SYNTHESIS AND RECOMMENDATIONS

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INTRODUCTION

The 8th Conference of the Parties (COP8) of the UNCCD decided to strengthen the scientific basis underpinning the Convention and guided the Committee on Science and Technology (CST) to conduct its future sessions in a predominantly Conference format, addressing specified themes.

The theme *"bio-physical and socio-economic monitoring and assessment of desertification and land degradation, to support decision-making in land and water management"* was chosen as the first priority theme. The UNCCD 10-year Strategy (2008 – 2009 biennium) highlights the importance given to the development and implementation of scientifically-based and sound methods for monitoring and assessing desertification and underlines the need for a holistic view.

In order to prepare for the Conference, the Dryland Science for Development (DSD) consortium convened three global working groups of scientists to analyze and summarize the leading scientific knowledge on the priority theme in order to generate practical and actionable recommendations.

This document provides the key findings of the three Working Groups, organized by eleven key messages/recommendations.

1. **Desertification, land degradation and drought (DLDD) as defined by the United Nations Convention to Combat Desertification (UNCCD) results from dynamic, interconnected, contextual human-environment interactions — requiring the application of complex system science in monitoring and assessment.**

The text of the United Nations Convention to Combat Desertification places humans *"at the centre of concerns to combat desertification and mitigate the effects of drought"*. It notes that DLDD "*is caused by complex interactions among physical, biological, political, social, cultural and economic factors*", and is interrelated with *"social problems such as poverty, poor health and nutrition, lack of food insecurity"* and others. The UNCCD 10-Year Strategy reconfirms this mission orientation as reflected in its science- related Strategic Objectives (1-3) and their associated Expected Impacts.

To meet UNCCD expectations, therefore monitoring and assessment of DLDD must effectively address complex human-environment interactions. This is a formidable challenge. The analysis of complex systems lies at the frontier of earth systems science and global change science.

Monitoring and assessment procedures have so far been largely empirical and focused on the symptoms of DLDD rather than on the underlying drivers and processes. Only since the late 1990s have synergies between human and climatic drivers as well as the temporal and spatial scales of the phenomenon been integrated in these concepts and frameworks, building on the interrelationships within coupled human-environmental systems that cause DLDD.

Innovative assessment and monitoring concepts are required to translate these frameworks into concrete action. Building on recent advances in monitoring the state (condition) of land surfaces and its temporal trends (e.g. in the analysis of indicators of ecosystem health, in social, economic, policy and knowledge dynamics, and in restoration and preservation methods), advanced integration concepts and tools are needed to satisfy the request for efficient adaptation strategies and successful mitigation efforts.

Leading conceptual frameworks for analyzing complex DLDD information proposed in recent years include *DPSIR* (driving-force, pressure, state, impact, response initiated by OECD) and *the persistent reduction in the capacity of ecosystems to supply services* (Millennium Ecosystem Assessment 2005). The recent **Dryland Development Paradigm (DDP**) (Reynolds et al. 2007) attempts to synthesize this conceptual progress into an integrated framework centered on the coupling between human and environment systems as they co-adapt to each other in a dynamic fashion in drylands.

This progress in framing complexity in addressable ways is helping guide the development of holistic, yet scientifically-sound monitoring and assessment strategies and methods. While much more progress is needed, tools are available now that can significantly enrich the insights obtained from monitoring and assessment.

Following Reynolds et al. (2007), research and practice in these fields have increasingly converged on a set of general lessons concerning the condition and dynamics of Human-Environment systems that can form a conceptual guideline for more effective monitoring and assessment.

i. Both researchers and practitioners need to adopt an integrated approach: Ecological and social issues are fundamentally interwoven, as are the options for livelihood support and ecological management.

ii. There needs to be a heightened awareness of slowly evolving conditions: Short-term measures tend to be superficial and do not resolve persistent, chronic problems nor deal with continual change.

iii. Nonlinear processes need to be recognized: Dryland systems are often not in equilibrium, have multiple thresholds, and thus often exhibit multiple ecological and social states.

iv. Cross-scale interactions must be anticipated: Problems and solutions at one scale influence, and are influenced by, those at other scales.

v. A much greater value must be placed on local environmental knowledge.

This progress in framing complexity in addressable ways is helping guide the development of holistic, yet scientifically-sound monitoring and assessment strategies and methods. While much more progress is needed, a number of tools and methods are available already now that can significantly enrich the insights obtained from knowledge driven monitoring and assessment.

The foregoing discussion leads to the conclusion that DLDD cannot be measured in terms of a single numerical value. Nor can the need be met by index values calculated from mathematical combinations of qualitatively different parameters (e.g. soil erosion, human well-being, ecosystem resilience etc.), because these combine "apples and oranges" without reflecting the context-specificity and dynamism of each component.

2. **To be sufficiently realistic and insightful in the face of this complexity, monitoring and assessment must make use of a wide range of analytical methodologies, and distill their lessons into forms useful for decision-makers through integrated assessment modeling.**

People-centered monitoring and assessment of DLDD must deal with the reality that different stakeholders have different perceptions about land degradation. From an environmentalist perspective, the clearance of land for agriculture may represent degradation, whereas from a land-user perspective it may represent an improvement, because it changes the land in ways that yield more immediately-valuable agro-ecosystem services. Therefore the assessment of the biophysical condition of land must be complemented by an assessment of what that condition means to stakeholders.

Simple indicators only reveal a small part of the complex DLDD picture, and do not reflect the dynamic nature of human-environment systems co-adaptation and stakeholder's perception of land condition. To reduce costs of data collection, institutions sometimes seek indicators from readily-available non-DLDD databases (e.g. water, environment, agriculture, health sectors), but a consequence is that they only partially and indirectly relate to DLDD.

Due to these limitations, monitoring and assessment based on a minimum indicator set may be only a starting point for assessing the broad impacts of the UNCCD's implementation. Rather than fixed indicator sets alone, the UNCCD community should make progressively greater use of the full toolbox of analytical methods that are available within the framework of a carefully-planned, holistic, multi-scalar monitoring and assessment regime. This will enable the more flexible and insightful use of indicators attuned to the intent of the UNCCD.

Proven techniques already exist within the methodological realms of field research and case studies, modeling, mapping, diagnostics, scenario analysis, participatory analysis, cost-benefit analysis, trend analysis, development pathway analysis, knowledge systems analysis, stakeholder analysis, sustainability analysis and many others. The application of multiple knowledge sources also helps to 'triangulate' the investigation in order to more accurately and fully characterize the entity that is being monitored and assessed.

Given the complexity of DLDD, the use of expert knowledge (including that of land users) will remain a valuable component of monitoring and assessment. Expert knowledge can integrate and compare complex information in ways that lie beyond the capabilities of analytical instruments, but needs to be framed by commonly agreed criteria and principles of judgment procedures. Furthermore, expert knowledge needs to be incorporated in analytical methods. Several systematic methods are at hand and experience has been gained in the field of DLDD. When stakeholders and decision-makers with diverse backgrounds participate in the conceptual stage of formulating a model, this tends to reduce ambiguities and logical inconsistencies and focus attention on the main processes and state variables most crucial to the DLDD problem at hand.

Through the analytical methods listed above, a wide range of complementary information can be generated that then needs to be integrated. 'Integrated assessment models' serve this purpose, particularly linking the human and biophysical dimensions of DLDD in ways that generate useful knowledge for decision-makers. Integrated assessment models improve the quality of discussions in support of decision-making because they allow the scientific exploration of the complex interactions that occur in human-environment systems. They reveal information such as policy and decision trade-offs and consequences, stakeholder negotiation outcomes, risks, uncertainties and vulnerabilities, and ranking of choices among competing priorities.

Practical examples of first steps to implement these concepts at larger, quasi-operational scales are, among others, initiatives such as WOCAT, LADA and ACRIS which are described further in item 3 below.

3. Public land use and land management decisions are mainly taken at national and sub-national levels, so a UNCCD global monitoring and assessment strategy should be designed to be compatible and synergistic with other scale levels.

Decision-makers at all scale levels need to know, but in differing degrees of detail:

i. The nature (e.g. erosion, productivity decline, bush encroachment etc.), spatial distribution, severity and extent of DLDD and trends over time. This requires a baseline against which to monitor change, and periodic re-observation and assessment to determine the direction and rate of change.

ii. The causes of DLDD. Both social and environmental drivers need to be considered, as do influences arising from other scale levels.

iii. The risk of DLDD occurring in areas currently not affected.

iv. Actions that can counter DLDD, and their outcomes and impacts.

v. The benefits/costs (both monetary and non-monetary) of doing nothing, versus those of preventing or correcting DLDD problems.

Since policy and institutional decision-making authority is usually concentrated at national and sub-national scales in most areas of the world, DLDD monitoring and assessment information needs to especially provide the degree of detail needed by decision-makers at those levels.

Much of the global-level DLDD information desired by UNCCD can be built from careful analysis of such national and sub-national information, as long as compatible protocols and standards are used. Therefore, efforts are needed to ensure compatible, useful and scientifically-valid standards and protocols for monitoring and assessment across scale levels. This harmonization is a contribution that the UNCCD's science partners can make, with UNCCD endorsement.

The DDP conceptual framework described earlier asserts that *"coupled H-E systems are hierarchical, nested, and networked across multiple scales"*. While bearing scale-specific characteristics, dryland social, economic and ecological systems are also linked through social networks, communications and infrastructures to other scalar domains (Stafford-Smith et al., 2009). Cross-scale linkages of stakeholders require particular attention not only at the institutional level but also for data and information transfer across other scale dimensions.

Building on these social implications, this DDP principle recognizes that the issue of scale is crucial for monitoring and assessment strategy. Key ecosystem services offer a consistent set of themes across scale, eventually emphasized differently at the various scales, to nest key variables in order to up-scale data meaningfully. Based on scoping local knowledge and integrated assessment model s, conceptualized knowledge on the particular DLDD situations and H-E processes for each scale and location can determine the most important variables to monitor.

These variables comprise internal controlling drivers, such as water availability and stocking rates at household or communal level – at that scale these are often perceived as 'fast' changing - and external drivers resulting from processes at a higher scale, e.g. landscape functions, land use and climate change, at national and global scales - usually these are perceived as 'slow' at the household scale. Nesting 'slow' variables in consistent themes permits some data and information to be scaled-up in a diagnostic and coherent way that relates to persistent changes in ecosystem function. This architecture should best be designed using insights provided by the syndrome approach.

At the global level Geist and Lambin (2004) surveyed 132 desertification case studies and identified typical repeating causal patterns, resolving into four major proximate causes explained by six major underlying drivers. In a similar, albeit broader concept, Schellnhuber et al. (1997) hypothesized that a mere sixteen syndromes (bundles of interactive processes and symptoms) might explain all major global environmental change phenomena, including those related to DLDD.

The effect of cross-scale interactions on dryland systems down to local scale and the need to focus on appropriate slow variables to determine the state of co-evolutionary systems has been described in several studies in Niger, China, Australia (Stafford-Smith et al. 2009). Numerous studies of smallholder farming systems in Africa have observed that the great diversity of soil conditions can often be resolved for purposes of analysis into a small number of land states and trends, e.g. resulting from patterns of transferring scarce nutrients from outer fields to those near the household in order to increase the yields of the most important food crops — although the story does not end there. Influences from other scale levels such as global trade and development policies affect decision-making by such small-scale farmers (Scoones 2001).

It is this conceptual description of scalar influences on H-E processes, hierarchically linked through a consistent set of themes that provides strategies for designing monitoring needs and for scaling the assessment information. Such strategies can greatly increase the power and cost-effectiveness of monitoring and assessment activities. Rather than collecting large, comprehensive sets of indicator data in all locations including many variables that are only relevant to a subset of locations, monitoring and assessment teams can focus on the key nested variables, patterns and syndromes that can be meaningfully linked across scales.

A number of recent, pilot-scale monitoring initiatives are currently establishing multi-scale systems for knowledge gathering, monitoring and analysis. Multi-temporal analysis of remote sensing data is increasingly integrated with interpretation schemes based on conceptual models of H-E systems (Hill et al. 2008). The ARIDnet network is exploring the application of H-E systems principles in several Latin American countries (www.biology.duke.edu/aridnet/index.html). The challenge of linking local level approaches to national and higher scales is addressed by Reed et al. (2008).

WOCAT (World Overview of Conservation Approaches and Technologies, www.wocat.net) has developed methods and tools to document and evaluate SLM technologies and approaches at local levels and to assess their dissemination to sub-national or national levels. Recently, these case studies have been integrated into a participatory process of identifying and selecting best-suited implementation measures. WOCAT's mapping method has been further developed and tested together with the LADA (Land Degradation Assessment in Drylands) project coordinated by FAO. Similarly, Australia has launched ACRIS (Australian Collaborative Rangeland Information System) which addresses H-E interactions in the assessment of national rangeland states and trends.

These frontline applied research initiatives provide excellent building blocks that can blend with emerging advances on integrated assessment models and novel knowledge management techniques.

4. Addressing the UNCCD's core mission to *combat* desertification, prospective solutions to DLDD such as sustainable land management should be fully integrated into DLDD monitoring and assessment.

Historically, monitoring and assessment emphasis has been placed on delineating the nature and extent of the *problem* of DLDD. Noting that the title of the UNCCD expresses a mission to ***combat*** desertification, it would also be appropriate and desirable to place a strong emphasis on the monitoring and assessment of *solutions*. LADA for example has drawn heavily on WOCAT and DESIRE methodologies to broaden its monitoring and assessment regime to include sustainable land management solutions, as mentioned in item #3 above.

Information on the progress of solutions to DLDD will be valuable to those who are investing in such solutions or are considering doing so, and could spark greater support for the UNCCD. It will also enable them to identify corrective actions if needed to improve progress. Sustainable land management (SLM) solutions, for example form the core strategy of the Global Environment Facility

(GEF)'s Land Degradation Focal Area. Since its inception, GEF has invested $792 million in projects and programs supporting SLM to combat DLDD and deforestation (www.theGEF.org). GEF is developing monitoring and assessment procedures to track SLM gains and benefits resulting from these investments (KM: Land Project, http://www.inweh.unu.edu/drylands/KMLand.htm).

A working definition of SLM suited to the UNCCD's human-environment interactions perspective might be *"Land managed in such a way as to maintain or improve ecosystem services for human well-being, as negotiated by all stakeholders"*. Observations of land cover, land use and land management systems provide entry points for monitoring and assessing the sustainability of land management, i.e. determining whether soil, water, nutrient, vegetation and other sustainability-determining assets are being managed in ways likely to support their continued viability.

However the judgments of stakeholders may differ on the preferred configuration and magnitude of different assets and the services that ecosystems produce; some may benefit more from farmland, others from rangelands, and still others from wild lands, for example. Each land use system can be managed sustainably or un-sustainably within its own context; such context must be considered in SLM monitoring and assessment. Participatory monitoring and assessment involving a representative range of stakeholders is therefore required.

Water is a major constraint for SLM in drylands. The potential for irrigation development is hampered by many issues (cost, secondary impacts etc.). Local knowledge is a rich source of ingenious water-harvesting solutions. Adaptation of agricultural species and management practices is often the only feasible solution, but is only a partial one. Drought can erase hard-won development gains and makes land users risk-averse, inhibiting SLM investments. Social safety nets and alternative livelihoods have an important role to play in reducing vulnerability. Water status and drought vulnerability are important SLM-related dimensions of monitoring and assessment.

SLM requires a balancing of system inputs and outputs such as nutrients needed for vegetative growth. Purchased inputs can replace those exported from the farm but in a long-term global perspective this strategy creates concern, so this issue should be monitored and assessed. Economic forces may push purchased inputs beyond the reach of many dryland poor; prices of key fertilizers are likely to climb steeply in the coming decades due to high costs of energy used in nitrogen production and diminishing global supplies of phosphorus. Strongly negative continental nutrient balances have been estimated for sub-Saharan Africa. Nutrient losses also create pollution problems in downstream ecosystems.

Nutrient monitoring and assessment however can be costly and is plagued by spatial variability. Infrared (IR) spectroscopy is an important advance that provides rapid, low-cost measurements of several nutrients that is now being applied for continental-scale soil health surveillance through the Africa Soil Information Service (www.africasoils.net).

Low soil carbon content is a widespread constraint in drylands, limiting productivity through a number of biophysical mechanisms. Models available today can provide valuable indications of carbon states, trends and impacts, but continued improvements are needed to increase accuracy and precision in drylands. SLM practices can increase soil carbon content, but scarcities of nutrients and water as well as economic drivers tend to constrain the achievement of this potential.

Additions of carbon to dryland soils in the form of 'biochar' may hold potential for improving productivity in sustainable ways; this hypothesis needs to be urgently tested. Additions of biochar would simultaneously combat climate change and generate renewable energy (see http://www.biochar-international.org). Its economical viability needs to be considered and precautions taken to avoid it becoming a driver of deforestation. Biochar can be easily monitored, since known quantities would be added to known areas of land.

5. DLDD monitoring and assessment should include the collection of information relating it to climate change and biodiversity loss, and to other land-related issues that are the focus of Multilateral Environmental Agreements.

The global environment is deteriorating in a number of interrelated ways that have triggered international action through Multilateral Environmental Agreements (MEA). While the UNCCD brings focus to the issue of DLDD, land dynamics also impact the issues of its sister Rio Summit MEAs (the United Nations Framework Convention on Climate Change - UNFCCC, and the Convention on Biological Diversity -CBD). Land issues also impact the topical areas of the Ramsar Convention on Wetlands (1971), the World Heritage Convention (1972) and the Convention on Migratory Species (1979).

The interconnections between DLDD, climate change and biodiversity loss were highlighted by the Millennium Ecosystem Assessment (MA Desertification Synthesis 2005). MA notes that drylands, which cover a third of the earth's land surface, hold more than one-quarter of the world's organic carbon stores and that DLDD causes the release of an estimated 300 million tons of carbon into the atmosphere annually. The loss of vegetation due to DLDD exposes the soil to erosion and disables the recycling of nutrients, further degrading biomass productivity. These effects also degrade habitats and adaptation conditions needed to support diverse plant and animal species. Less vegetation results in increased surface albedo (reflection) and dust, which may affect the climate at local and global scales. Dust can also affect other ecosystems and human health.

These interconnections also imply strong positive synergies are achievable from actions that counteract DLDD. For example increases in carbon sequestered in soil also increase crop yields and therefore food supplies and food security, while also increasing land cover, reducing soil erosion.

The future adoption of carbon-enhancing and sequestering SLM practices is likely to be strongly driven by economic incentives such as carbon credit policies currently under global discussion. These social forces should also be monitored and assessed in order to inform DLDD decision-making so that effective carbon policies are devised and implemented.

Natural biodiversity supports crucial ecosystem services related to DLDD such as nutrient cycling, erosion control, water flow moderation and purification, pollination, pest control, energy (fuelwood), structural materials, medicines, herbs, foods, ecotourism and esthetic value, among others. Agricultural biodiversity particularly supports food and feed supplies, livelihoods and income, pest and disease management, and the sustainability of land use systems. Wild species related to cultivated crops serve as a source of valuable genetic variation for plant breeding. The loss of habitat and migratory pathways and services for fauna can degrade ecotourism value.

The clearance of land for agriculture can be considered as a DLDD dynamic that usually results in a large reduction in biodiversity. Agricultural development strategies need to be designed in ways that minimize that damage, for example via the 'ecoagriculture' concept (www.ecoagriculture.org) and others. Local knowledge can often reveal the value of biodiversity components that are not familiar to commercial market channels. Even when value is uncertain, the extinction of biodiversity components would be irreversible so a precautionary approach should be taken in adherence to Principle 15 of the Rio Earth Summit (UN Conference on Environment and Development, 1992) and other international agreements.

Monitoring and assessment data is essential for biodiversity conservation. The 2010 Biodiversity Indicators Partnership (2010-BIP, www.twentyten.net), for example is producing global-scale, DLDD-relevant indicators aiming to significantly reduce the rate of biodiversity loss by 2010., many of which are also applicable at regional, national and sub-national scale.

Climate change and human activities will alter habitats resulting in shifts in species and in gene frequencies for adaptive traits (e.g. heat, pest and disease resistance, etc.) Some changes may be too rapid for evolutionary adaptation, causing thresholds to be crossed that can destabilize ecosystems in disastrous ways e.g. by causing massive pest/disease epidemics, fires, and shifts in dominant species. Such disasters can debilitate carbon sequestration, nutrient recycling and other ecosystem functions, generating feedback loops that further aggravate climate change and DLDD. An example that has degraded many dryland areas is the encroachment of woody shrubs into rangelands. Monitoring and assessment tools are needed that can foresee such risks and thresholds to provide early warnings for decision-makers.

6. **To aid in priority-setting by decision-makers, monitoring and assessment should collect information on the costs of DLDD, and the benefits of combating DLDD.**

National decision-makers are flooded with urgent demands for action on a wide range of issues, and must make choices among them. A major factor influencing those decisions is the prospective return on investment, as demonstrated by the impressive impacts of the "Stern Review on the Economics of Climate Change" and highly anticipated impacts of the "Economics of Ecosystems and Biodiversity" on decision-making by governments.

Due to insufficient data, DLDD-related benefit/cost analyses are few and based on coarse assumptions. This shortcoming is unfortunate, because combating DLDD in principle should yield very significant returns on investment. The benefits/costs of monitoring and assessing itself (as advocated in Recommendation 1) should also be delineated, so that Parties gain a clear rationale for engaging in this activity.

Sustainable land management (SLM) interventions can transform DLDD losses into gains by raising incomes, reducing vulnerability to climatic fluctuations, and extending the productive use of land well into the future. Other means of combating desertification and sustaining livelihoods can also deliver important benefits (e.g. land rehabilitation, carbon sequestration, ecotourism, off-farm employment etc.)

An accurate benefit/cost analysis must consider the value of environmental services, whether or not a mechanism exists for actual monetary payments for their use. Not all values (benefits or costs) are monetary; the land provides a range of ecosystem services that benefit humans in both tangible and intangible ways (e.g. for cultural and spiritual services).

Much research is underway globally to establish values of ecosystem assets, goods and services (and the loss of them e.g. due to DLDD) including both monetary and non-monetary values. Valuation of biodiversity has made particular progress. The principles can be extended in straightforward manner to other DLDD assets, goods and services.

Even when no fees are paid for ecosystem services, revealed preferences of economic agents can be observed to directly estimate values. Such methods include public pricing, avoided-damage values, replacement / substitution costs, travel expenditures to a site to gain ecosystem services, mitigation costs, hedonic pricing, contingent valuation (willingness to pay for a service), local group evaluations and others.

Where economic agents cannot be directly observed, indirect valuation is used. This approach assigns a monetary value to the damage caused by land degradation using dose-response and replacement cost methods. For example, the cost of fertilizer is a way to estimate the value of the losses of soil fertility that it replaces.

A benefit/cost analysis leads naturally to an examination of the potential for payments for environmental services (PES). Candidate ecosystem services most frequently mentioned for potential PES are i) watershed protection, ii) biodiversity conservation, iii) landscape aesthetics, and iv) carbon sequestration. More than 400 PES schemes are currently under operation in many countries with public-private partnerships (not only in drylands).

International payments for carbon sequestration (IPES) linked to the proposed REDD mechanism under the UNFCCC could generate financial resources for dryland countries. Forgiveness of debt by lending nations in exchange for protection of ecosystems by developing countries (debt-for-nature swaps) and microcredit to stimulate sustainable livelihoods are related opportunities for financing efforts to combat DLDD.

7. Monitoring and assessment should utilize knowledge management approaches to stimulate valuable synergies between different sources of expertise across scale levels, social settings, institutions, scientific disciplines and development sectors.

The complexity of DLDD demands monitoring and assessment approaches that are richly based in knowledge. Since many diverse interests (people, governments, and institutions) hold stakes in land issues, monitoring and assessment must utilize multiple knowledge sources at different scales. Knowledge management (KM) addresses the conservation, access to and sharing of knowledge.

KM requires an understanding of how people learn in different settings (institutional, cultural, social) and overcoming barriers to that sharing and learning. A vast literature has developed on how learning occurs or fails to occur in such settings. Much is known about the role of social networks, communities of practice, knowledge brokering and the role of intermediaries in the sharing of knowledge. Agent-based models have been developed that explain how knowledge flows (or becomes sequestered) within social networks depending on behavioral characteristics.

As societies develop, the erosion of local knowledge is an especially urgent concern, particularly with respect to land management. Attempts to conserve local knowledge in databases have led to disappointment; knowledge tends to preserved, developed and shared only when it is used. In practice, much knowledge exchange takes place during knowledge generation itself, dissolving the boundaries between knowledge production, transfer and application. Research in Namibia for example found that land users had a deeper understanding of causes and effects of environmental change and a richer set of indicators compared to those monitored by the formal sector. In Australia, Aboriginal knowledge has repeatedly exposed the limitations of short-term ecological research paradigms.

By hybridizing local and scientific knowledge, more effective monitoring and assessment can be achieved. In Namibia, indicators identified by local farmers based on their information needs are monitored by the famers themselves; experts from the formal sector help to analyze and interpret their data and work with them to identify options to deal with rangeland problems. This approach is captured within a systematic framework for DLDD monitoring, assessment and remediation by Reed et al. (2006).

A variety of methods exist for evaluating, combining and integrating local and scientific knowledge. However, the use of these tools is often inhibited by institutional, cultural, scale-level, language and other boundaries that inhibit knowledge flows. ‘Boundary organizations’ have emerged in an attempt to straddle these barriers.

For example, the global Drynet network acts as knowledge broker between organizations interested in dryland degradation and SLM. In Namibia, the Forum for Integrated Resource Management (FIRM) fosters knowledge exchanges between farmers and those who provide services to them. The EC MEDRAP Concerted Action (2001 – 2004) promotes knowledge exchange between the UNCCD institutional community and the scientific research community in Greece, Italy, Portugal, Spain and Turkey. WOCAT (described earlier) performs a clearing-house function for sustainable land management approaches while at the same time serving as a network of experts and practitioners at the national, regional and international scales, facilitating expert knowledge exchanges through direct contacts.

The effective storage and dissemination of knowledge requires bodies that carry out knowledge clearing-house functions. The Sahel-Sahara Observatory (OSS) launched an initiative in 2000 called Desertification Information Systems – Environmental Information (DIS-EISI). DIVERSITAS carries out such a role in the field of biodiversity as well as utilizing that knowledge to develop science plans and to communicate policy implications to decision-makers.

The use of monitoring and assessment knowledge within the UNCCD and related bodies poses challenges. The implementation of MEA obligations by national governments has been constrained by limited financial and human resources. Although there is wide agreement on the need for more coherence in the implementations of the Rio Multilateral Environmental Agreements, this has been difficult to put into practice. Within the UN system, numerous organizations and specialized agencies work on different aspects of DLDD, including FAO, UNDP, UNEP, WMO, the World Food Programme, UNESCO, the CSD, UNFF, and the General Assembly, as well as the donor agencies that support their work, e.g. IFAD, the World Bank, GEF, and the regional development banks. Knowledge-sharing between these institutions needs to be improved.

The 7th Millennium Development Goal requires countries to integrate (mainstream) the principles of sustainable development into their policies and programs – a knowledge flow gap confounded by many institutional obstacles. However the National Action Programmes (NAPs) developed by many Parties to the UNCCD have yet to be mainstreamed in most cases. Tunisia is an exception; its efforts to combat desertification are now embedded in the country's social and economic development plans. Swaziland has also established its NAP within the National Development Strategy, the Swaziland Environment Action Plan, the Poverty Reduction Strategy and Action Plan as well as in other strategies.

8. Knowledge-sharing science can simultaneously enhance monitoring and assessment while also strengthening human and institutional capacities.

The overarching constraint reported by ministries, agencies, NGOs, scientists, research projects and others in developing countries and identified by virtually all studies and reports on the implementation of Multilateral Environmental Agreements, is a lack of adequate institutional, financial and human capacity to adequately address physical, human resources and skills requirements. Capacity affects responses to and the effectiveness of monitoring and knowledge exchange, along with the ability to effectively implement treaties.

Knowledge management can help overcome this constraint if barriers to knowledge-sharing and knowledge management between local, national, regional and international scales are eased. Capacity building needs to be cross-sectoral to overcome past shortcomings in addressing the complexities of DLDD, including the need to mainstream actions into government agendas, analyses, frameworks and policies.

In addition capacity building needs to foster greater collaboration and coordination of activities at regional, national and local levels. A pre-requisite to such capacity building would involve strengthening national/regional academic curricula on dryland science for development, thus training the decision makers of tomorrow and supporting strong ties between research and policy communities on sustainable dryland development.

The monitoring and assessment process itself acts as a capacity-building function as diverse stakeholders share their expertise and knowledge about the conditions and trends of land. Knowledge from different scale levels, including local knowledge brings new and enlightening perspectives to the other stakeholders. The integration of monitoring and assessing both the problem of DLDD and its solutions, as discussed earlier, provides a mechanism for not only building capacities but also for leveraging them into actions to solve DLDD problems.

Capacities should be built in a way that strengthens existing institutions in affected countries, increasing the acceptance of the continuing need for monitoring and assessment activity. For example, the BIOTA AFRICA project has trained local 'para-ecologists' to carry out degradation assessments and monitoring using knowledge-sharing methods that inform local management decisions; they become key knowledge-sharers in their communities. LADA is strengthening monitoring and assessment agencies in major dryland zones on three continents by developing regional training centers within national institutions.

9. **Coordination and dissemination of new knowledge and methodologies for integrated approaches to DLDD requires the establishment of an international, inter-disciplinary scientific advisory mechanism that would include (but not be limited to) monitoring and assessment, with clear channels for consideration of its advice in Convention decision-making.**

The breadth of scientific studies on DLDD is rapidly expanding the knowledge resources and toolkits available to make fresh progress against this difficult problem. These emerging opportunities need to be identified, evaluated and utilized on a continuing basis in ways that best support the UNCCD's mission.

The UNCCD has taken an important first step in this direction through the organization of its First Scientific Conference. However, conferences may not be the optimum vehicles for providing ongoing scientific advice, building scientific knowledge bases, and carrying out in-depth assessments and analyses. To provide the continuity, breadth and depth of support that the UNCCD's mission requires, an ongoing, independent, scientifically-credible mechanism is needed.

Such a mechanism should be policy-relevant but not policy-prescriptive. It should allow decision-makers to be objectively informed about the likely consequences of different policy and implementation choices they might make.

The value of such a mechanism will depend on the degree to which it is perceived by the world as scientifically credible. To be credible, it must be transparently free of non-scientific influences, and thus managerially independent from the political process of the UNCCD. It must base its analyses on evidence that is verifiable, and subject its conclusions to widely-recognized science quality control processes such as peer reviews.

The mechanism should not conduct research itself, but should draw from scientific knowledge and research findings that are continually emerging from the thousands of institutions and agencies worldwide that address different aspects of DLDD by tapping organized knowledge sources, where these exist (see item 11), and link to capacity-building efforts (see item 8). It should interact closely with national and regional science mechanisms that address DLDD.

10. In order to propel principles into action, regular global DLDD monitoring and assessment mechanisms should be organized and implemented based on agreed standards and protocols, harmonizing with other efforts worldwide and minimizing duplication of efforts.

A mechanism is needed to implement the modern principles of DLDD monitoring and assessment described in this document. The UNCCD is the only one of the three Rio Conventions that is not supported by a dedicated observation system. The UNFCCC benefits from the Global Climate Observing System (GCOS) and the CBD is supported by the GEO BON system within GEOSS (Global Earth Observation System of Systems, www.earthobservations.org). These facilitate the integration and inter-operability of existing observation networks and enhance the credibility of these two Conventions. These systems were launched in response to the 2002 World Summit on Sustainable Development and given impetus by the G8 group of leading industrialized nations.

In similar fashion, many DLDD scientists have urged for the establishment of a Global Drylands Observing System, or GDOS to support the UNCCD. The GDOS concept would avoid replicating or duplicating existing monitoring and assessment systems; rather it would integrate and harmonize them, developing agreed standards and protocols which, as discussed earlier are essential for an integrated global assessment. A GDOS-type mechanism would synthesize and build on learning gained from pioneering DLDD monitoring and assessment initiatives such as ACRIS, ARIDnet, AGRYMET, Asia-TPN1, BIOTA AFRICA, DESIRE, DISMED, GLASOD, GLP, GTOS, LADA, ROSELT/OSS, WOCAT and others. It would provide a platform for the continued evolution of monitoring and assessment systems, for example, through the testing and implementation of emerging scientific concepts and techniques such as the DDP synthetic framework described in item 1.

11. The UNCCD community would benefit from a science networking mechanism so that the large yet dispersed body of DLDD research worldwide can be more effectively accessed, used and shared.

Due to its complex nature, DLDD research cuts across many scientific disciplines and also intersects with other knowledge bases (e.g. development practitioners' and land users' knowledge). As a consequence, DLDD research and related knowledge is highly dispersed across thousands of universities, institutes, agencies and organizations around the world. For example, identifying and mobilizing this dispersed community in a short time frame emerged as a major challenge in organizing the First UNCCD Scientific Conference.

This dispersion significantly impedes the flow of coherent scientific information to the UNCCD. It also impedes the development of integrated scientific approaches, and allows inefficiencies resulting from duplication and constrained knowledge flows.

In order to provide more comprehensive and responsive scientific input into the UNCCD, a networking and coordination mechanism for the global DLDD science community is needed that would feed into the science advisory mechanism recommended in item 10, improving the efficiency and effectiveness of that advisory mechanism. In this way the UNCCD could benefit from valuable services such as:

- Determining the prevailing views of scientists worldwide on pressing DLDD questions
- Mobilizing scientific expertise to address specific questions and issues in more depth
- Formulating widely-supported science plans requiring global cooperation and donor backing
- Providing a clearing-house and platform for exchanging science knowledge and stimulating discussions about DLDD
- Providing a mechanism for forming scientific partnerships to tackle high-priority DLDD research challenges
- Providing a referral mechanism for scientific capacity-building and mentoring opportunities on DLDD

DLDD scientists have begun organizing themselves through networks such as DesertNet International and the Global Network of Dryland Research Institutes (GNDRI). This good start should be given more support and impetus. It should tap the Earth Science System Partnership (ESSP) framework that already contributes substantially to the knowledge bases of sister environmental conventions through the IPCC and the CBD. Other arrangements could also be envisioned. UNCCD endorsement of the need would provide support for the initiation of discussions by a range of scientific bodies on institutional formats for such a 'network of networks' mechanism.

SUMMARY OF KEY MESSAGES/RECOMMENDATIONS

1. Desertification, land degradation and drought (DLDD) as defined by the United Nations Convention to Combat Desertification (UNCCD) results from dynamic, interconnected, contextual human-environment interactions — requiring the application of complex system science in monitoring and assessment.

2. To be sufficiently realistic and insightful in the face of this complexity, monitoring and assessment must make use of a wide range of analytical methodologies, and distill their lessons into forms useful for decision-makers through integrated assessment modeling.

3. Public land use and land management decisions are mainly taken at national and sub-national levels, so a UNCCD global monitoring and assessment strategy should be designed to be compatible and synergistic with other scale levels.

4. Addressing the UNCCD's core mission to *combat* desertification, prospective solutions to DLDD such as sustainable land management should be fully integrated into DLDD monitoring and assessment.

5. DLDD monitoring and assessment should include the collection of information relating it to climate change and biodiversity loss, and to other land-related issues that are the focus of Multilateral Environmental Agreements.

6. To aid in priority-setting by decision-makers, monitoring and assessment should collect information on the costs of DLDD, and the benefits of combating DLDD.

7. Monitoring and assessment should utilize knowledge management approaches to stimulate valuable synergies between different sources of expertise across scale levels, social settings, institutions, scientific disciplines and development sectors.

8. Knowledge-sharing science can simultaneously enhance monitoring and assessment while also strengthening human and institutional capacities.

9. Coordination and dissemination of new knowledge and methodologies for integrated approaches to DLDD requires the establishment of an international, inter-disciplinary scientific advisory mechanism that would include (but not be limited to) monitoring and assessment, with clear channels for consideration of its advice in Convention decision-making.

10. In order to propel principles into action, regular global DLDD monitoring and assessment mechanisms should be organized and implemented based on agreed standards and protocols, harmonizing with other efforts worldwide and minimizing duplication of efforts.

11. The UNCCD community would benefit from a science networking mechanism so that the large yet dispersed body of DLDD research worldwide can be more effectively accessed, used and shared.