LADA countries, and a preliminary scientific peer review (Nachtergaele *et al*. 2011). Following the review, the system has been updated and it is undergoing a further scientific and country based review – September to November 2011.

Preliminary GLADIS results are available for the entire globe, also for each country, or for specific land use systems within a country. A few GLADIS global maps are shown here for illustrative purposes only, until the review process will have been completed. Also, aggregated indexes and classes of degradation can be produced. They will be made available after the reviewing process, that will give indications on the weight to be given to the individual components.

Participatory approaches

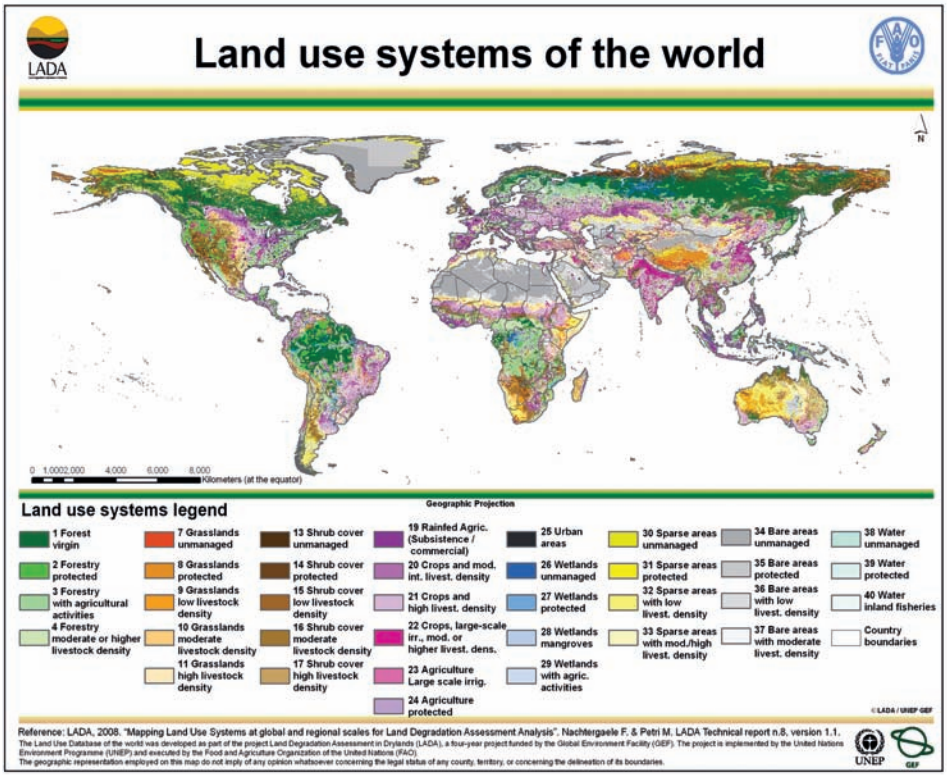
As described above, a key innovation of the LADA project has been its insistence on the creation of multidisciplinary teams at the various scales of enquiry. This has been very successful in supporting the sub-national and local assessments in all the six LADA countries. LADA did, however, also find that it was sometimes difficult to set up a genuine multi-disciplinary team drawn from natural resources and social sectors at the sub-national level, also including land users, experts and district extension officers at the local level. True participation, integrating all stakeholders on an equal footing, has not always been easy to achieve. Experience shows that establishing a real link with the district under investigation is important to ensure the quality of the outputs.

Argentina – Soil salinity
Photo: R. Biancalani 2010

LADA outputs: complementary products at different levels

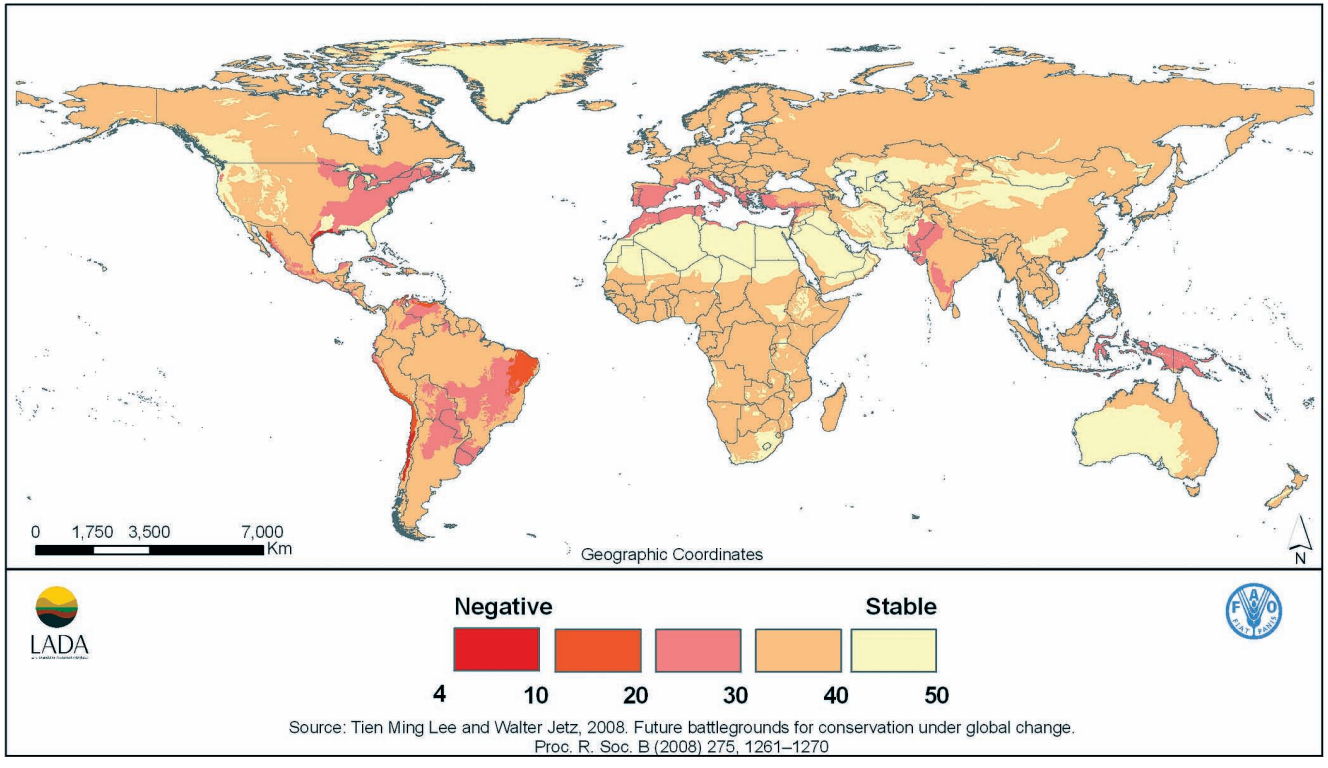
The LADA project has greatly improved the state of knowledge about the occurrence, severity and extent of land degradation. In addition, it provides many lessons about the processes involved in defining, collecting, collating and reporting on land degradation, sustainable use and land improvement. The maps in the following pages show examples of the results of the land degradation and sustainable land management mapping exercises at global and national level.

Selected GLADIS maps



Preliminary results for illustrative purpose only.
The system is undergoing scientific and users driven review – September 2011.

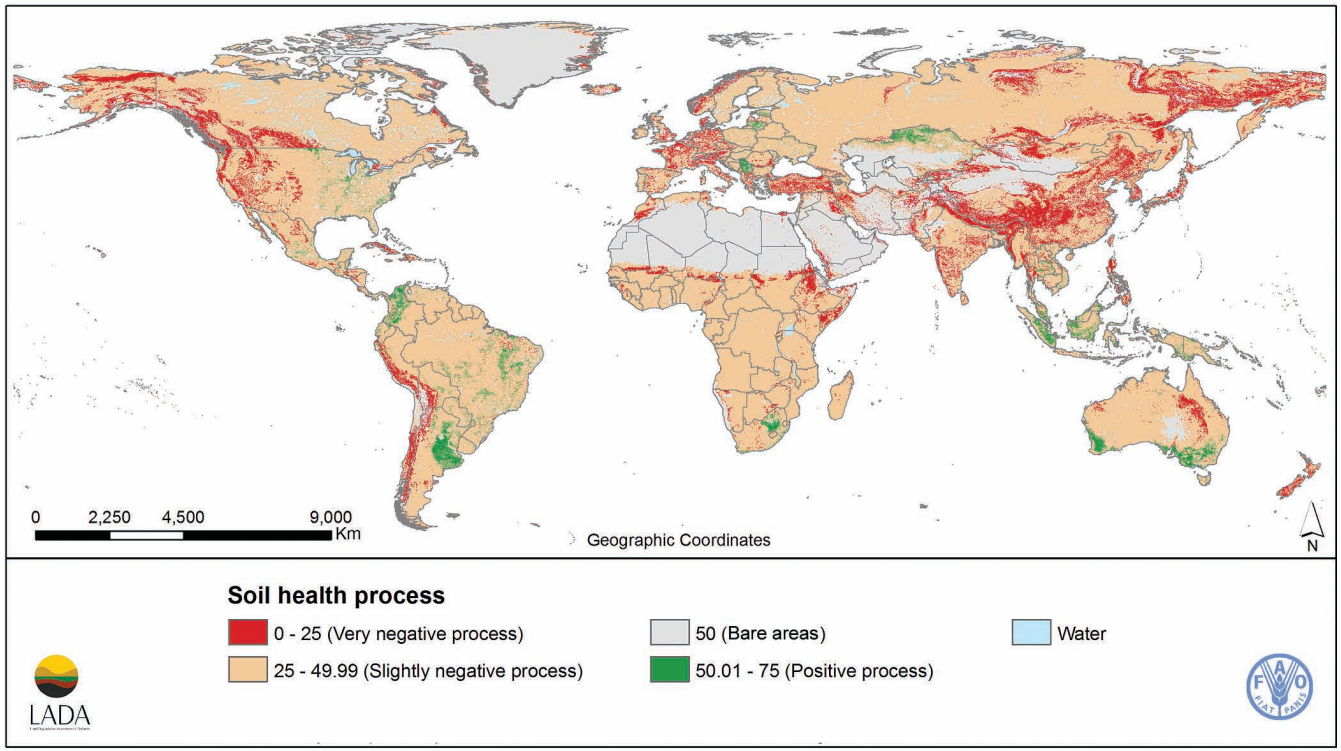
Biodiversity process index



Source: Tien Ming Lee and Walter Jetz, 2008. Future battlegrounds for conservation under global change. Proc. R. Soc. B (2008) 275, 1261–1270

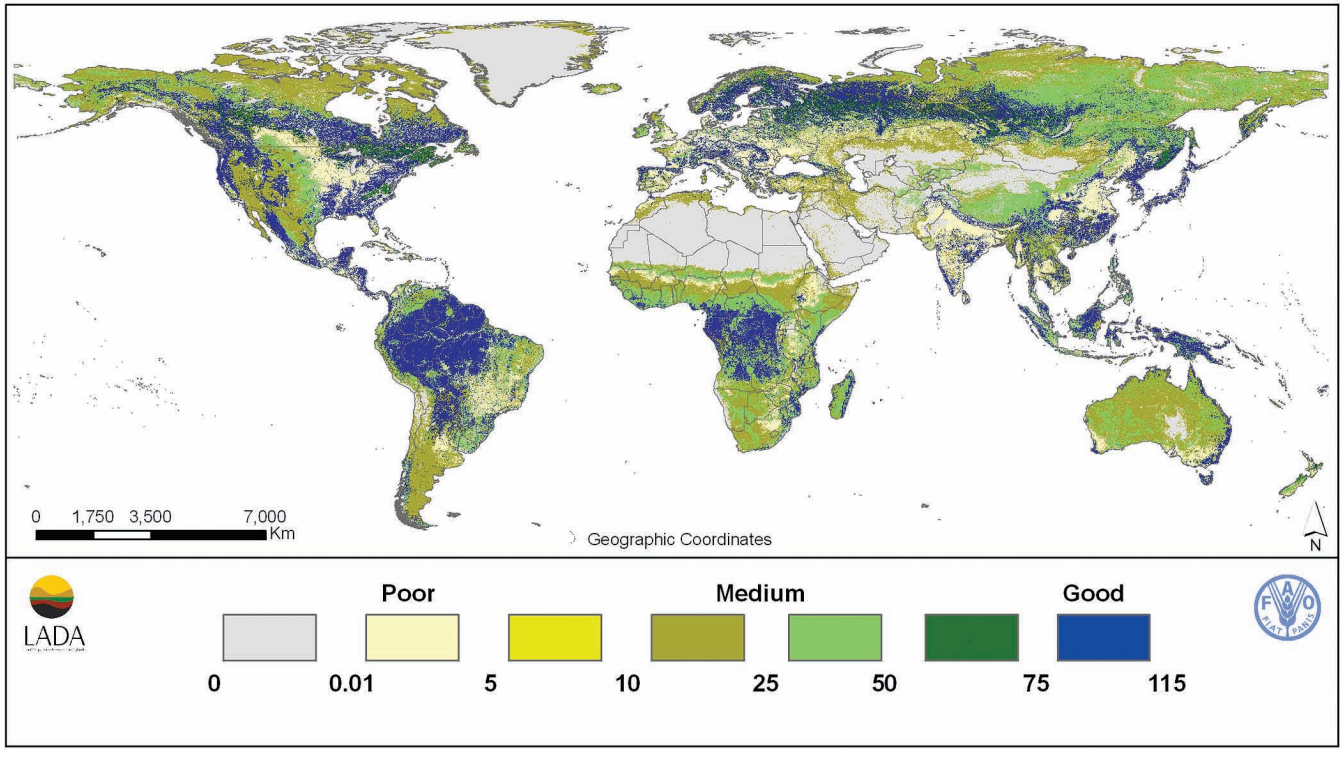
Preliminary results for illustrative purpose only.
The system is undergoing scientific and users driven review – September 2011.

Soil resources process index



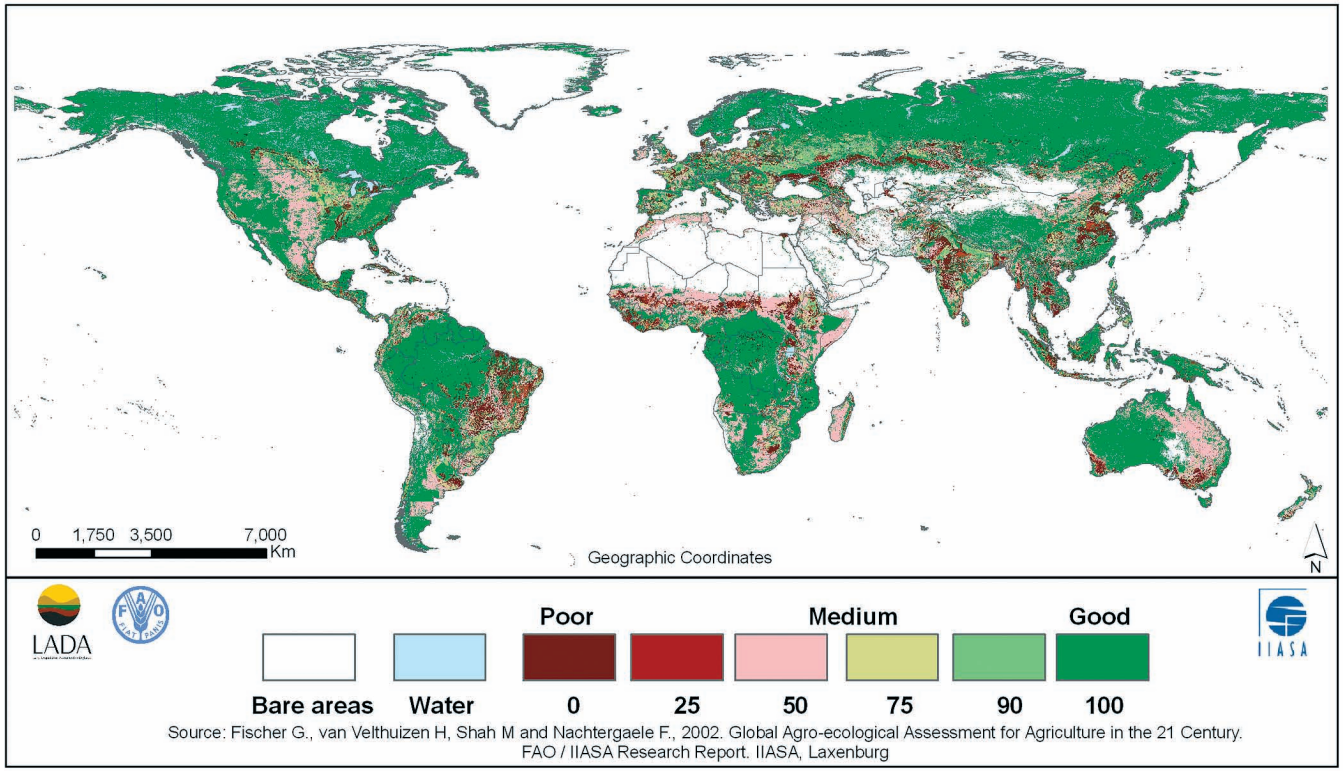
Preliminary results for illustrative purpose only.
The system is undergoing scientific and users driven review – September 2011.

Biomass status index

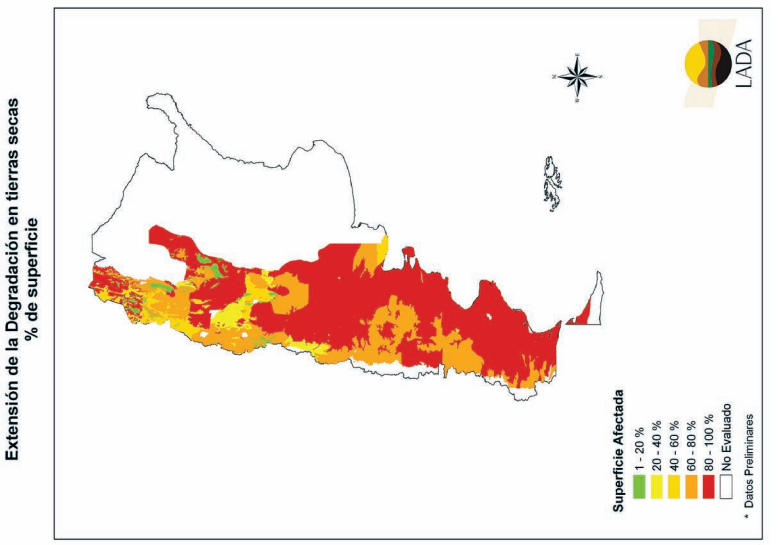


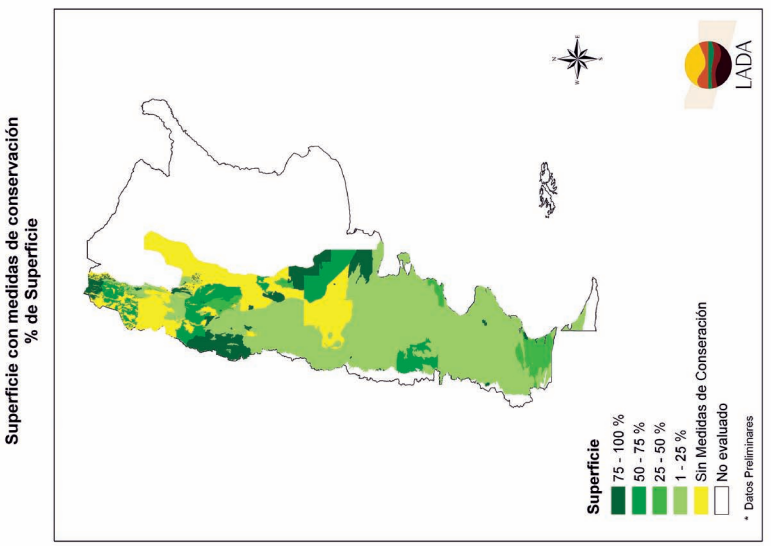
Preliminary results for illustrative purpose only.
The system is undergoing scientific and users driven review – September 2011.

Soil resources status index

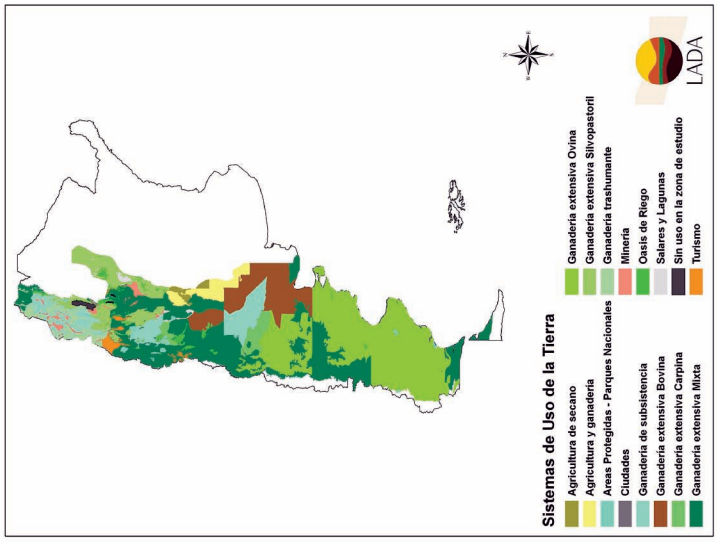


Argentina

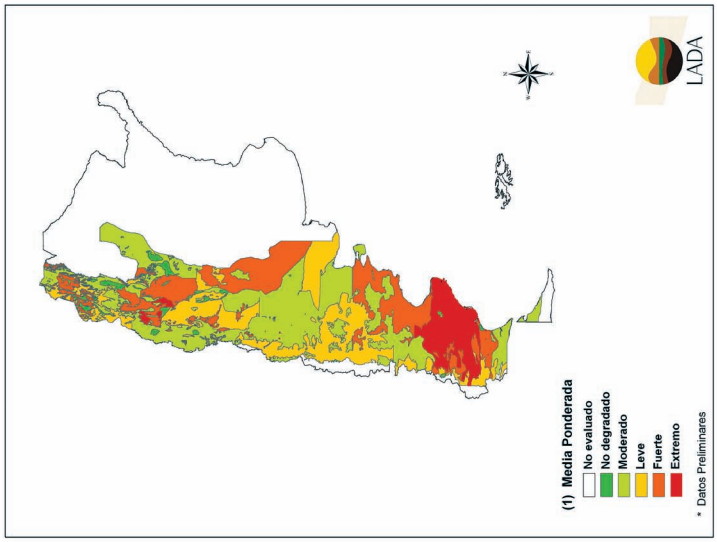

Extensión de la Degradación en tierras secas
% de superficie
Superficie Afectada
1 - 20 %
20 - 40 %
40 - 60 %
60 - 80 %
80 - 100 %
No Evaluado
* Datos Preliminares
LADA

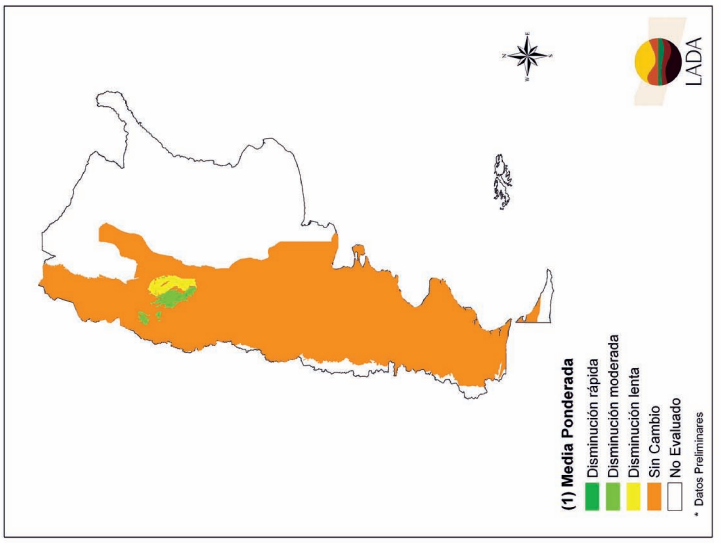

Superficie con medidas de conservación
% de Superficie
Superficie
75 - 100 %
50 - 75 %
25 - 50 %
1 - 25 %
Sin Medidas de Conseración
No evaluado
* Datos Preliminares
LADA

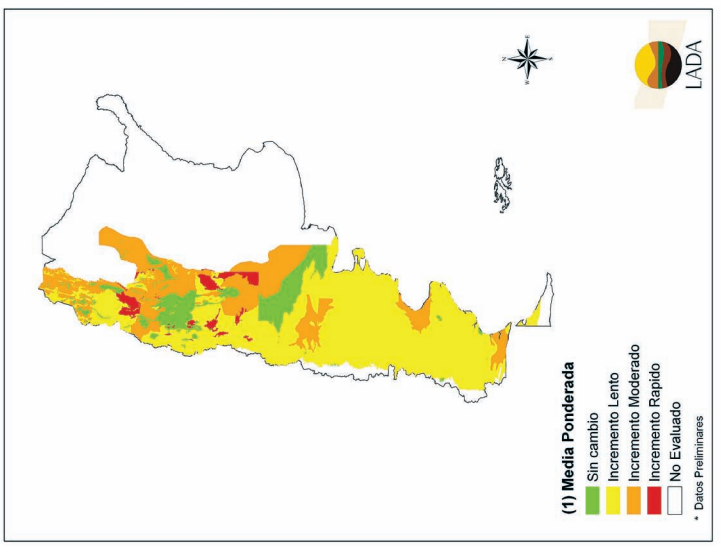
Sistemas de Uso de la Tierra
LUS



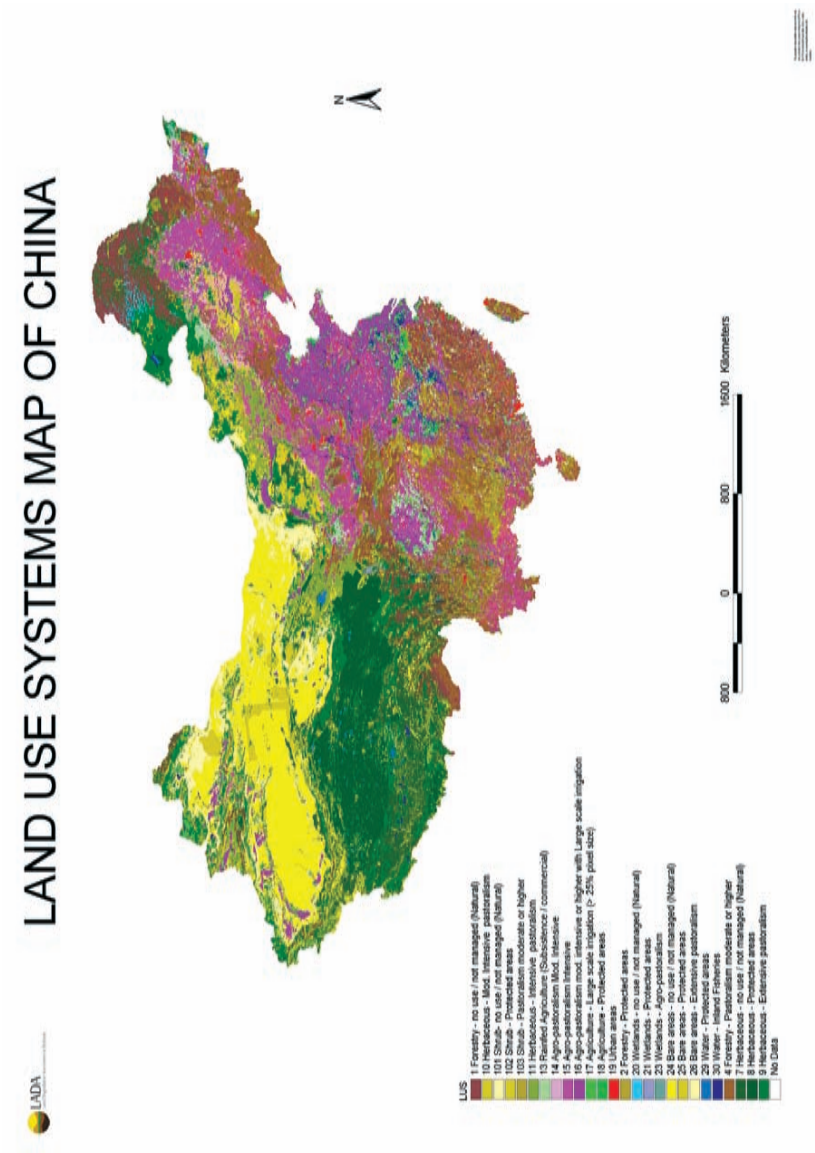
Grado de la degradación en tierras secas (1)

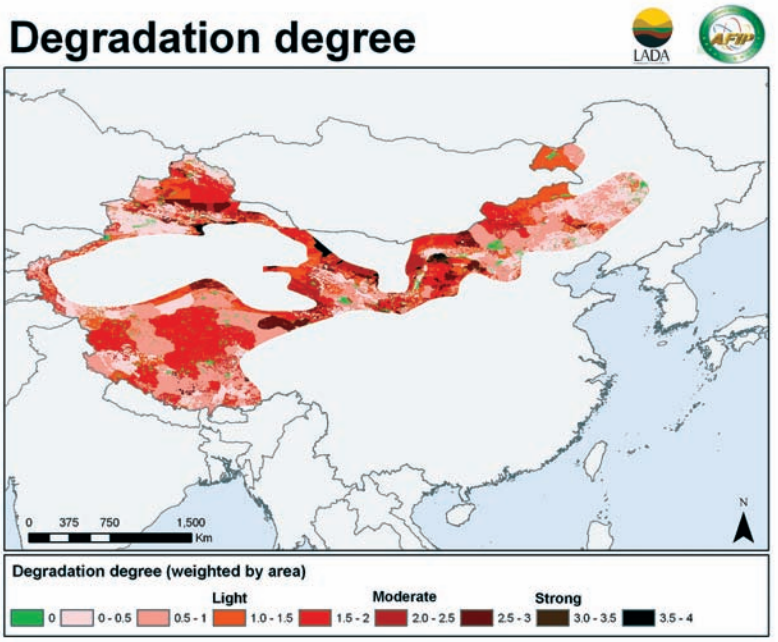


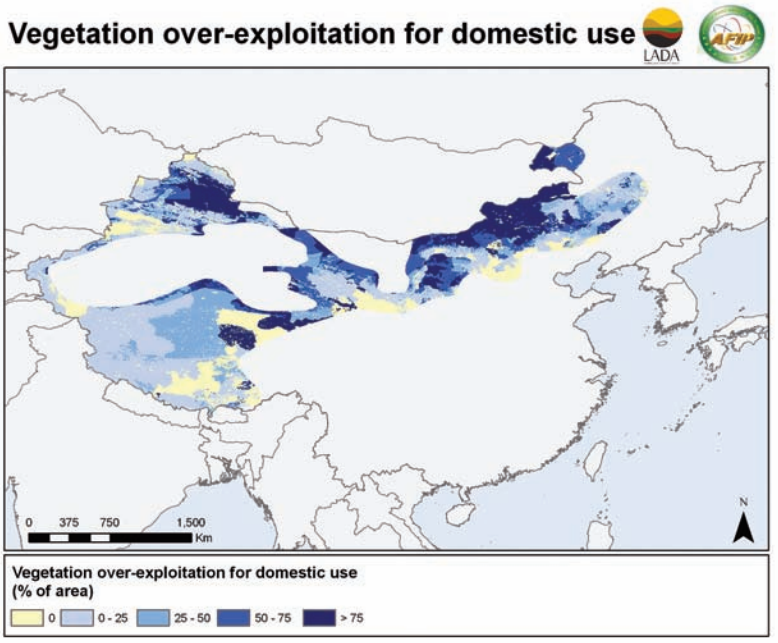

Tasa de decremento de la degradación (1)
(1) Media Ponderada
Disminución rápida
Disminución moderada
Disminución lenta
Sin Cambio
No Evaluado
* Datos Preliminares
LADA

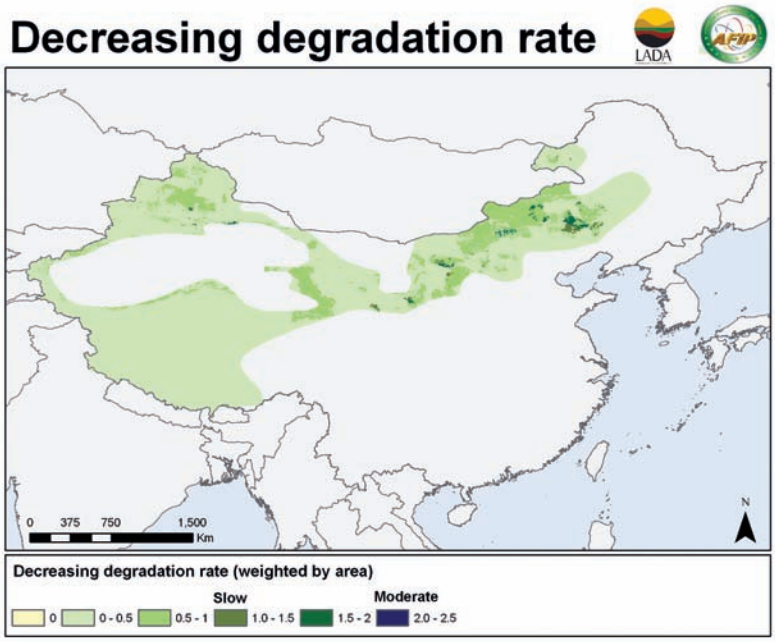

Tasa de aumento de la degradación (1)
(1) Media Ponderada
Sin cambio
Incremento Lento
Incremento Moderado
Incremento Rapido
No Evaluado
* Datos Preliminares
LADA

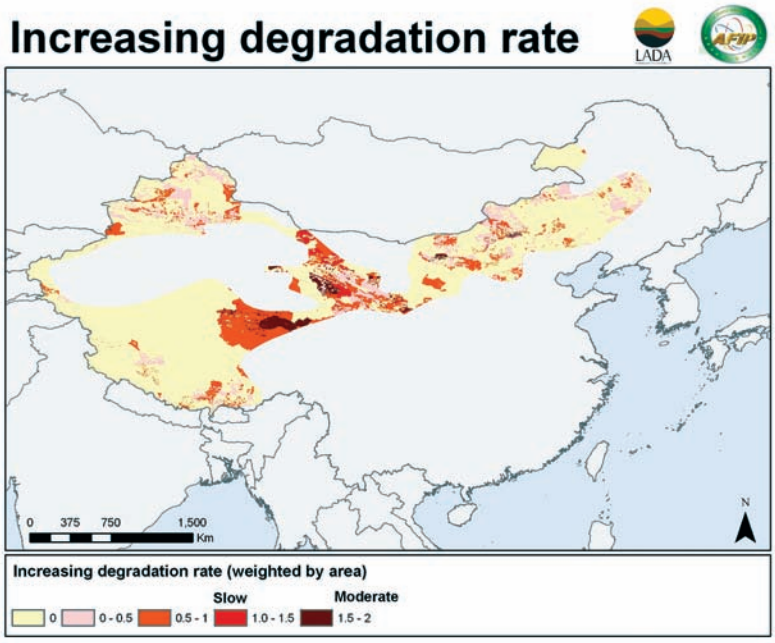
China


LAND USE SYSTEMS MAP OF CHINA
LADA
N
LUS
1 Forestry - no use / not managed (Natural)
10 Herbaceous - Mix intensive pasturalism
101 Shrub - no use / not managed (Natural)
102 Shrub - Protected areas
103 Shrub - Pasturalism moderate or higher
11 Herbaceous - Intensive pasturalism
13 Rainfed Agriculture (Subsistence / commercial)
14 Agro-pasturalism Mod. Intensive
15 Agro-pasturalism Intensive
16 Agro-pasturalism mod. intensive or higher with Large scale irrigation
17 Agriculture - Large scale irrigation (> 25% pixel size)
18 Agriculture - Protected areas
19 Urban areas
2 Forestry - Protected areas
20 Wetlands - no use / not managed (Natural)
21 Wetlands - Protected areas
23 Wetlands - Agro-pasturalism
24 Bare areas - no use / not managed (Natural)
26 Bare areas - Protected areas
28 Bare areas - Extensive pasturalism
29 Water - Protected areas
30 Water - Inland Fisheries
4 Forestry - Pasturalism moderate or higher
7 Herbaceous - no use / not managed (Natural)
8 Herbaceous - Protected areas
9 Herbaceous - Extensive pasturalism
No Data
800
0
800
1600 Kilometers

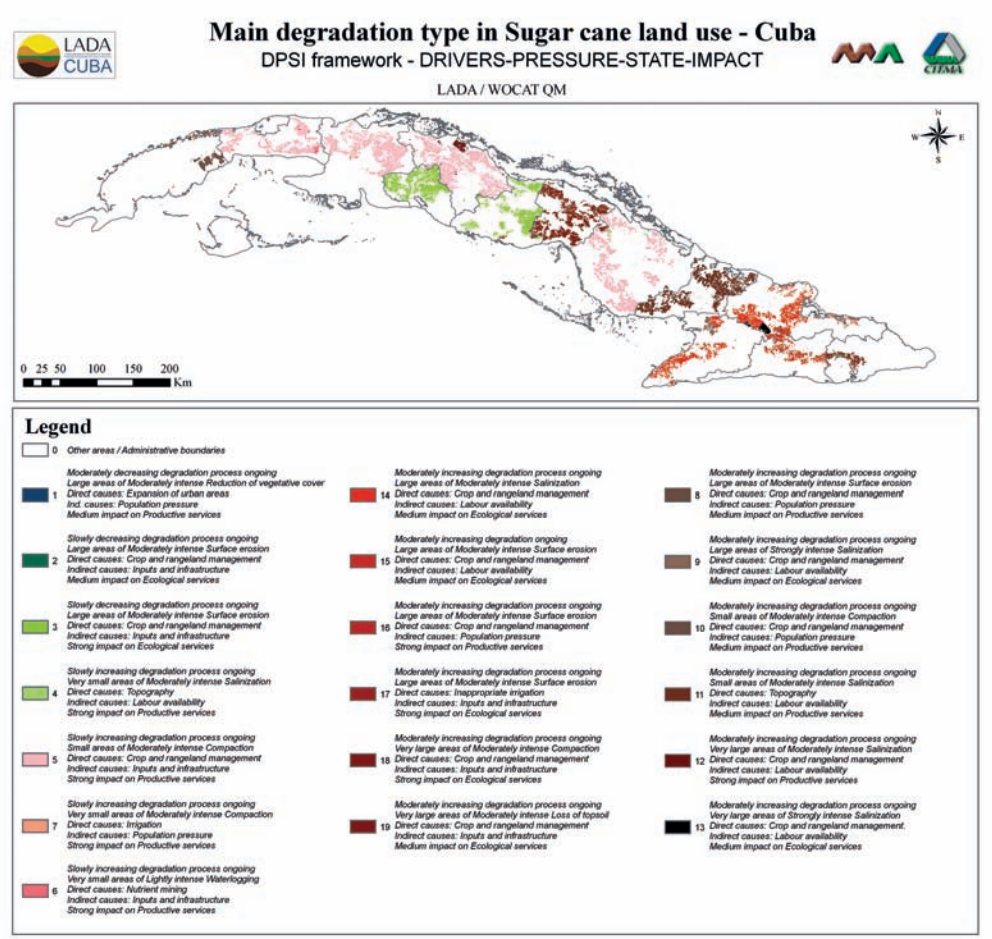

Degradation degree
LADA
0 375 750 1,500
Km
N
Degradation degree (weighted by area)
Light
Moderate
Strong
0
0 - 0.5
0.5 - 1
1.0 - 1.5
1.5 - 2
2.0 - 2.5
2.5 - 3
3.0 - 3.5
3.5 - 4

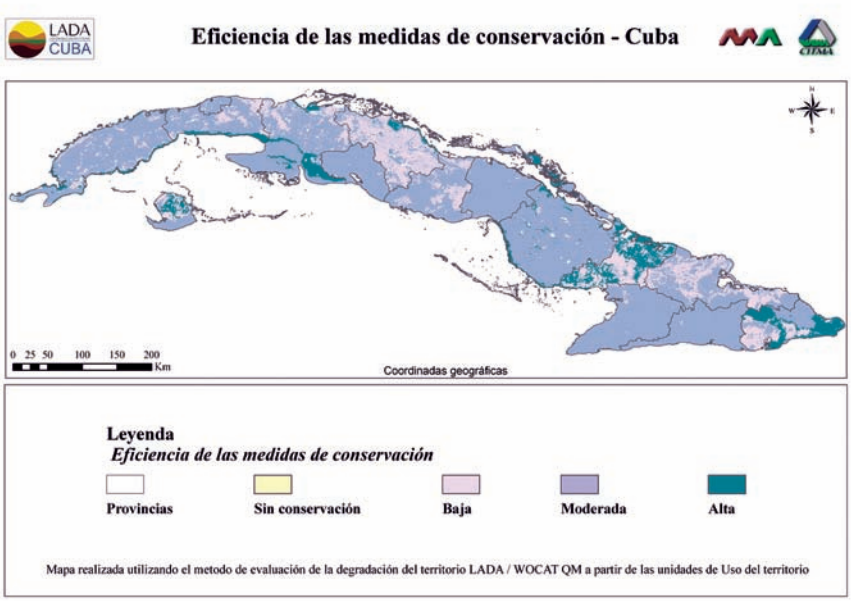

Vegetation over-exploitation for domestic use
LADA
0 375 750 1,500
Km
N
Vegetation over-exploitation for domestic use
(% of area)
0
0 - 25
25 - 50
50 - 75
> 75

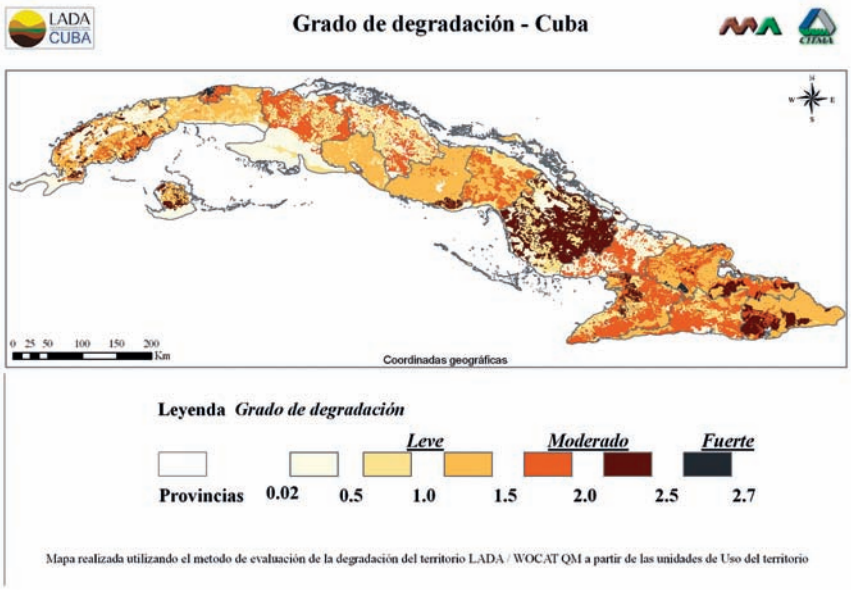

Decreasing degradation rate
LADA
0 375 750 1,500
Km
N
Decreasing degradation rate (weighted by area)
Slow
Moderate
0
0 - 0.5
0.5 - 1
1.0 - 1.5
1.5 - 2
2.0 - 2.5

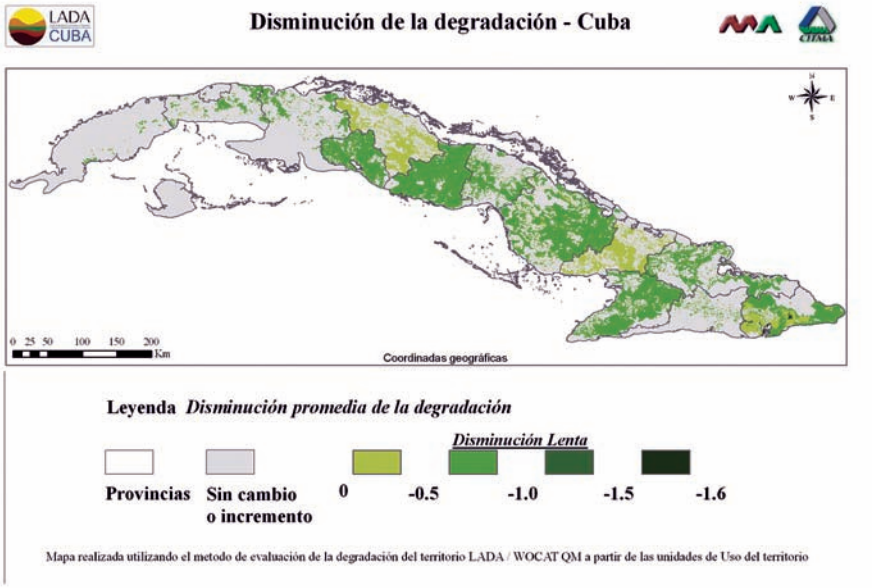

Increasing degradation rate
LADA
0 375 750 1,500
Km
N
Increasing degradation rate (weighted by area)
Slow
Moderate
0
0 - 0.5
0.5 - 1
1.0 - 1.5
1.5 - 2

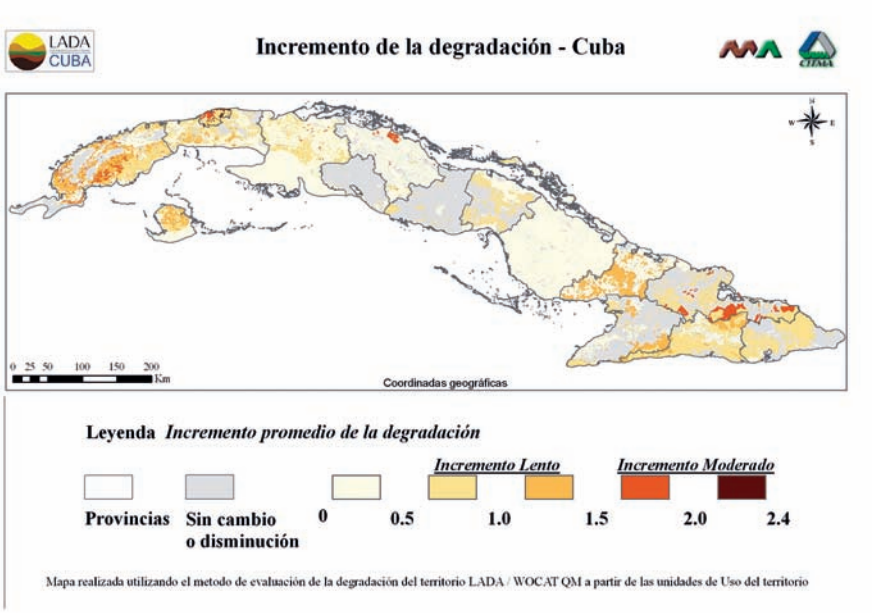
Cuba

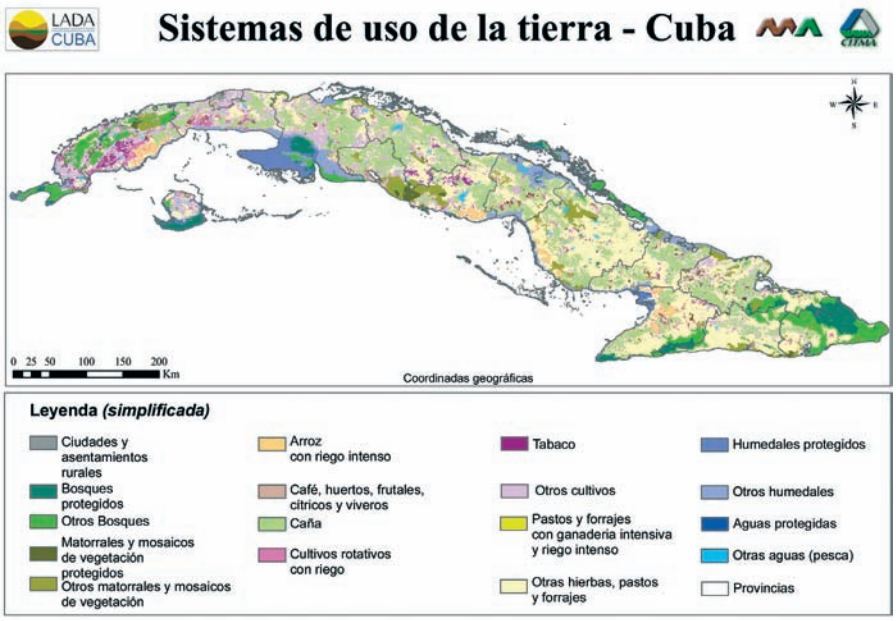

Main degradation type in Sugar cane land use - Cuba
DPSI framework - DRIVERS-PRESSURE-STATE-IMPACT
LADA / WOCAT QM
0 25 50 100 150 200
Km
Legend
0 Other areas / Administrative boundaries
1 Moderately decreasing degradation process ongoing
Large areas of Moderately intense Reduction of vegetative cover
Direct causes: Expansion of urban areas
Ind. causes: Population pressure
Medium impact on Productive services
2 Slowly decreasing degradation process ongoing
Large areas of Moderately intense Surface erosion
Direct causes: Crop and rangeland management
Indirect causes: Inputs and infrastructure
Medium impact on Ecological services
3 Slowly decreasing degradation process ongoing
Large areas of Moderately intense Surface erosion
Direct causes: Crop and rangeland management
Indirect causes: Inputs and infrastructure
Strong impact on Ecological services
4 Slowly increasing degradation process ongoing
Very small areas of Moderately intense Salinization
Direct causes: Topography
Indirect causes: Labour availability
Strong impact on Productive services
5 Slowly increasing degradation process ongoing
Small areas of Moderately intense Compaction
Direct causes: Crop and rangeland management
Indirect causes: Inputs and infrastructure
Strong impact on Productive services
7 Slowly increasing degradation process ongoing
Very small areas of Moderately intense Compaction
Direct causes: Irrigation
Indirect causes: Population pressure
Strong impact on Productive services
6 Slowly increasing degradation process ongoing
Very small areas of Lightly intense Waterlogging
Direct causes: Nutrient mining
Indirect causes: Inputs and infrastructure
Strong impact on Productive services
14 Moderately increasing degradation process ongoing
Large areas of Moderately intense Salinization
Direct causes: Crop and rangeland management
Indirect causes: Labour availability
Medium impact on Ecological services
15 Moderately increasing degradation ongoing
Large areas of Moderately intense Surface erosion
Direct causes: Crop and rangeland management
Indirect causes: Labour availability
Medium impact on Ecological services
16 Moderately increasing degradation process ongoing
Large areas of Moderately intense Surface erosion
Direct causes: Crop and rangeland management
Indirect causes: Population pressure
Strong impact on Productive services
17 Moderately increasing degradation process ongoing
Large areas of Moderately intense Surface erosion
Direct causes: Inappropriate irrigation
Indirect causes: Inputs and infrastructure
Strong impact on Ecological services
18 Moderately increasing degradation process ongoing
Very large areas of Moderately intense Compaction
Direct causes: Crop and rangeland management
Indirect causes: Inputs and infrastructure
Strong impact on Ecological services
19 Moderately increasing degradation process ongoing
Very large areas of Moderately intense Loss of topsoil
Direct causes: Crop and rangeland management
Indirect causes: Inputs and infrastructure
Medium impact on Ecological services
8 Moderately increasing degradation process ongoing
Large areas of Moderately intense Surface erosion
Direct causes: Crop and rangeland management
Indirect causes: Population pressure
Medium impact on Productive services
9 Moderately increasing degradation process ongoing
Large areas of Strongly intense Salinization
Direct causes: Crop and rangeland management
Indirect causes: Labour availability
Medium impact on Ecological services
10 Moderately increasing degradation process ongoing
Small areas of Moderately intense Compaction
Direct causes: Crop and rangeland management
Indirect causes: Population pressure
Medium impact on Productive services
11 Moderately increasing degradation process ongoing
Small areas of Moderately intense Salinization
Direct causes: Topography
Indirect causes: Labour availability
Medium impact on Productive services
12 Moderately increasing degradation process ongoing
Very large areas of Moderately intense Salinization
Direct causes: Crop and rangeland management
Indirect causes: Labour availability
Strong impact on Productive services
13 Moderately increasing degradation process ongoing
Very large areas of Strongly intense Salinization
Direct causes: Crop and rangeland management.
Indirect causes: Labour availability
Medium impact on Ecological services

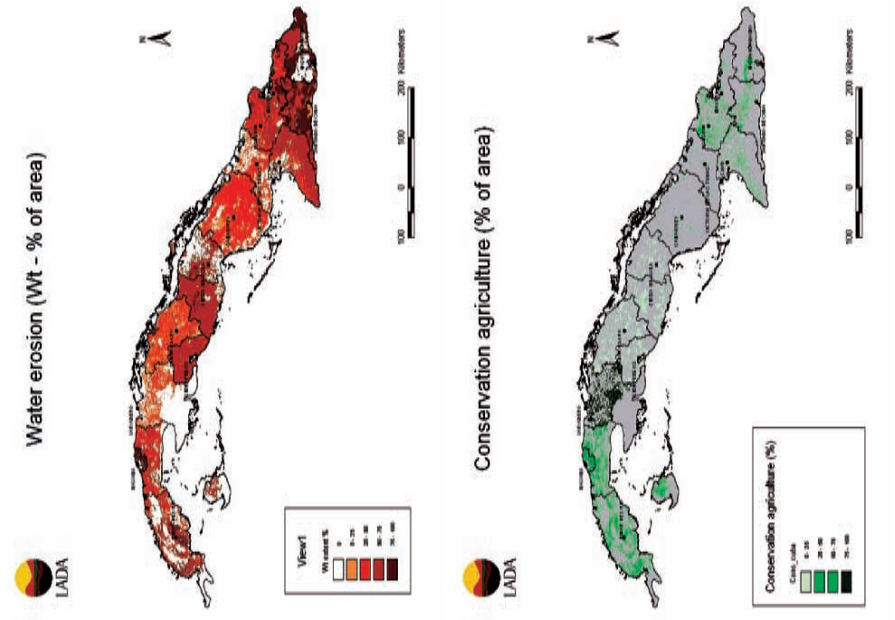

LADA CUBA
Eficiencia de las medidas de conservación - Cuba
0 25 50 100 150 200
Km
Coordinadas geográficas
Leyenda
Eficiencia de las medidas de conservación
Provincias
Sin conservación
Baja
Moderada
Alta
Mapa realizada utilizando el metodo de evaluación de la degradación del territorio LADA / WOCAT QM a partir de las unidades de Uso del territorio

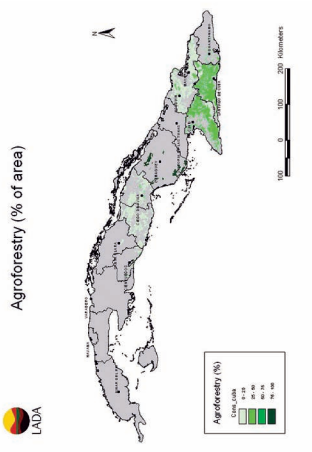

LADA CUBA
Grado de degradación - Cuba
0 25 50 100 150 200
Km
Coordinadas geográficas
Leyenda Grado de degradación
Leve
Moderado
Fuerte
Provincias
0.02
0.5
1.0
1.5
2.0
2.5
2.7
Mapa realizada utilizando el metodo de evaluación de la degradación del territorio LADA / WOCAT QM a partir de las unidades de Uso del territorio

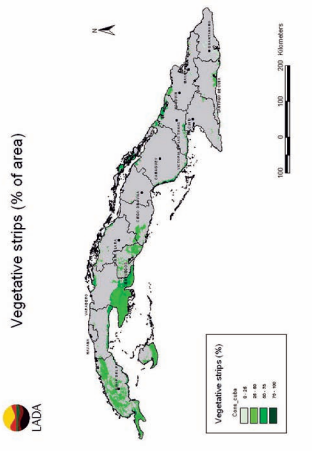

LADA CUBA
Disminución de la degradación - Cuba
0 25 50 100 150 200 Km
Coordinadas geográficas
Leyenda Disminución promedia de la degradación
Disminución Lenta
Provincias
Sin cambio o incremento
0
-0.5
-1.0
-1.5
-1.6
Mapa realizada utilizando el metodo de evaluación de la degradación del territorio LADA / WOCAT QM a partir de las unidades de Uso del territorio

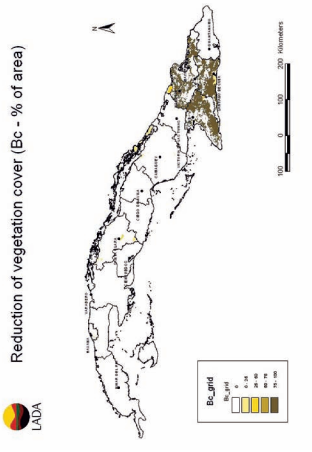

LADA CUBA
Incremento de la degradación - Cuba
0 25 50 100 150 200 Km
Coordinadas geográficas
Leyenda Incremento promedio de la degradación
Incremento Lento
Incremento Moderado
Provincias
Sin cambio o disminución
0
0.5
1.0
1.5
2.0
2.4
Mapa realizada utilizando el metodo de evaluación de la degradación del territorio LADA / WOCAT QM a partir de las unidades de Uso del territorio

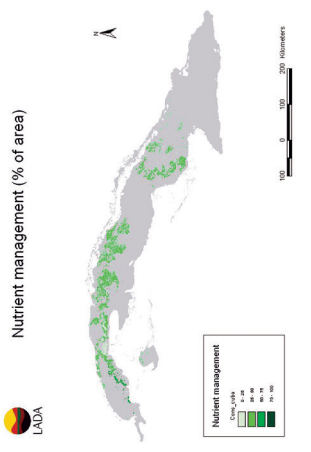

LADA CUBA
Sistemas de uso de la tierra - Cuba
0 25 50 100 150 200
Km
Coordinadas geográficas
Leyenda (simplificada)
Ciudades y asentamientos rurales
Bosques protegidos
Otros Bosques
Matorrales y mosaicos de vegetación protegidos
Otros matorrales y mosaicos de vegetación
Arroz con riego intenso
Café, huertos, frutales, cítricos y viveros
Caña
Cultivos rotativos con riego
Tabaco
Otros cultivos
Pastos y forrajes con ganadería intensiva y riego intenso
Otras hierbas, pastos y forrajes
Humedales protegidos
Otros humedales
Aguas protegidas
Otras aguas (pesca)
Provincias

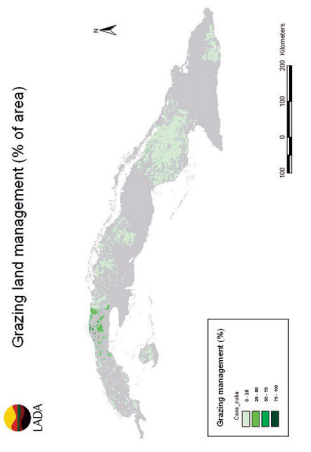

Water erosion (Wt - % of area)
LADA
Conservation agriculture (% of area)
LADA

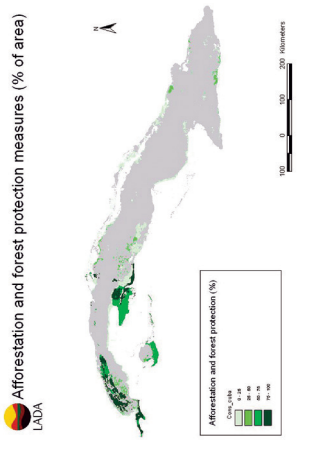

Agroforestry (% of area)
LADA
Agroforestry (%)
Cons_cobi
0 - 25
25 - 50
50 - 75
75 - 100
N
100 0 100 200 Kilometers


Vegetative strips (% of area)
LADA
Vegetative strips (%)
Cons_cobi
0 - 25
25 - 50
50 - 75
75 - 100
N
100 0 100 200 Kilometers

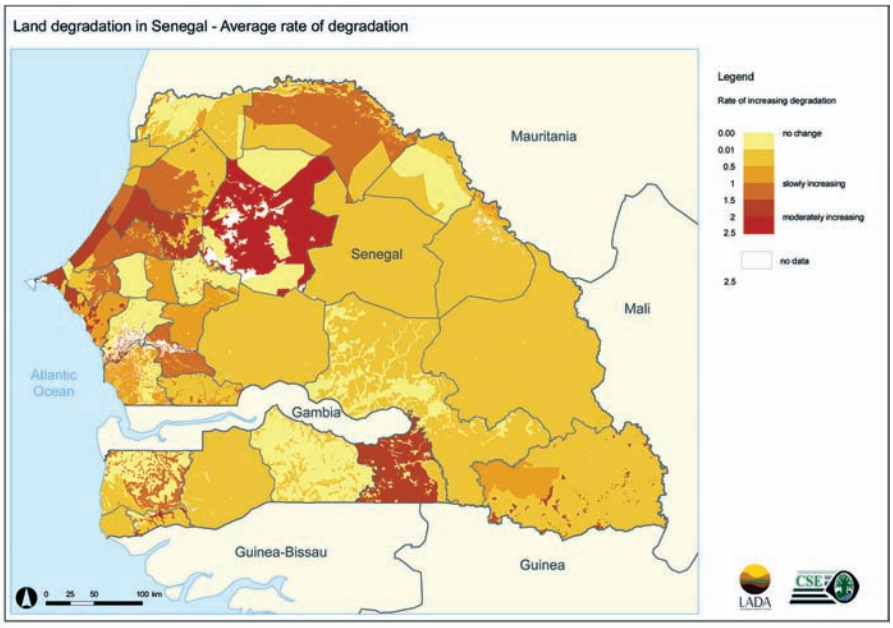

Reduction of vegetation cover (Bc - % of area)
LADA
Bc_grid
Bc_grid
0 - 25
25 - 50
50 - 75
75 - 100
N
100 0 100 200 Kilometers

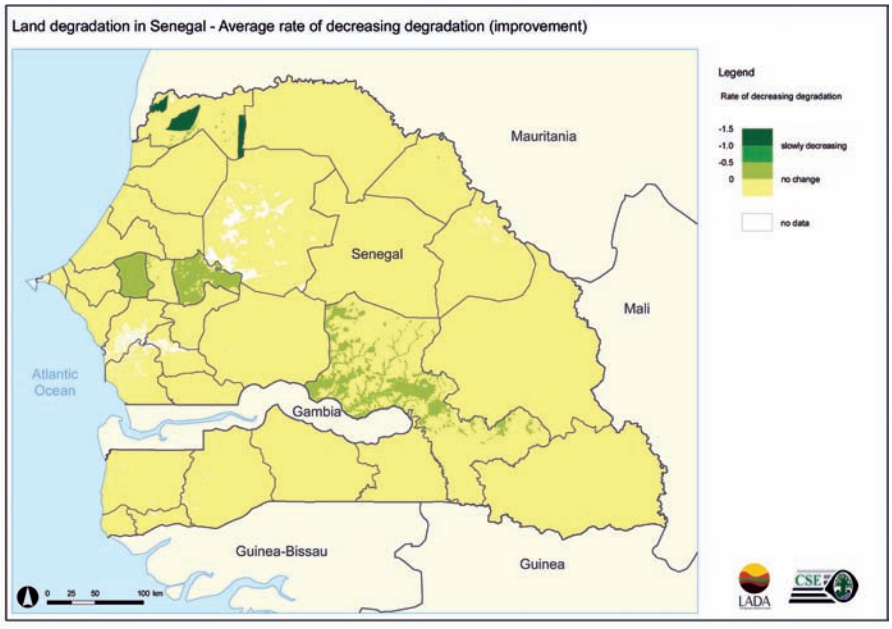

Nutrient management (% of area)
LADA
Nutrient management
Cons_cobi
0 - 25
25 - 50
50 - 75
75 - 100
N
100 0 100 200 Kilometers

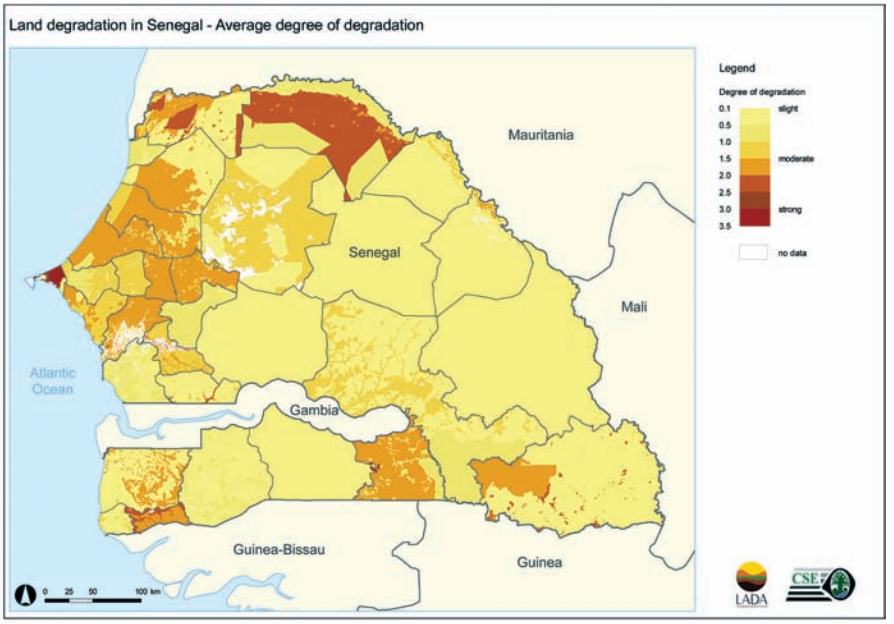

Grazing land management (% of area)
LADA
Grazing management (%)
Cons_cobi
0 - 25
25 - 50
50 - 75
75 - 100
N
100 0 100 200 Kilometers

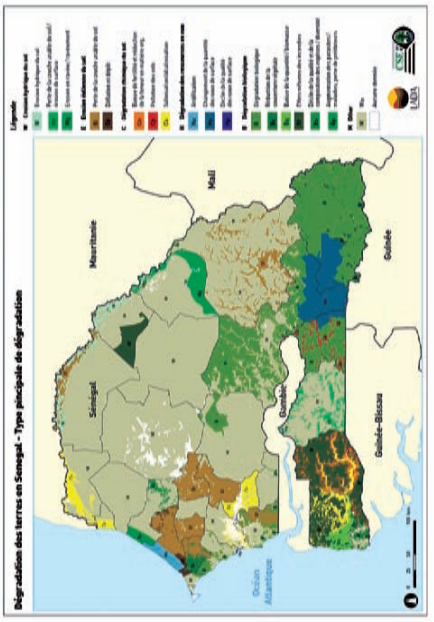

Afforestation and forest protection measures (% of area)
LADA
Afforestation and forest protection (%)
Cons_cobi
0 - 25
25 - 50
50 - 75
75 - 100
N
100 0 100 200 Kilometers

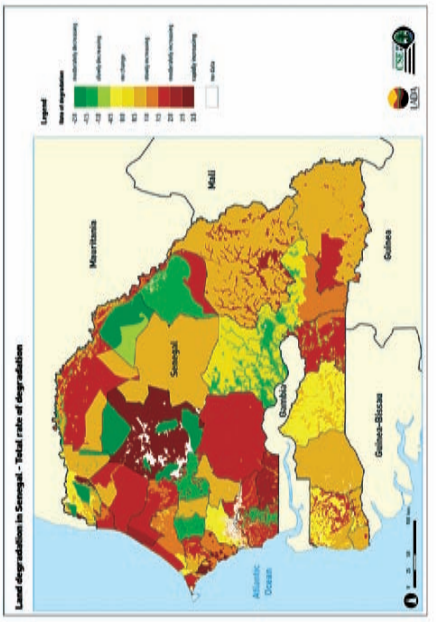
Senegal

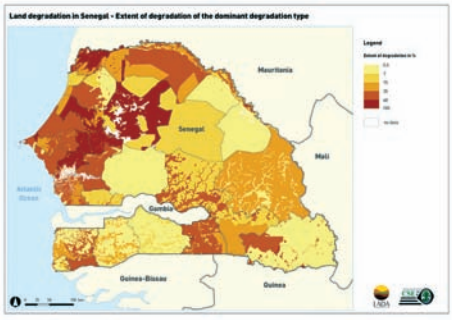

Land degradation in Senegal - Average rate of degradation
Legend
Rate of increasing degradation
0.00
0.01
0.5
1
1.5
2
2.5
no change
slowly increasing
moderately increasing
no data
2.5
Mauritania
Senegal
Mali
Atlantic Ocean
Gambia
Guinea-Bissau
Guinea
0 25 50 100 km
LADA
CSE

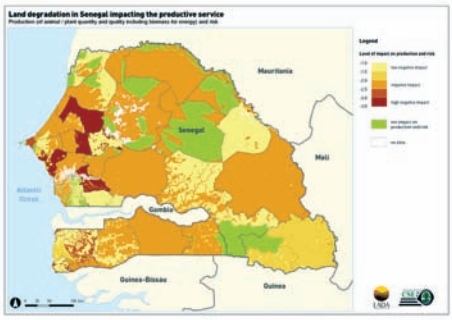

Land degradation in Senegal - Average rate of decreasing degradation (improvement)
Legend
Rate of decreasing degradation
-1.5
-1.0
-0.5
0
slowly decreasing
no change
no data
Mauritania
Senegal
Mali
Atlantic Ocean
Gambia
Guinea-Bissau
Guinea
0 25 50 100 km
LADA
CSE

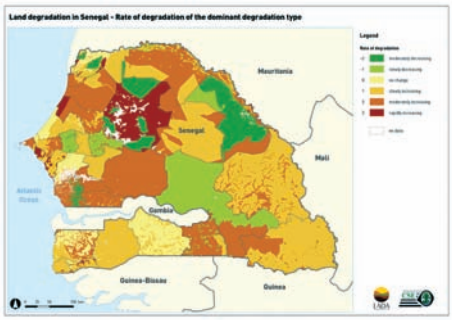

Land degradation in Senegal - Average degree of degradation
Legend
Degree of degradation
0.1
0.5
1.0
1.5
2.0
2.5
3.0
3.5
slight
moderate
strong
no data
Mauritania
Senegal
Mali
Atlantic Ocean
Gambia
Guinea-Bissau
Guinea
0 25 50 100 km
LADA
CSE

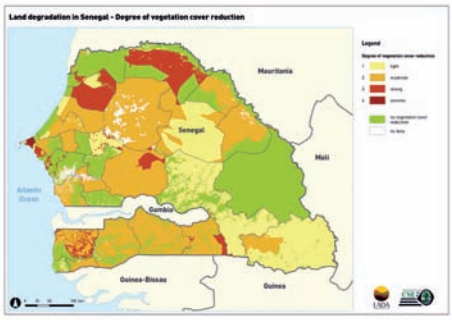

Mali
Mauritanie
Guinée
Sénégal
Gambie
Guinée-Bissau
Océan Atlantique

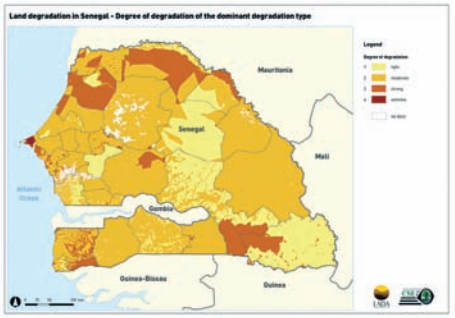

Mali
Mauritania
Guinea
Senegal
Gambia
Guinea-Bissau
Atlantic Ocean

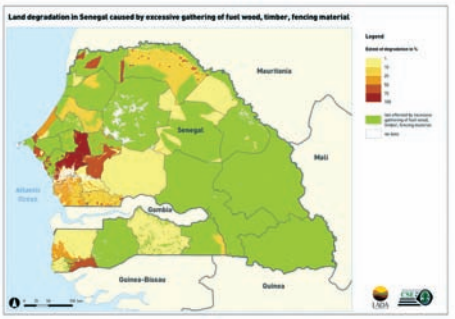

Land degradation in Senegal - Extent of degradation of the dominant degradation type
Mauritania
Senegal
Mali
Gambia
Guinea-Bissau
Guinea

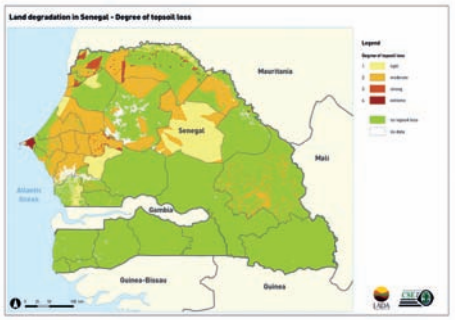

Land degradation in Senegal impacting the productive service
Mauritania
Senegal
Mali
Gambia
Guinea-Bissau
Guinea

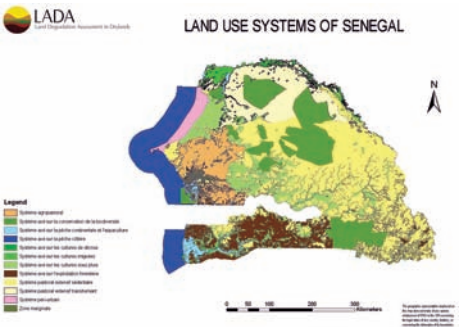

Land degradation in Senegal - Rate of degradation of the dominant degradation type
Mauritania
Senegal
Mali
Gambia
Guinea-Bissau
Guinea


Land degradation in Senegal - Degree of vegetation cover reduction
Mauritania
Senegal
Mali
Gambia
Guinea-Bissau
Guinea

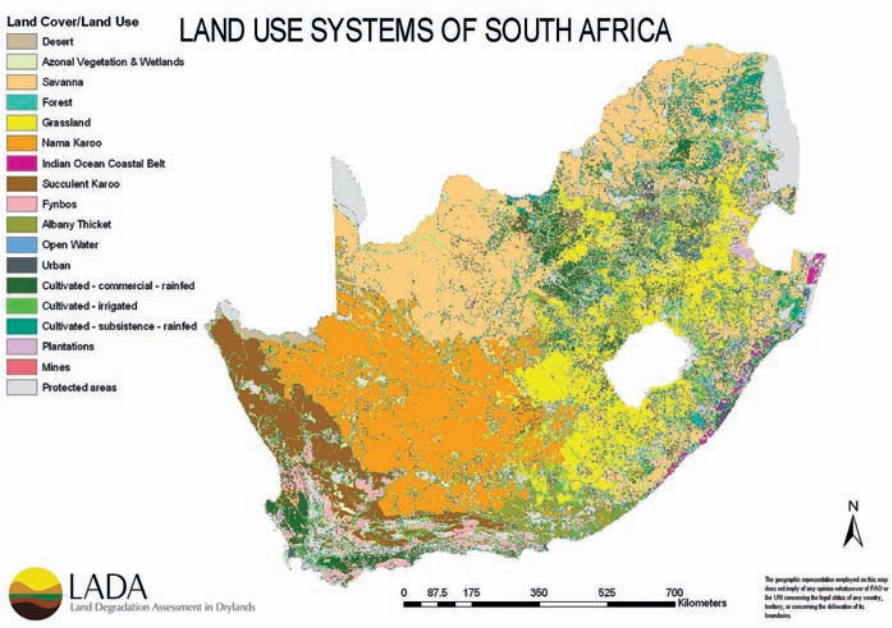

Land degradation in Senegal - Degree of degradation of the dominant degradation type
Mauritania
Senegal
Mali
Gambia
Guinea-Bissau
Guinea
Atlantic Ocean
Legend
LADA

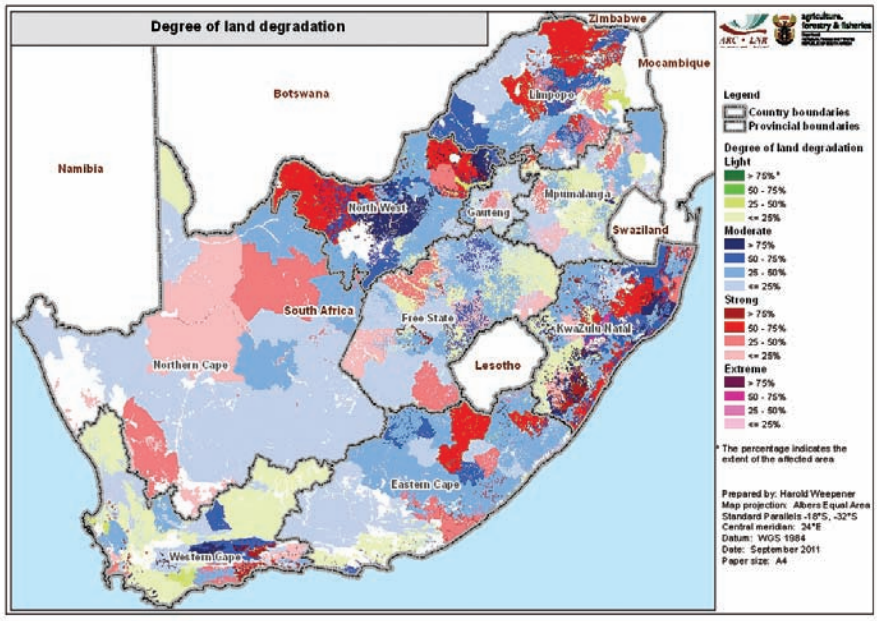

Land degradation in Senegal caused by excessive gathering of fuel wood, timber, fencing material
Mauritania
Senegal
Mali
Gambia
Guinea-Bissau
Guinea
Atlantic Ocean
Legend
LADA

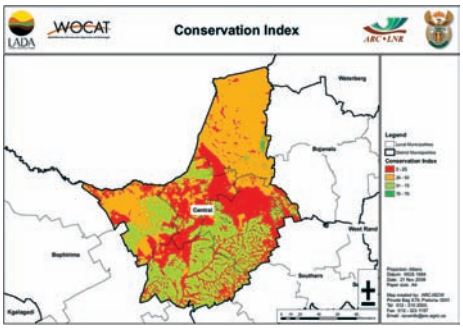

Land degradation in Senegal - Degree of topsoil loss
Mauritania
Senegal
Mali
Gambia
Guinea-Bissau
Guinea
Atlantic Ocean
Legend
LADA

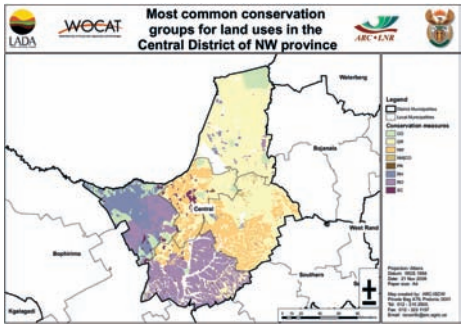

LADA
LAND USE SYSTEMS OF SENEGAL
N
Legend

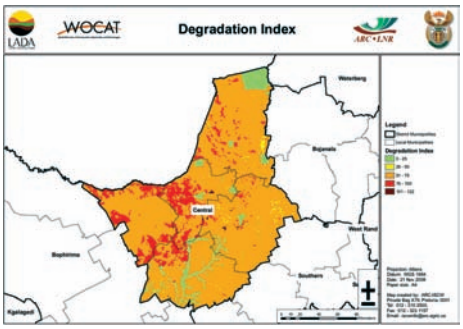
South Africa

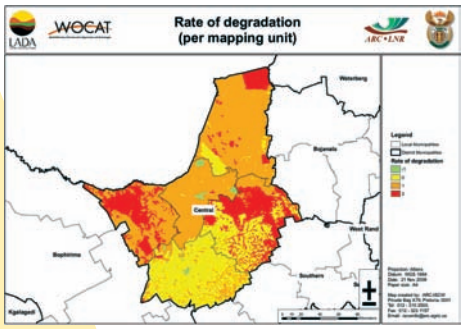


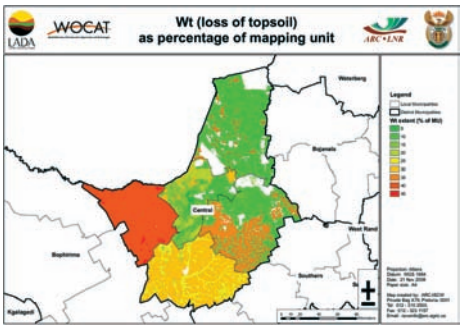



WOCAT
LADA
Conservation Index
ARC•LNR
Central
Waterberg
Bojanala
West Rand
Rustenburg
Southern
Kgalagadi

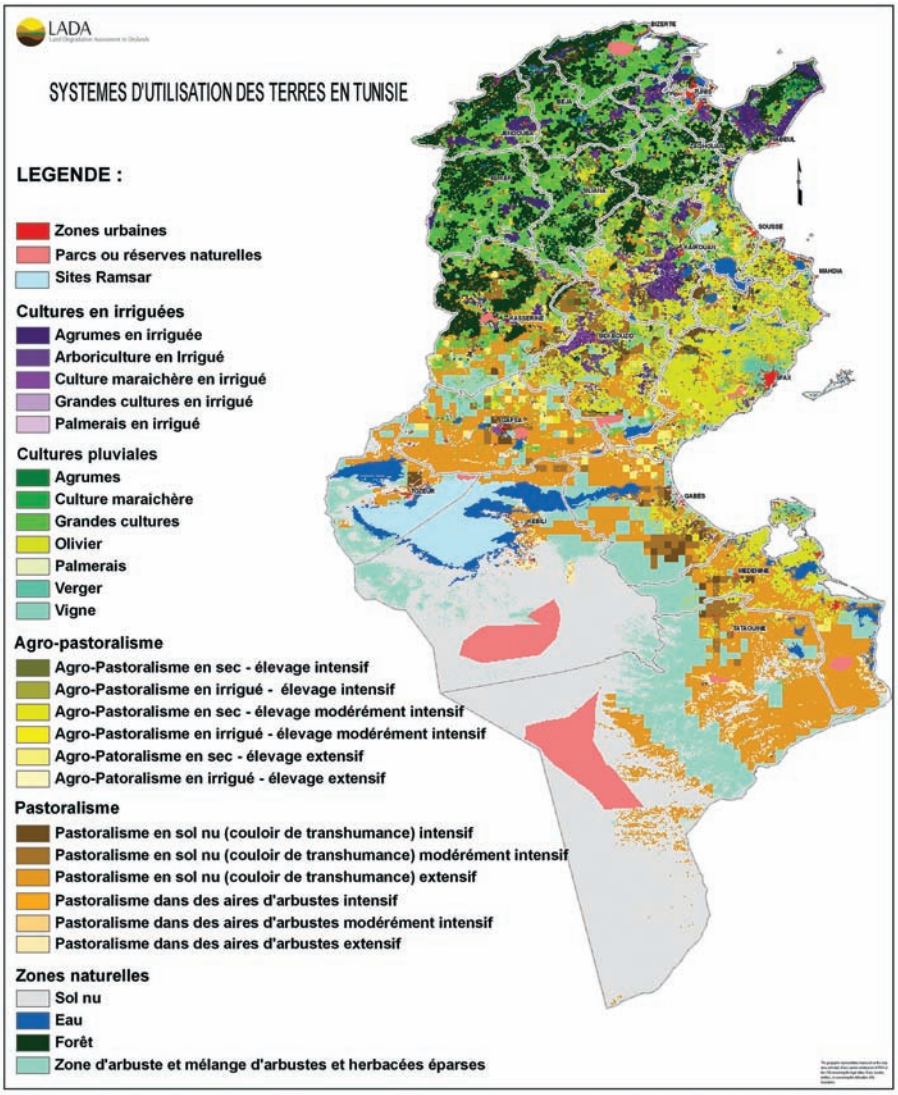

WOCAT
LADA
Most common conservation groups for land uses in the Central District of NW province
ARC•LNR
Central
Waterberg
Bojanala
West Rand
Rustenburg
Southern
Kgalagadi

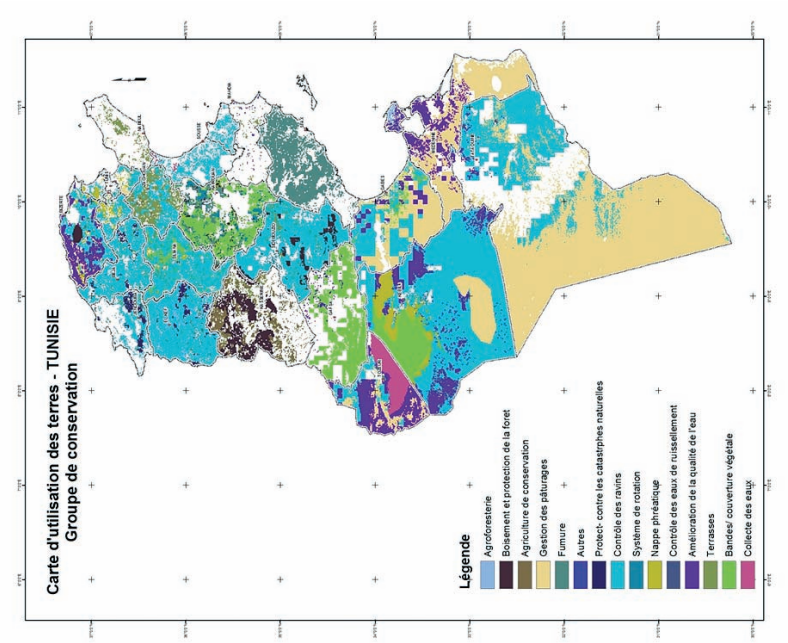

WOCAT
LADA
Degradation Index
ARC•LNR
Central
Waterberg
Bojanala
West Rand
Rustenburg
Southern
Kgalagadi

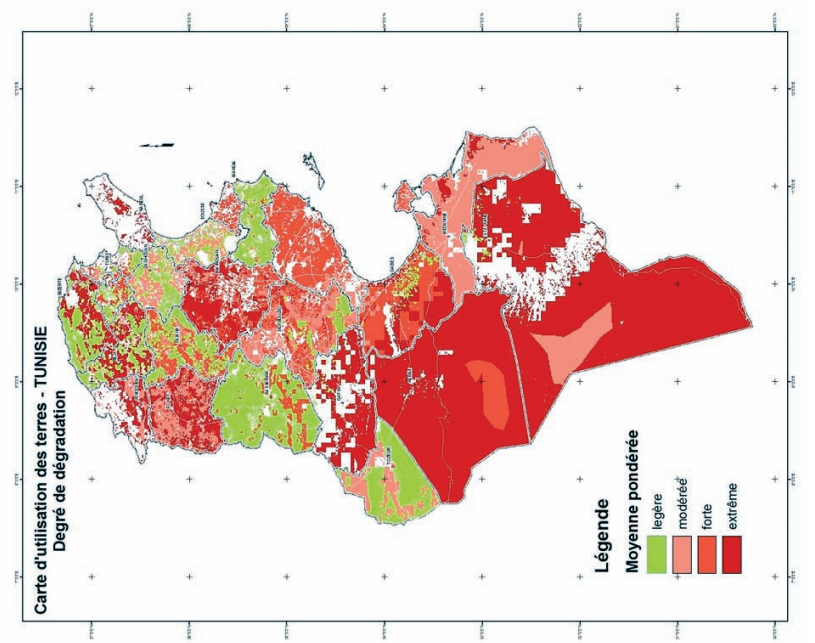

WOCAT
LADA
Rate of degradation (per mapping unit)
ARC•LNR
Central
Waterberg
Bojanala
West Rand
Rustenburg
Southern
Kgalagadi

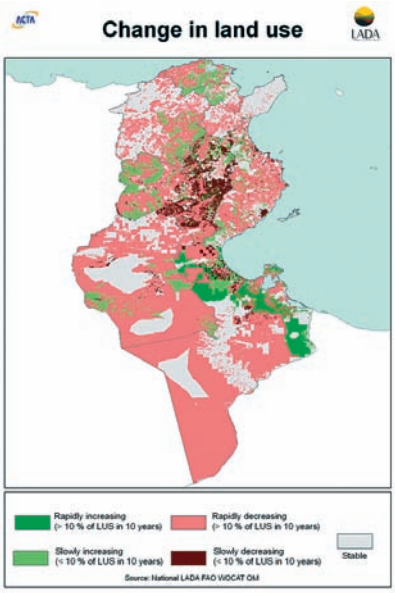

WOCAT
LADA
Wt (loss of topsoil) as percentage of mapping unit
ARC•LNR
Central
Waterberg
Bojanala
West Rand
Rustenburg
Southern
Kgalagadi

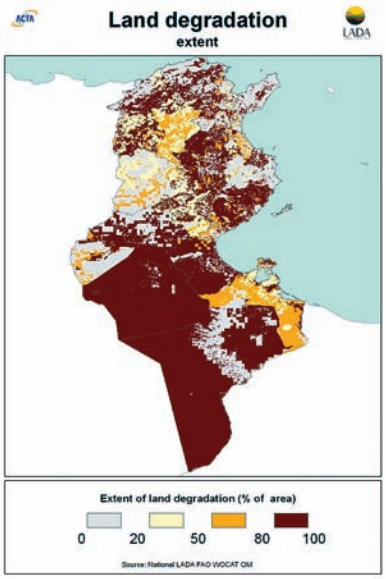
Tunisia

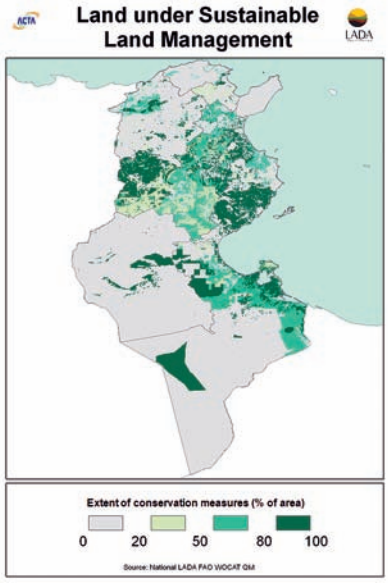

LADA
SYSTEMES D'UTILISATION DES TERRES EN TUNISIE
LEGENDE :
Zones urbaines
Parcs ou réserves naturelles
Sites Ramsar
Cultures en irriguées
Agrumes en irriguée
Arboriculture en Irrigué
Culture maraichère en irrigué
Grandes cultures en irrigué
Palmerais en irrigué
Cultures pluviales
Agrumes
Culture maraichère
Grandes cultures
Olivier
Palmerais
Verger
Vigne
Agro-pastoralisme
Agro-Pastoralisme en sec - élevage intensif
Agro-Pastoralisme en irrigué - élevage intensif
Agro-Pastoralisme en sec - élevage modérément intensif
Agro-Pastoralisme en irrigué - élevage modérément intensif
Agro-Patoralisme en sec - élevage extensif
Agro-Patoralisme en irrigué - élevage extensif
Pastoralisme
Pastoralisme en sol nu (couloir de transhumance) intensif
Pastoralisme en sol nu (couloir de transhumance) modérément intensif
Pastoralisme en sol nu (couloir de transhumance) extensif
Pastoralisme dans des aires d'arbustes intensif
Pastoralisme dans des aires d'arbustes modérément intensif
Pastoralisme dans des aires d'arbustes extensif
Zones naturelles
Sol nu
Eau
Forêt
Zone d'arbuste et mélange d'arbustes et herbacées éparses


Carte d'utilisation des terres - TUNISIE
Groupe de conservation
Légende
Agroforesterie
Boisement et protection de la foret
Agriculture de conservation
Gestion des pâturages
Fumure
Autres
Protect- contre les catastrophes naturelles
Contrôle des ravins
Système de rotation
Nappe phréatique
Contrôle des eaux de ruissellement
Amélioration de la qualité de l'eau
Terrasses
Bandes/ couverture végétale
Collecte des eaux


Carte d'utilisation des terres - TUNISIE
Degré de dégradation
Légende
Moyenne pondérée
legère
modérée
forte
extrême


Change in land use
Rapidly increasing (> 10 % of LUS in 10 years)
Rapidly decreasing (> 10 % of LUS in 10 years)
Slowly increasing (< 10 % of LUS in 10 years)
Slowly decreasing (< 10 % of LUS in 10 years)
Stable
Source: National LADA FAO WOCAT GM


Land degradation
extent
Extent of land degradation (% of area)
0
20
50
80
100
Source: National LADA FAO WOCAT GM


Land under Sustainable Land Management
Extent of conservation measures (% of area)
0
20
50
80
100
Source: National LADA FAO WOCAT GM

Future perspectives

Further action is now needed to facilitate take-up and application of the assessment methods and tools by other countries. This will provide the opportunity for further refinement of LADA methodologies, thereby improving knowledge of land degradation status and trends, also of the effectiveness of current measures to combat degradation, desertification and drought. This is urgently needed to fully integrate the monitoring and assessment of sustainable land management and the decision support process, so as to improve planning SLM interventions based on sound interdisciplinary knowledge and practice on the ground.

Upscaling of the LADA / WOCAT programme can be expected to deliver:

- increased country capacity to assess the status and effects of land degradation and sustainable land management and to implement SLM through wider application (mainstreaming) of LADA / WOCAT tools and methods into intersectoral and interdisciplinary processes
- targeted interventions to promote the adoption of SLM measures and to generate improved agro-ecosystem goods and services, including soil nutrients and carbon cycle, the hydrological cycle (water infiltration, retention and supply) and the sustaining of biological habitats and diversity at intra- and inter-species levels as part of the production landscape;
- reduced greenhouse gas (GHG) emissions from agriculture and increased carbon sequestration in land under SLM;
- reduced vulnerability of agro-ecosystems to climate variability and change through enhanced resilience of land-use systems to extreme weather events and changes in rainfall, hydrological and temperature regimes caused by long term climate trends;
- improved and sustainable livelihoods for people dependent on the use and management of land resources (soil, water, biodiversity);
- reduced vulnerability to the impacts of climate variability of people dependent on the use and management of natural resources in agricultural ecosystems;
- strengthened global and regional scientific reference-based information – with databases, knowledge sharing, technical support, capacity building, and adaptation of methods and tools to meet emerging needs.

This calls for concerted actions by donors and governments to make the required commitments and provide the necessary funds for the scaling-up of the use of LADA-WOCAT mapping, assessment, analytical methods and tools. Finance is a major constraint on progress for assessment and monitoring over the longer term, however the multiple products and decision support will more than justify the initial investment.

Also, action will be neededby the scientific community, which needs to further analyse the benefits and cost-effectiveness of the holistic, scientifically-based and multi-scale approach that LADA-WOCAT methods and tools provide, which have been shown to be economic, practicable and consistent.

Key findings about global land degradation (derived from GLADIS/GLADA)

The *incidence* of land degradation is highly variable. Degraded land occurs most in drylands and steep lands, which therefore merit special attention.

The *nature* of land degradation is also highly variable, it may take many forms, including poor and declining soil quality, biomass, biodiversity, also reduction in the economic and social services derived from the ecosystem. Ecosystems which have lower potential decline proportionately less than ecosystems with larger potentiality.

Land use is determined by natural conditions, culture and socio-economic factors, including institutional settings, infrastructure, education and market availability. Agriculture, namely cropping and livestock management, is the main cause of land degradation compared with non-agricultural uses. A wide range of natural and human factors contribute to land degradation, but as these are closely interwoven, it is difficult to distinguish the respective impacts of the different contributory factors.

Thirty percent of the earth surface is unpopulated, including areas covered by dense tropical forests and semi-deserts with sparse vegetation. Adding bare lands to this category increases the unoccupied area of earth's surface to 46 percent. Outside these areas, population seems to be disproportionately present in more degraded areas, suggesting an overall link between population pressure and the occurrence of more degraded land. Eventually, breaking points are reached where people are forced to leave very severely degraded areas, or to substantively invest to thereby reverse land degradation.

The picture in urban areas is more mixed. Urban areas occupy less than 3 percent of the land area, but contain nearly 40 percent of the world's population (based on year 2000 figures, though the proportion has risen since then). However, urban areas place heavy demands over hinterlands and rural areas to meet the needs for food, fibre, fuel, water and other services.

The economic costs of land degradation are significant in most developing countries and may be enormous if one considers the loss both of goods produced and also of the range of ecosystem services. However, quantification of the direct and indirect costs and their attribution to specific causes remains a major challenge because of the complexity of the human-natural interrelations at various temporal and spatial scales. The LADA methodology allows assessment teams to score the impacts of land degradation on the various goods and services, even though it does not pursue economic analysis of these effects.

DPSIR framework with national LADA indicators

STATE OF LAND DEGRADATION

- Type of land degradation (soil, biological, water)
- Degree of land degradation
- Rate of land degradation

DIRECT PRESSURES TOWARDS LAND DEGRADATION

- Land use area trend
- Land use intensity trend
- Crop management level
- Deforestation
- Over-exploitation of vegetation
- Overgrazing
- Industrial activities
- Urbanization
- Natural causes
- Discharge of effluents
- Washing out of pollutants
- Airborne pollutants

WIDER INFLUENCES ON LAND DEGRADATION: "DRIVING FORCES"

- Incidence of poverty/wealth
- Access rights/tenure
- Population density
- Labour availability
- Inputs and infrastructure
- Occurrence of conflicts
- Education, knowledge and access to support service
- Protected areas

IMPACTS OF LAND DEGRADATION

- Impact on ecosystem services
- Productivity decline
- Carbon storage loss
- Water availability decline
- Water quality
- Biodiversity decline
- Tourism

RESPONSES

- Macro-economic policies
- Land policies and policy instruments
- Conservation and Rehabilitation
- Monitoring and Early Warning Systems
- Commitments to international conventions
- Investments in land water resources

GLADIS ecosystem goods and services status, pressures and consequent land degradation process

	PRESSURES		
Status axis	**Natural**	**Human induced**	**Process axis**
Axis 1: Biomass status	Bush invasion (+) and Fire (-)	Deforestation (-)	**Axis 1: Biomass change**
Land Cover/Organic Carbon	Drought increase (-)	Other Land use change (-) or (+)	Greenness change / Deforestation rate
Axis 2: Soil health status			**Axis 2: Soil Health change**
Soil suitability for actual land use			
	Podzolization, Ferallitization, Salinization, Sodification, etc. (-)		
		Mechanization (-), Overstocking (-)	Compaction
	Steep Topography (-)		Water Erosion
	High rainfall Intensity (-)		Sealing, Water erosion
	Low soil resistance to erosion (-)		Water erosion
	Low land cover (-)	Land management (-) or (+)	
	Low soil nutrient stock (-)	Subsistence management (-)	Nutrient mining
		Use of very high inputs (-), Irrigation (-)	Pollution, Salinization
Axis 3: Water quantity status	Low water availability	Water use (-) or (+)	**Axis 3: Water resource change**
Amount per hectare per year	Drought increase		
Axis 4: Biodiversity status	Drought increase	Land use (change)	**Axis 4: Biodiversity threat**
Land cover		Legal protected area (+)	
Axis 5: Economic provision status	Ecosystem type (desert/ polar)	Land use choice	**Axis 5: Economic value change**
Crop value	Bush invasion (-)	Inputs/Management trend	Crop + Livestock gross value
Livestock value		Irrigation (+)	Forest gross value
Forest value		Economic supply/demand (+) or (-)	
Urban (100)			
Axis 6: Social provision status	None	Policies leading to HDI decline (-)	**Axis 6: Social services change**
Accessibility		Distance to markets (-) or (+)	Not yet available
Tourism			
Protected areas			

China – Sand dunes fixation
Photo: R. Biancalani 2011

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of the United Nations

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