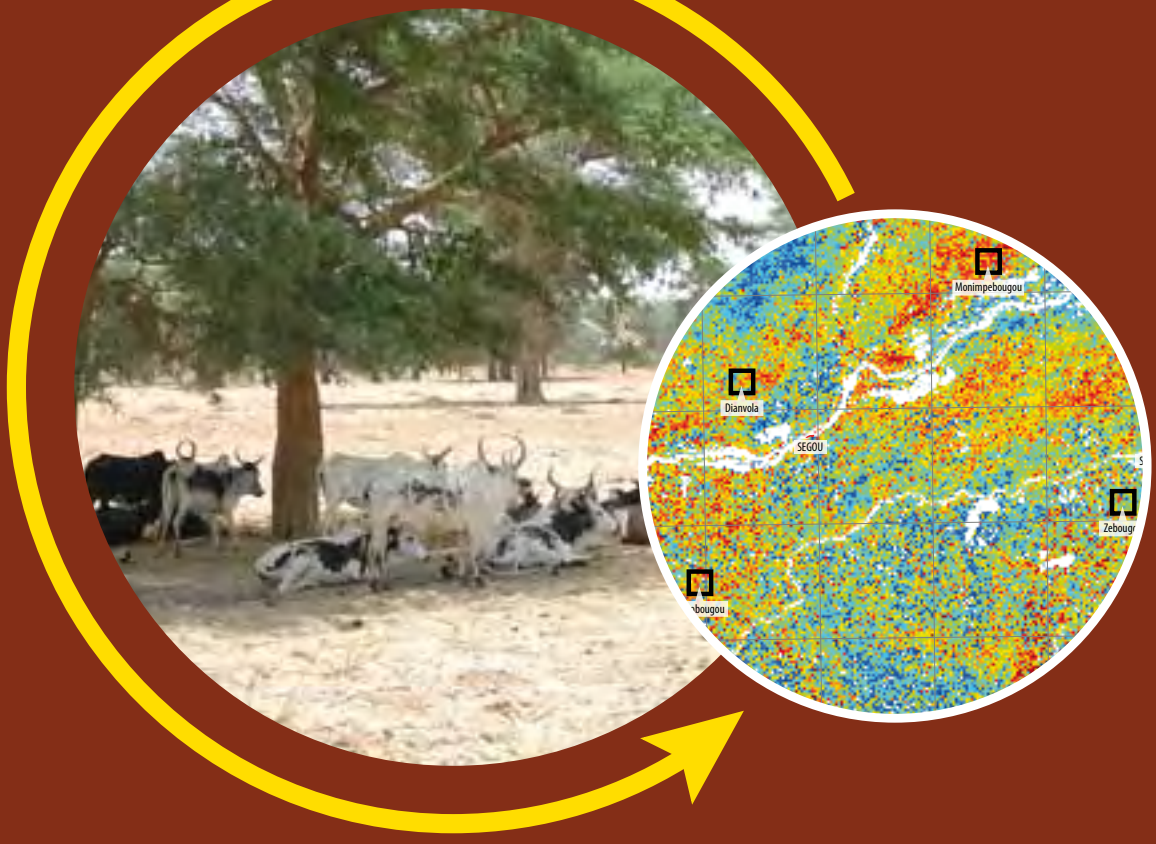
LAND HEALTH SURVEILLANCE

an Evidence-based Approach to Land Ecosystem Management

Illustrated with a Case Study in the West Africa Sahel

SUMMARY FOR DECISION MAKERS



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World Agroforestry Centre
TRANSFORMING LIVES AND LANDSCAPES

This Summary for Decision Makers synthesizes the findings of the main report: *Land Health Surveillance: An Evidence-Based Approach to Land Ecosystem Management. Illustrated with a Case Study in the West Africa Sahel*. United Nations Environment Programme, Nairobi.

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Contents

Abbreviations and acronyms

AVHRR	Advanced Very High Resolution Radiometer
DNCN	"Directorate for Nature Conservation, Mali"
IER	"Institut d'Economie Rural, Mali"
LAI	leaf area index
LDSF	Land Degradation Surveillance Framework
MDGs	Millennium Development Goals
MODIS	Moderate Resolution Imaging Spectroradiometer
NDVI	Normalized Difference Vegetation Index
*NDVI	Scaled NDVI
$NDVI_0$	bare soil value of NDVI
QB	Quickbird
RNNDVI	Rain Normalized NDVI
RUE	Rain Use Efficiency
SC	soil condition
SIMPLS	an algorithm for partial least squares regression
SOC	soil organic carbon
UN	United Nations
UNCBD	United Nations Convention on Biological Diversity
UNCCD	United Nations Convention to Combat Desertification
UNEP	United Nations Environment Program

Main messages

Livelihoods and economies in most developing countries depend critically on the ecosystem services that land provides. However, current information on land health and degradation is grossly inadequate for the task of planning and evaluating land management interventions. Policymakers and development agencies urgently need objective, quantitative, cost-efficient and practical assessments of land degradation and the associated risk factors to justify, target and prioritise investments. This report describes and exemplifies Land Health Surveillance – a science-based approach to land health assessment and monitoring designed to address this need.

LAND HEALTH SURVEILLANCE

- Land health surveillance is modelled on evidence-based approaches used in the public health sector, where surveillance is the main mechanism for determining public health policy and practice.
- Land health surveillance aims to answer many critical questions related to sustainable land management – where land problems exist; whom they affect; where programmatic and prevention activities should be directed; and how well they are working.
- This scientific and evidence-based approach sets out to (i) acquire statistically valid estimates of land health problems, (ii) quantify key risk factors associated with land degradation, and (iii) target cost-effective interventions to reduce or reverse these risks.
- The scientific principles of health surveillance emphasize:
  - Taking random samples from populations (units of land) so that unbiased prevalence estimates of health problems and their associated risk factors can be obtained.
  - Using standardized protocols and procedures for assessing health problems and for measuring associated risks so that results can be aggregated at different scales (e.g. district or watershed, national, regional).
  - Strategies for active dissemination of surveillance findings to different decision makers to ensure findings are used and to assess their impact.
- Regional surveillance is designed to identify degraded areas and provide early warning of land degradation, so that these sites can be screened for further investigation. Vegetation indices extracted from remote-sensing data are used as an indicator of land degradation, after controlling for temporal and spatial variations in rainfall.
- Sentinel site surveillance is designed to provide accurate baseline data and monitoring of land health and factors affecting it. A Land Degradation Surveillance Framework is described, based on sentinel sites consisting of 10 x 10 km blocks (or samples of the landscape), within which randomized sample plots are used for field characterization of vegetation and soil characteristics. The spatial sampling deign is also used for collecting socioeconomic data on people and livestock. Land health indicators and risk factors derived from the ground survey results are linked to fine resolution satellite imagery using statistical models, so that the indicators can be inferred for the whole area and mapped. These results are then used to spatially target and prioritize land management interventions.
- Enormous resource savings are possible from use of land health surveillance to spatially target and prioritize interventions. Knowing not only the size of the areas to be targeted with specific interventions but also their exact location enables the design of cost-effective development programmes with well-defined and quantified targets.
- Land health surveillance provides a scientific approach for evidence-based decision-making on land management and should be an integral part of development policy and practice in tropical developing countries.
- There is a new and revitalized role for land resource departments and a need for capacity building in the new surveillance scientific concepts, technologies and tools.

REGIONAL LAND HEALTH SURVEILLANCE IN THE WEST AFRICA SAHEL

- Debates on the degree, extent and causes of desertification in the Sahel have persisted for

almost a century and still remain unresolved. This uncertainty impedes policy development for sustainable land management.

- Current understanding of vegetation-climate relationships recognizes that long-term climate fluctuations are inevitable, but maintaining vegetation plays an important stabilizing role, by localizing rainfall and stabilizing rainfall levels between years, until a gradual change causes a new vegetation and rainfall regime to dominate. However, large decreases in vegetation can reduce resilience and lead to a change to a drier climate regime. Therefore maintaining good vegetation cover is important to avoid undesirable flips to a drier climate and to buffer against climate change.
- New analysis of vegetation growth from remote-sensing and rainfall data for 1982–2006 suggests that land over 50% of the area of the West Africa Sahel with annual rainfall less than 900 mm has degraded (95% certainty). The vegetation recovery since the droughts in the early 1980s has not matched the increase in annual rainfall.
- The Parklands (integrated tree-crop-livestock) ecosystem, located between 11° N and 15° N of the equator, has not degraded as much as surrounding areas. Maintenance of the Parklands is critical for stabilizing regional climate and provisioning of ecosystem services for livelihoods and economies.
- There is insufficient evidence to claim widespread positive impacts on vegetation recovery due to agricultural innovation. Further studies are needed to investigate positive trends in some agricultural areas but not others.
- Follow-up studies using finer-resolution satellite imagery and systematic ground sampling are needed to establish proper baselines and confirm and monitor trends. Large uncertainties will remain until this is done.

SENTINEL SITE SURVEILLANCE IN SEGOU REGION, MALI

- Segou Region includes predominantly pastoralist systems in the drier north, with 27% of the land area under cultivation, to agro-ecosystems in the south, where 73% of the land area is cultivated. These are predominantly Parkland systems. Population density in this area has more than doubled over the past 40 years, but 80% of the population between 15 and 65 years old are still illiterate and primarily depend on agriculture for their livelihoods.
- Semi-natural areas (not cultivated or managed) were identified as being prone to water run-off and soil erosion. Restoring woody cover in these areas is important to maintain overall ecosystem health. The semi-natural areas requiring increased woody vegetation cover make up between 19–42% of the whole landscape, but the areas with high inherent degradation risk, which should be accorded highest priority, make up less than 5% of the total area. Thus reforestation efforts can be accurately targeted to these areas. The surveillance results provide quantified targets for how many trees to plant where.
- The regional surveillance study pointed to the critical importance of maintaining vegetation cover in the Parklands ecosystem. The sentinel site surveillance provided accurate information on how many trees need to be planted where for enrichment planting to maintain optimal tree densities in the Parklands. These interventions will improve the resilience and adaptive capacity of the ecosystems and at the same time contribute to increased carbon sequestration for climate change management.
- Contingent valuation surveys identified the cost of tree seedlings as the key constraint on farmers planting more trees. Policies are needed to support cheaper production methods and extension of farmer tree nurseries.
- There is evidence for critically low soil fertility levels and widespread soil health degradation associated with current cultivation practices, threatening food security and soil-related ecosystem services. Low soil available phosphorus is a key fundamental constraint, but exchangeable bases and soil organic matter levels are also critically low for sustainable production.There is limited scope for increasing area under cultivation without further damaging ecosystems, due to the high soil degradation risk associated with inherent soil physical constraints in semi-natural areas. Thus it is imperative that soil health is improved in existing cultivated areas.
- Cultivated areas with no inherent soil physical constraints should be targeted for soil fertility replenishment programmes, centred on phosphorus applications. These areas comprise 31% of the total area and 50% of the currently cultivated area. Lower input conservation agriculture and agroforestry systems can be targeted to currently cultivated areas with high

inherent risk of soil degradation, comprising 7–21% of the area.

- Fertilizer response trials suggest soil fertility management will need to combine organic and inorganic inputs: strategies based on inorganic fertilizers alone may fail. Systematic testing of soil management options is urgently needed to provide a firm evidence base for intervention programmes.
- Maps at fine spatial resolution (2 m) are provided showing land health constraints and priority intervention areas for sentinel blocks. Key indicators are also mapped for Segou Region at medium spatial resolution (30 m).
- If the trends found in Segou Region are found to be representative of those across the Sahel, then there is a looming regional food security and environmental crisis, unless well-targeted land management programmes are put in place. Land health surveillance can speed reliable learning and increase efficiencies by targeting cost-effective interventions and assessing outcomes with scientific rigour.

Policy recommendations

Maintenance of the integrity of the Sahelian Parkland system is critical for regional food security, sustainable ecosystem management, climate change adaptation and mitigation, and economic development. Several key policy recommendations for sustainable management of the West Africa Sahel are synthesized below from this study. Investments in land health surveillance and management must become an integral part of national and regional strategies for economic development, poverty reduction, environmental management, and climate change adaptation and mitigation.

REGIONAL PRIORITIES

Establish and maintain regional and national land health surveillance systems to provide a scientifically sound and policy-relevant approach to land health management. Investments are needed to:

- Establish a regional-scale, synoptic early warning system based on MODIS satellite data, linked to systematic ground sampling.
- Implement a systematic ground sampling scheme based on the sentinel site protocols described in this report.
- Quantify behavioural risk factors associated with land degradation and identify population-wide interventions.
- Evaluate the cost-effectiveness of alternative population-wide interventions for reducing and reversing land health risks.

concepts and associated scientific and technical methods, including surveillance and sampling theory, remote sensing, geographical information systems, soil infrared spectroscopy, digital soil mapping, and advanced multivariate and hierarchical statistical analysis.

Specific priority areas for further research include:

- Developing improved remote-sensing indicators of land degradation and their validation through systematic ground observations.
- Further methods for spatial and syndromic land health surveillance, including incorporating uncertainty through Bayesian hierarchical modelling of land health surveillance data.

PRIORITIES FOR SEGOU REGION AND SIMILAR AREAS

To secure food production for rapidly growing population of the region, investments must be urgently targeted to improve soil fertility in areas with relatively high agricultural potential. These areas, which can be accurately mapped, make up only one third of the total land area and one half of the presently cultivated area. Investments needed are:

- Apply phosphorous fertilizers to overcome chronically low soil phosphorous levels, which currently pose a basic constraint to crop productivity.
- Promote integrated nutrient management to increase organic matter, nutrient retention, and basic cation levels as a foundation for sustained crop production. This includes improved