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Scientific review of the UNCCD provisionally accepted set of impact indicators to measure the implementation of strategic objectives 1, 2 and 3

Summary

Development of this document (hereafter referred to as the "white paper") follows decision 17/COP.9[1] of the ninth session of the Conference of the Parties (COP 9) of the United Nations Convention to Combat Desertification (UNCCD), requesting the Committee on Science and Technology to develop proposals, for consideration at COP 11, for the refinement of the set of the provisionally accepted impact indicators[2] being developed to "…measure progress on strategic objectives 1, 2 and 3 of the 10-year strategic plan and framework to enhance the implementation of the Convention 2008–2018 (The Strategy)".[3] It responds to the Synthesis and Recommendations resulting from the UNCCD 1st Scientific Conference,[4] primarily to provide a scientific foundation for this refinement process and to maximize possible synergies with other programmes pursuing related goals. It is a synthesis of a participatory, formative and iterative process involving over 64 technical experts from the scientific community between September 2010 and January 2011.

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List of abbreviations

AQUASTAT	FAO global information system on water and agriculture
AVHRR	Advanced Very High Resolution Radiometer
CBD	United Nations Convention on Biological Diversity
COP	Conference of the Parties
CSDF	Comité Scientifique Français de la Désertification (French Scientific Committee on Desertification)
CST	Committee on Science and Technology
DLDD	desertification/land degradation and drought
DPSIR	Driving Force-Pressure-State-Impact-Response
ECV	Essential Climate Variables (of the UNFCCC)
EDN	European DesertNet: European Network for Global Desertification Research
ESSI	Ecosystem Services Status Index
FAO	Food and Agriculture Organization of the United Nations
FDES	United Nations Framework for the Development of Environment Statistics
GDOS	Global Drylands Observation System
GEF	Global Environment Facility
GIMMS	Global Inventory Modeling and Mapping Studies
GLADA	Global Assessment of Land Degradation and Improvement
GLADIS	Global Land Degradation Information System
GLC 2000	Global Land Cover 2000
GTOS	Global Terrestrial Observing System
HDI	Human Development Index
H-E	coupled human-environment (H-E) systems
ISRIC	International Soil Reference and Information Centre
JMP	WHO/UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation
JRC	Joint Research Centre (European Commission)
KM:Land	The GEF Land Degradation Focal Area
LADA	Land Degradation Assessment in Drylands
LCCS	Land Cover Classification System (developed by FAO)
LDI	Land Degradation Index
LPD	Living Planet Database
LPI	Living Planet Index
LUS	land-use system
MA	Millennium Ecosystem Assessment
MDG	Millennium Development Goal
MMR	maternal mortality ratio
MSP	medium scale project
NAP	national action programme (UNCCD)
NDVI	normalized difference vegetation index
NPP	net primary productivity
NRD	Nucleo Ricerca Desertificazione (University of Sassari)
OECD	Organisation for Economic Co-operation and Development
OSS	Observatoire du Sahara et du Sahel (Sahara and Sahel Observatory)
ROSELT	Réseau d'Observatoires de Surveillance Ecologique à Long Terme (Long-term Ecological Monitoring Observatories Network) (part of OSS)
RUE	rain use efficiency
QM	LADA QM pressure indicators (semi-quantitative indicators derived in part from a questionnaire for mapping)
SLM	sustainable land management

SPI	Standardized Precipitation Index
STAP	Scientific and Technical Advisory Panel (of the GEF)
The Strategy	10-year strategic plan and framework to enhance the implementation of the Convention (2008–2018)
TPN	thematic programme network (UNCCD)
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNH WSAG	University of New Hampshire Water Systems Analysis Group
UNICEF	United Nations Children's Fund
UNU-INWEH	United Nations University Institute for Water, Environment & Health
WBI	Global Wild Bird Index
WHO	World Health Organization
WOCAT	World Overview of Conservation Approaches and Technologies
WWF	World Wildlife Fund for Nature
ZSL	Zoological Society of London
WAD	World Atlas of Desertification

I. Background

1. During its eighth session in Madrid in September 2007, the Conference of the Parties (COP) of the United Nations Convention to Combat Desertification (UNCCD), adopted a ten-year strategic plan and framework to enhance the implementation of the Convention (2008–2018) (The Strategy).

2. By decision 3/COP 8,[5] the Committee on Science and Technology (CST) was requested to advise COP 9 on how best to measure progress on the achievement of strategic objectives 1, 2, and 3 of The Strategy:

- Strategic Objective 1: To improve the living conditions of affected populations
- Strategic Objective 2: To improve the condition of the ecosystems
- Strategic Objective 3: To generate global benefits through effective implementation of the Convention

3. The Strategy contains seven core indicators which are indicative of the types of indicators to be established to provide information on trends in affected areas. The CST was requested to refine these core indicators further, capitalizing on existing sources of data.

4. As a first step towards carrying out the assignment of the COP, a framework document, “Elements for provision of advice on how best to measure progress on strategic objectives 1, 2 and 3 of the 10-year strategic plan and framework to enhance the implementation of the Convention (The Strategy)”,[3] was presented and discussed at the first special session of the Committee on Science and Technology (CST S-1), held in Istanbul in November 2008.

5. The framework document, together with the output of the CST deliberations, provided input for the preparation of an in-session document which outlined the concrete steps to be taken and activities to be carried out for the selection of a minimum set of impact indicators coherent with the seven core indicators relating to strategic objectives 1, 2 and 3 as outlined in The Strategy.[6]

6. Three sets of studies were carried out to achieve the selection of a minimum set of impact indicators and identify the short- to medium-term capacity-building needs of the Parties: (a) global consultations with affected Parties on currently utilized impact indicators of relevance to the three strategic objectives,[7] (b) regional consultations on methodologies for collecting and using the required data as well as capacity-building needs to ensure effective utilization of the identified minimum set of impact indicators,[8] and (c) identification of United Nations agencies and intergovernmental organizations which have the existing information and data required for effective use of the identified minimum set of indicators on either a default or a complementary basis.[9] The findings of these three studies were synthesized in a comprehensive document that was presented at COP 9.[2]

7. Furthermore, the UNCCD 1st Scientific Conference, organized at COP 9, tackled issues and made recommendations regarding the biophysical and socio-economic monitoring and assessment of desertification and land degradation.[4,10]

8. In decision 17/COP.9, the COP decided provisionally to accept the proposed, minimum but not exclusive, set of eleven impact indicators. The indicators were organized in a matrix in the annex to decision 17/COP.9 (table 1), which links them to both the core indicators and the strategic objectives of The Strategy and shows their suitability for use at the national and/or the global level.

9. In decision 17/COP.9, a sub-set of two impact indicators (that is, III Proportion of the population in affected areas living above the poverty line; IX Land cover status) was identified as the minimum required for reporting by affected countries beginning in 2012. The remaining nine impact indicators, while recommended, were considered optional for inclusion in reports by affected countries.

Table 1
Set of impact indicators recommended to the UNCCD for refinement

Recommended set of impact indicators		
	National level	**Global level**
Objective 1: To improve the living conditions of affected populations		
Core indicator S-1: Decrease in the number of people negatively impacted by the process of desertification/land degradation and drought	• I Water availability per capita in affected areas • II Change in land use	• I Water availability per capita in affected areas
Core indicator S-2: Increase in the proportion of households living above the poverty line in affected areas	• III Proportion of the population in affected areas living above the poverty line*	• III Proportion of population in affected areas living above the poverty line
Core indicator S-3: Reduction in the proportion of the population below the minimum level of dietary energy consumption in affected areas	• IV Childhood malnutrition and/or food consumption/ calorie intake per capita in affected areas	• V The HDI as defined by UNDP
Objective 2: To improve the condition of ecosystems		
Core indicator S-4: Reduction in the total area affected by desertification/land degradation and drought	• II Change in land use • VI Level of land degradation (including salinization, water and wind erosion, etc.)	
Core indicator S-5: Increases in net primary productivity in affected areas	• VII Plant and animal biodiversity • VIII The aridity index • IX Land cover status*	• IX Land cover status
Objective 3: To generate global benefits through effective implementation of the UNCCD		
	• VII Plant and animal biodiversity • III Proportion of the population in affected areas living above the poverty line	• III Proportion of the population in affected areas living above the poverty line
Core indicator S-6: Increases in carbon stocks (soil and plant biomass) in affected areas	• X Carbon stocks above and below ground	
Core indicator S-7: Areas of forest, agricultural and aquaculture ecosystems under sustainable management	• XI Land under SLM	• XI Land under SLM

* The two impact indicators highlighted constitute the minimum required for reporting by affected countries beginning in 2012: i) Proportion of the population in affected areas living above the poverty

line; ii) Land cover status. The remaining impact indicators in the list, while recommended, are optional for inclusion in reports by affected countries.

Source: Decision 17/COP.9 (UNCCD 2009a) [1]

10. Annex 1 of decision 17/COP.9 is drawn directly from the report of Berry et al. (2009), which also includes proposed metrics or proxies for each indicator. Table 2 is a summary of this information.

Table 2

Brief technical definitions of the 11 provisionally recommended impact indicators provided in the UNCCD Minimum set of Impact Indicators report[7,11]

Provisional impact indicators		*Stated purpose*	*Metric/proxy definition*
I	Water availability per capita in affected areas	Monitor progress in access of the population to improved water sources.	Population with water stress – United Nations Sustainable Development Indicators [%] [and below]
II	Change in land use	Highlight changes in the productive or protective uses of the land resource.	Proportion of change of each land use category to another per unit of time [%]
III	Proportion of the population in affected areas living above the poverty line	Monitor poverty as the most important defining characteristic of underdevelopment and as a root cause and consequence, of desertification.	The percentage of the affected population with a standard of living above the poverty line [%]
IV	Childhood malnutrition and/or food consumption/ calorie intake per capita in affected areas	Measure long-term nutritional imbalance and malnutrition. Nutritional status is the best global indicator of well-being in children and an indicator of the availability of ecosystem services.	Percentage of underweight (weight-for-age below -2 standard deviation (SD) of the WHO Child Growth Standards median) among children under five years of age, percentage of stuntedness (height-for-age below -2 SD of the WHO Child Growth Standards median) among children under five years of age, and percentage of overweight (weight-for-height above +2SD of the WHO Child Growth Standards median) among children under five years of age. [%]
V	The HDI as defined by UNDP	Approximate the status and change in the well-being of populations. Applied in affected areas it will be an effective surrogate for the impact of the efforts to combat desertification on the livelihood of peoples.	HDI of the UNDP, based on 4 basic indicators: life expectancy at birth; adult literacy; combined gross enrolment in primary, secondary and tertiary level education; gross domestic product per capita in purchasing power parity United States dollars [Parametric index]
VI	Level of land degradation (including salinization, water and wind erosion, etc.)	Measure the extent of land degradation at the national level. It also measures the impact of agreements and programmes in addressing land degradation and reclaiming degraded lands.	The amount of land affected by degradation and its proportion of national territory, LADA. [Area (km^2) and % of land area affected]

	Provisional impact indicators	*Stated purpose*	*Metric/proxy definition*
VII	Plant and animal biodiversity	Approximate overall biodiversity condition of a region relative to a 'pristine' state. The current condition in protected areas is used as a surrogate measure of this pristine state.	Biodiversity intactness index (BII) [Rate of change of BII in percentage (%)]
VIII	The aridity index	Use as base indicator for characterizing sensitive and desertification-affected areas.	UNEP Aridity Index (Bioclimatic Index), defined as the ratio between mean annual precipitation (P) and mean annual evapotranspiration: (ETP) $I_a = P_a / Et_o$ [Indicative value of the ratio P_a / Et_o]
IX	Land cover status	Monitor land degradation in terms of long-term loss of ecosystem primary productivity and taking into account effects of rainfall on NPP.	GLADA - Land cover status -in both cultivated and non-cultivated lands-based on NPP and RUE trends as obtained through long term series NDVI data. [kgC ha-1 year-1% (NPP) and mm-1 (RUE)]
X	Carbon stocks above and below ground	Encourage countries to monitor their carbon stocks and to record changes in above and below ground stocks as a global benefit.	Indicator to be developed in conjunction with IPCC process [tons/ha]
XI	Land under SLM	Land under SLM is an important surrogate for a number of global benefits.	Area of land under SLM (World Bank) [ha]

Source: Adapted from Zucca and Biancalani (2010) [11] summary drawn from Berry et al. (2009). [7]

II. Aim and scope

A. Foundation

11. The foundation for this white paper involves a considerable body of work conducted over the past three decades on desertification indicator development, the origin of which has been attributed to Barry and Ford (1977) and Reining (1978).[12-14] The UNCCD began formally to address the challenge of indicator development and selection in 1998, when, in accordance with decision 22/COP.1 of the first session of the COP,[15] the first Ad Hoc Panel on Benchmarks and Indicators was convened in Beijing.[16] Subsequent work led to a list of indicators for governments to use in preparing their national reports. This in turn led to contributions to the indicator development process from individual country Parties, particularly through UNCCD "country profile" reporting and monitoring.[17] Since that time, extensive work has been carried out by numerous subgroups of scientists who were appointed by the CST as members of the Group of Experts working towards a minimum set of national/global indicators for monitoring desertification, land degradation and drought (DLDD). This work resulted in a number of highly relevant reports and peer-reviewed

publications (for example,[18-20]). The work continues today; in early 2011, a special issue of *Land Degradation & Development* will focus on indicators.[21]

12. This report builds on several steps taken recently to identify and define suitable indicators for monitoring and assessment of the implementation of the Convention, the impact of national action programmes (NAPs), and the processes and impacts of desertification.[22] In support of UNCCD requests to improve consistency and coherence, these steps have included (a) determining what benchmarks and indicators country Parties were already using to monitor and assess desertification and its mitigation, and identifying synergies (especially commonly-used basic indicators) across countries and regions,[7] (b) identifying methodologies for measuring these provisional indicators,[8] (c) identifying relevant data sources.[9] These efforts formed the basis for the preliminary list of provisional impact indicators currently under refinement (table 1).

13. This white paper responds to the evaluation of the outcomes of the UNCCD 1st Scientific Conference. These include a synthesis and recommendations provided by the Dryland Science for Development Consortium,[4] guidance on developing a baseline survey for monitoring DLDD,[23] and guidance on refinement of the proposed impact indicators, which was provided by the Scientific and Technical Advisory Panel (STAP) of the Global Environment Facility (GEF).[24] Annex 1 provides a synthesis of those recommendations relating to the refinement of the provisional impact indicator set.

14. This white paper also makes use of the relevant work of several parallel synergistic activities. These include indicator development work of the United Nations Convention on Biological Diversity (CBD),[25,26] the United Nations Framework Convention on Climate Change (UNFCCC), Essential Climate Variables (ECV),[27,28] the GEF-UNDP KM:Land "Ensuring Impacts from SLM - Development of a Global Indicator System" medium scale project (MSP),[29] the Land Degradation Assessment in Drylands (LADA) indicator toolbox development effort,[30] a joint French Scientific Committee on Desertification (CSDF) - European DesertNet (EDN) indicator development effort,[31] the work of the Réseau d'Observatoires de Surveillance Ecologique à Long Terme/Observatoire du Sahara et du Sahel (ROSELT/OSS),[32] the World Atlas on Desertification (WAD),[33] and efforts to promote a Global Drylands Observing System (GDOS).[34]

B. Objectives

15. Based on decision 17/COP.9 by which the Parties required the UNCCD secretariat, under the guidance of the CST Bureau, to develop proposals to refine the provisionally accepted set of impact indicators, the aim is to review the relevance, accuracy and cost-effectiveness of the set of the eleven provisional impact indicators and to develop proposals and alternatives for their refinement, revision and improvement.[1] The review should be participatory, formative and iterative, involving input from the scientific community. It should be representative geographically and across disciplines. The review should build on past and current indicator development work (for example, a thorough document review), and maximize possible synergies with regional UNCCD efforts, as well as with parallel relevant programmes, projects and institutions, including those associated with the other Rio Conventions.

16. This review should result in:

(a) A scientifically grounded conceptual framework for the indicator set relative to the complexity of DLDD issues and coherence with The Strategy of the UNCCD;

(b) Scientifically justifiable indicator evaluation criteria to assess relevance and interpretation of each indicator relative to DLDD, The Strategy, policymakers, managers and other stakeholders, and what we know from science. These criteria should include:

(i) Scientific validity, including being based on well-understood and generally accepted approaches, the capacity to provide information about changes in important processes, sensitivity to change/variability without being overwhelmed by natural variability, and applicability at the appropriate temporal and spatial scale;

(ii) Feasibility, including accepted and cost-effective approaches for measurement, availability of appropriate monitoring systems and reliable data (or the future potential of these), and utility to decision makers;

(c) A hierarchical approach to defining the interrelationship of the indicator set and corresponding objectives. Using decision 17/COP.9, annex 1 (table 1) as the starting point, this should clarify the relationship between UNCCD strategic objectives (SO1–3), their corresponding core indicators (S1–7), the underlying general indicators (refinements to the list of provisional indicators I–XI), and potential metrics/proxies for measuring the general indicators (based on proposals from scientists involved in ongoing long-term indicator development and testing);

(d) A proposal, based on this hierarchy, for refinement in the naming and organization of the general indicators (based on refinement of the provisional indicators) and proposals for corresponding metrics/proxies, retained for further consideration based on a high level of agreement among scientists contributing to the review; this should also include an operational "readiness" assessment rating the development and potential implementation status of the metrics/proxies (such as readiness for testing or further development);

(e) A set of proposals designed to provide guidance on the scientific and operational issues identified during the review as having to be addressed in order to have a viable, scientifically valid and operationally effective impact indicator set.

III. Approach

A. Participatory, formative and iterative evaluation

17. Before, during and after COP 9, the scientific community expressed a strong interest in contributing to the UNCCD impact indicator refinement process. To maximize this diverse technical knowledge and expertise, the refinement approach was designed to be participatory and formative. It is participatory in that scientists from around the world and across disciplines were invited to contribute. It is formative in that multiple avenues of communication and engagement with technical experts were pursued, and at three junctures what was learned in previous stages became the basis of the next discussion.

18. Formative research attempts to contextualize and incorporate what a population thinks, does and says about some domain of experience, in this case indicator development in support of monitoring DLDD and the impact of The Strategy of the UNCCD. After each stage/iteration in the process, feedback from participants is used to adapt the findings to reflect what has been learned. The feedback can influence not only the objective (in this case, refinement of the impact indicators), but the overall approach, so that the outcome addresses not only the needs expressed at the outset, but also how those needs are perceived following interaction among the participating scientists.

19. A participatory and formative evaluation can be logistically challenging in that it requires hands-on engagement with the target population. But it has an added benefit that is essential for the UNCCD impact indicator refinement process. Through individual and social learning, knowledge is co-produced instead of being a unilateral flow of information. Self-reflection is made possible through open and responsive discourse and interaction

among diverse participants in order to develop a common framework of understanding and basis for joint action. While total consensus on any scientific issue is unlikely, this approach encourages engagement, sharing, learning, a sense of ownership, consensus and, ideally, better information.

B. Major steps in the evaluation/refinement process

20. In order to provide a scientific foundation for furthering the indicator refinement process the following steps have been undertaken:

(a) Development of a "zero draft" of this white paper based on the results of a thorough review of technical documents and the scientific literature. The zero draft included (i) background and objectives, (ii) a candidate conceptual scientific framework, (iii) a summary of recent scientific evaluations of the 11 provisional impact indicators, (iv) a detailed description of the proposed refinement metrics/proxies for each of the 11 provisional indicators (obtained from two major parallel indicator development activities conducted by scientists working with LADA and GEF KM:Land, and one contributed by the CBD), (v) indicator evaluation criteria, and (vi) an approach to evaluation of the alternative metrics/proxies based on an evaluation matrix incorporating the criteria. (August–October 2010);

(b) Identification of a broad set of candidate technical experts from each region and across disciplines who would be invited to review the zero draft and conduct an evaluation of the 22 metrics/proxies using the evaluation matrix. The UNCCD conducted the identification and invitation process, using chain referral (asking those identified early on for other candidate scientists) in order to identify those with appropriate expert technical knowledge, and to be as representative as possible;

(c) Presentation of the zero draft to the CST Bureau and approval to move to the next iteration. (November 2010);

(d) Initial Expert Review. This was the first technical expert review of the white paper and the proposed refinements to the provisional impact indicators. This involved the engagement (via email) of approximately 70 scientists for the initial review of the white paper and the evaluation of the 22 metrics/proxies proposed as candidates for refinement of the 11 provisional indicators. Of the approximately 70 scientists invited, 37 provided detailed written reviews of the white paper and the metrics/proxies under consideration; of these, 17 also completed the evaluation matrix. This was followed by analysis and compilation of their feedback, which was shared with the participants. (November–December 2010);

(e) Technical Workshop on Impact Indicators Refinement hosted at the UNCCD headquarters in Bonn, Germany (http://www.unccd.int/science/announce/ImpactIndicators.php). Participants included 41 scientists, including representatives of the major synergistic activities and of one of the other Rio Conventions, the CBD. Among those attending were 14 experts who had provided reviews of the zero draft and the indicators. Presentations were made on the white paper and indicator evaluation results to date, the role and potential contributions of synergistic efforts, and several key discussion topics (for example, conceptual framework, and indicator testing). Four working groups met, discussed and evaluated the current linkages between UNCCD strategic objectives, core indicators and the provisional indicators. They also assessed the 22 metrics/proxies. Outcomes included a draft of proposals for consideration by the CST which are incorporated into this white paper. (18–19 December 2010);

(f) Integration of the Technical Workshop results. The workshop results and feedback, together with information from the previous stages in the formative evaluation, were used to produce (i) a refined conceptual framework, (ii) a refinement of the indicator set hierarchy, (iii) proposals (with varying levels of agreement among the scientists) among the metrics/proxies reviewed for those which could be considered for testing or further development, (iv) a final version of associated workshop conclusions, framed as proposals for consideration by the CST, and (v) a final draft of this white paper. (January 2011);

(g) Presentation of the process and results at the Second Special Session of the Committee on Science and Technology (CST/S-2) (http://www.unccd.int/cop/cric9/menu.php) in Bonn, Germany (16–18 February 2011);

(h) Public comment. The final draft of the white paper will be subjected to a global public consultation through an e-forum facilitated by the UNCCD secretariat (http://eforum.unccd). It is expected that scientists and other stakeholders interested in developing and monitoring impact indicators relating to the DLDD issue provide feedback and suggestions for further fine-tuning of the white paper. As this process is formative and iterative, these comments will ultimately be incorporated into the final version of the white paper. The public discussion and continued scientific peer review of the UNCCD impact indicators will last six weeks, starting in February 2011.

C. Indicator evaluation criteria

21. After reviewing a variety of approaches toward indicator evaluation, the decision was made to use the evaluation criteria developed by the United States National Research Council in 2000[35] and the Millennium Ecosystem Assessment (MA).[36] In addition to these prior endorsements, the approach was selected for pragmatic considerations; it is less burdensome for reviewers (only seven questions), and has been used by several synergistic activities for their own indicator development, as well as a review of the 11 provisional indicators conducted by GEF-STAP. The indicator evaluation criteria questions are:

- Does the indicator provide information about changes *in important processes*?
- Is the indicator *sensitive enough to detect important changes* but not so sensitive that signals are masked by natural variability?
- Can the indicator *detect changes at the appropriate temporal and spatial scale* without being overwhelmed by variability?
- Is the indicator based on *well-understood and generally accepted* conceptual models of the system to which it is applied?
- Are *reliable data available* to assess trends, and is data collection a relatively straightforward process?
- Are *monitoring systems in place* for the underlying data needed to calculate the indicator?
- Can policymakers easily *understand* the indicator?

22. This aspect of the evaluation was facilitated by a matrix (within an Excel spreadsheet) where the columns represented the above criteria and the rows were those indicators (metrics/proxies) under review. The evaluation matrix also included guidance on the rating scale, consideration of the conceptual framework, and space for comments.

IV. Conceptual framework

A. The need for a conceptual framework

23. The general purpose of monitoring and assessment is to provide the capacity for a formal synthesis and quantitative analysis of information relating to specified goals. Indicators should reflect (a) what a project/programme/policy was intended to achieve, and (b) how it was to be achieved. Indicators must therefore be explained in the context of an understanding of the processes involved, and an explanation of how interventions will affect those processes. In this approach, if indicators do not perform as predicted in response to a prescribed intervention, it is possible to return to these basic understandings and to adjust/redesign/reconceptualize what is being done. Without this context all that can be done is to make an assessment that has little diagnostic or prescriptive value.

24. Indicators have the capacity to provide the necessary information, but only if, when taken in combination, they consider the full complexity of the system (attributes and stressors), remain simple enough to be regularly and systematically monitored, reflect clear long-term management and policy goals, and can be linked to the decision process.[37] A defined protocol for identifying, developing and refining indicators can provide scientific rigour to the process and help ensure that indicators capture the complexities of the system and provide the information needed for decision-making, ideally so that when they are taken together, they can capture the causality in the system among driving forces, state of the environment, and impacts of changes.[38] This in turn can help decision makers to connect the underlying processes with impacts, make linkages to related assessment areas, and ultimately support decision-making more directly.[39] This approach suggests the need for a causality-based conceptual framework as a foundation for monitoring and assessment and the development, organization and communication of associated indicators.

25. A second and equally important facet in determining the most appropriate conceptual framework for the development, refinement and use of an indicator set for the monitoring and assessment of desertification, its impacts, and its remedies through the implementation of the Convention is the capacity to encompass human-environment interactions. This issue is the first of eleven key messages in the Synthesis and Recommendations from the UNCCD 1st Scientific Conference COP 9:[4]

> *Desertification, land degradation and drought as defined by the United Nations Convention to Combat Desertification results from dynamic, interconnected, human-environment interactions in land systems, where land includes water, soil, vegetation and humans – requiring a rigorous scientific framework for monitoring and assessment, which has heretofore been lacking... The text of the United Nations Convention to Combat Desertification[40] places humans "at the centre of concerns to combat desertification and mitigate the effects of drought". It notes that desertification/land degradation and drought "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 security" and other factors.*

26. The MA provides a mechanism for integrating human and environmental systems through the concept of ecosystem services, defined as "the benefits people obtain from ecosystems".[41] The MA Desertification Synthesis describes desertification as being "…a result of a long-term failure to balance demand for and supply of ecosystem services in drylands".[42] This suggests that the conceptual framework adopted for the development, refinement, selection and ultimate use of desertification indicators should also include the ecosystems services approach to linking environmental change and human well-being.

B. Stress, response and causality within a conceptual framework

27. Rapport and Friend (1979) are credited with introducing the concept of framing environmental statistics on the basis of stress and response, the foundation for what are now termed causal chain conceptual frameworks.[43,44] The United Nations moved in this direction, starting with an extensive survey of the wide variety of methods available for the compilation of environmental statistics, followed by the development of the United Nations Framework for the Development of Environment Statistics (FDES) in 1984, which was ultimately endorsed by the Statistical Commission in 1995.[45] FDES is a combined media (information categories based on system components) and stress-response approach.[46]

28. Since that time, several stress and response frameworks have been developed and widely implemented for environmental assessment which emphasize the causal relationships between forces acting on the environment, associated consequences, and societal response, through a set of interlinked indicators (hence the descriptor of "causal chain" conceptual frameworks coined by Niemeijer and de Groot).[39] The most commonly used for environmental monitoring and assessment include (a) the Pressure-State-Response framework developed by the Organisation for Economic Co-operation and Development (OECD)[47] and the work of the Canadian government and UNEP,[48] which led to variations, including (b) the Driving Force-State Response framework developed by the United Nations Commission on Sustainable Development,[1,49] and used for agri-environmental assessment by OECD,[50] (c) the Driving Force-Pressure-State-Impact-Response (DPSIR) framework introduced by the European Environment Agency[38,51,52] and, more recently, (d) the Pressure-State-Use-Response-Capacity framework developed by the CBD.[53] These conceptual frameworks are similar in that each addresses both the origins and the consequences of whatever issue is being conceptualized, but differ in how each subdivides the causal chain.[39]

C. Driving Force-Pressure-State-Impact-Response framework

29. The DPSIR framework, depicted in figure 1, is explained in more detail in table 3. This particular framework has been singled out because it (a) incorporates most of the elements of the others mentioned thus far, (b) includes feedback responses (and thus is more dynamic than simple chains from input to impact), and (c) has been adopted or adapted by most of the groups working to develop indicators of desertification, and its mitigation through sustainable land management (SLM).

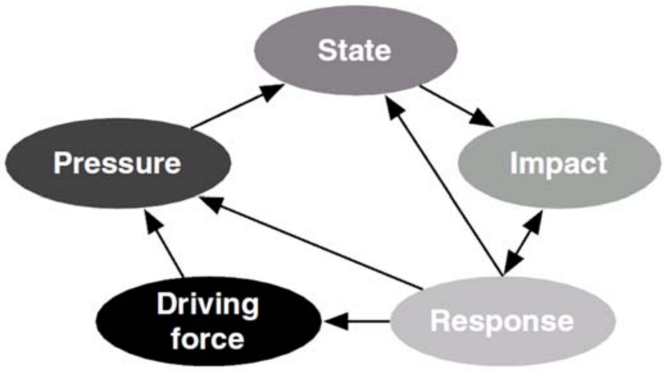
30. Among the major ongoing initiatives for obtaining desertification indicators that employ the DPSIR conceptual framework are:

- The GEF-UNDP KM:Land "Ensuring Impacts from SLM – Development of a Global Indicator System" MSP[29]
- The LADA indicator toolbox development[30]
- The desertification monitoring and assessment thematic programme network (TPN) for the Asia Region (TPN-1)[54]
- The benchmarks and indicators for the Latin America and Caribbean (TPN-1)[55]
- The joint CSDF-EDN indicator development effort[31]

[1] The UN CSD shifted to a Millennium Development Goals (MGD)-based monitoring framework in 2001.

- The local environments indicator development effort of the Long-term Ecological Monitoring Observatories Network (ROSELT) of the Sahara and the Sahel Observatory (OSS)[56]
- The GEF Carbon Benefits Project
- The WAD project[33]

Figure 1
DPSIR framework



Source: Niemeijer and de Groot 2008.[39]

Table 3
Elements of the DPSIR framework[57–59]

Driving forces are indirect or underlying factors that result in pressures which in turn cause changes in the quality and quantity or state of the resources. Drivers can involve both anthropogenic and natural forces. Socio-economic and socio-cultural forcing factors can drive human activity which increases or mitigates pressures on the environment. Human drivers can be subject to policy and management interventions or responses. Natural driving forces such as climate variability cannot be controlled but must be accounted for in policy development and management.
Pressures are direct drivers (stresses) that human activity places on the environment. Pressures include factors which lead to soil or vegetation loss and degradation, such as land-use pressure. Pressure indictors should ideally be linkable to specific drivers. For example, demographic change (a driving force) such as urban and suburban [exurban is an American term meaning prosperous areas beyond the suburbs; surely this isn't what is meant here?] population increase may lead to land-use change, land fragmentation (pressures) and the loss of wildlife habitat (a change in system state).
State variables are indicators of the condition of the system (including biophysical and socio-economic factors/processes). State variables also include trends, often referred to as environmental change, which could be both naturally and human induced. State variables may be interrelated, where a change in one may influence another.
Impacts are the effects on human well-being and the environment induced by state changes. Impacts are measured with respect to policy/management objectives and the risks associated with exceeding or falling below these targets and limits. Impacts are the consequences of environmental degradation. Environmental change may positively or negatively influence human well-being (as reflected in international goals and targets) through changes in ecosystem services and environmental stress.

Responses are the actions or interventions (regulatory and otherwise) that are carried out in response to predicted impacts. Forcing factors under human control trigger management responses when target values are not met as indicated by risk assessments. In land degradation, mitigation is the response to impact, while the response to drivers and pressures is prevention, and the response to changes in status/processes is adaptation. Changes in the core characteristics of a system may also require changes in ecosystem reference points that reflect the shifting environmental states. Responses are subject to feedback and intentional or unintentional by-products (for example, job creation can increase human well-being, but can also lead to further pressure on the land).

Source: Adapted from Levin et al. (2008-NOAA),[57] UNEP/GRID-Arendal (2002),[58] and UNEP-IEA (2008).[59]

D. Ecosystem services and drylands: The MA framework

31. Ecosystem services are defined as the conditions and processes through which natural systems support, sustain and enrich human life.[60,61] Reductions in these services in drylands, where more people are dependent on agro-ecological productivity for basic needs than in any other system, leads to loss of human well-being. These services are organized into four interrelated categories: provisioning, supporting, regulating and cultural services (table 4).

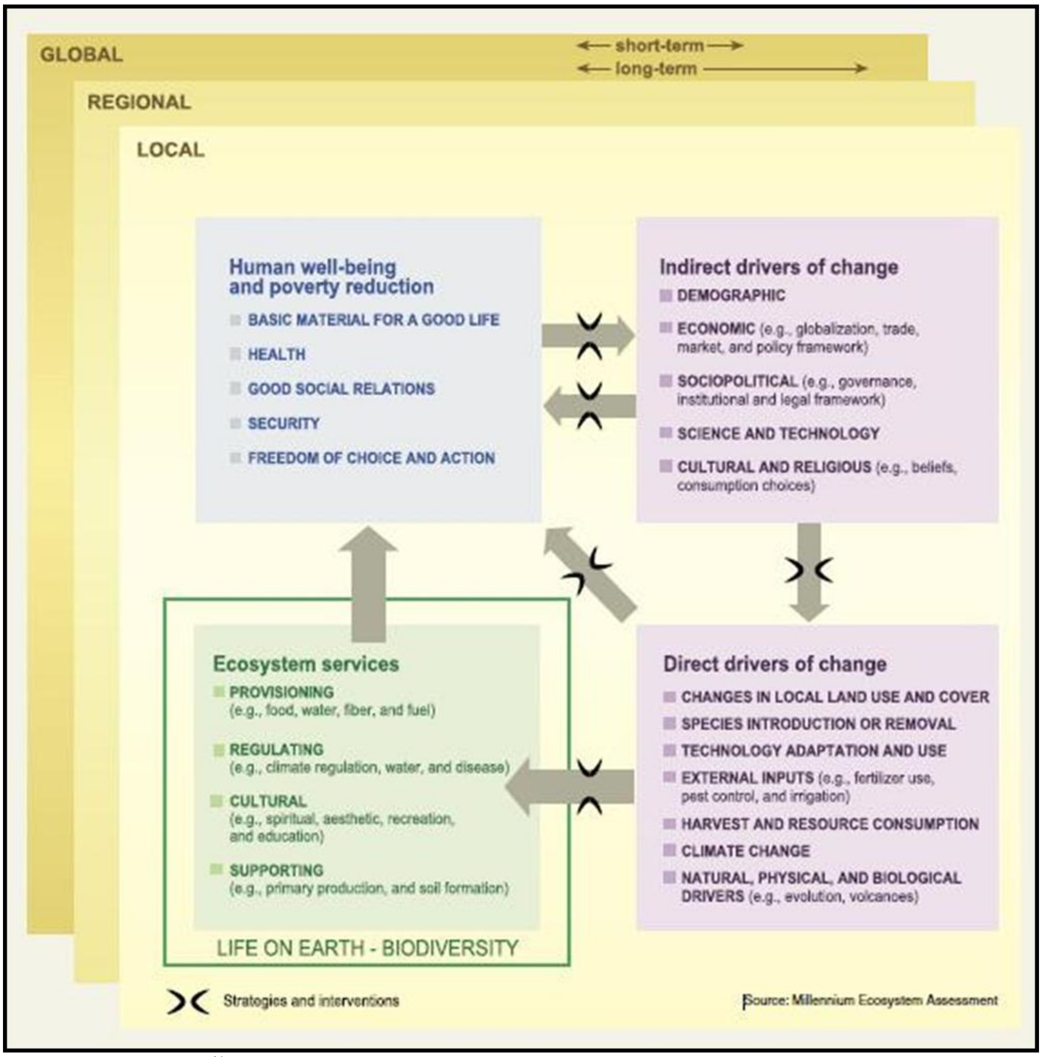
Table 4
Ecosystem services from drylands categorized in accordance with the Millennium Assessment framework

Provisioning service	Goods produced or provided by ecosystems	• Provisions derived from biological productivity: food, fibre, forage, fuelwood, and biochemicals • Fresh water
Regulating service	Benefits obtained from regulation of ecosystem processes	• Water purification and regulation • Pollination and seed dispersal • Climate regulation (local through vegetation cover and global through carbon sequestration)
Cultural service	Nonmaterial benefits obtained from ecosystems	• Recreation and tourism • Cultural identity and diversity • Cultural landscapes and heritage values • Indigenous knowledge systems • Spiritual, aesthetic and inspirational services
Supporting service	Services that maintain the conditions for life on Earth	• Soil development (conservation, formation) • Primary production • Nutrient cycling

Source: MA (2005b).[42]

32. Interactions between biodiversity, ecosystem services, human well-being and drivers of change form the basis of the MA conceptual framework (figure 3).[36]

Figure 2
Millennium Assessment conceptual framework



Source: MA (2005a).[41]

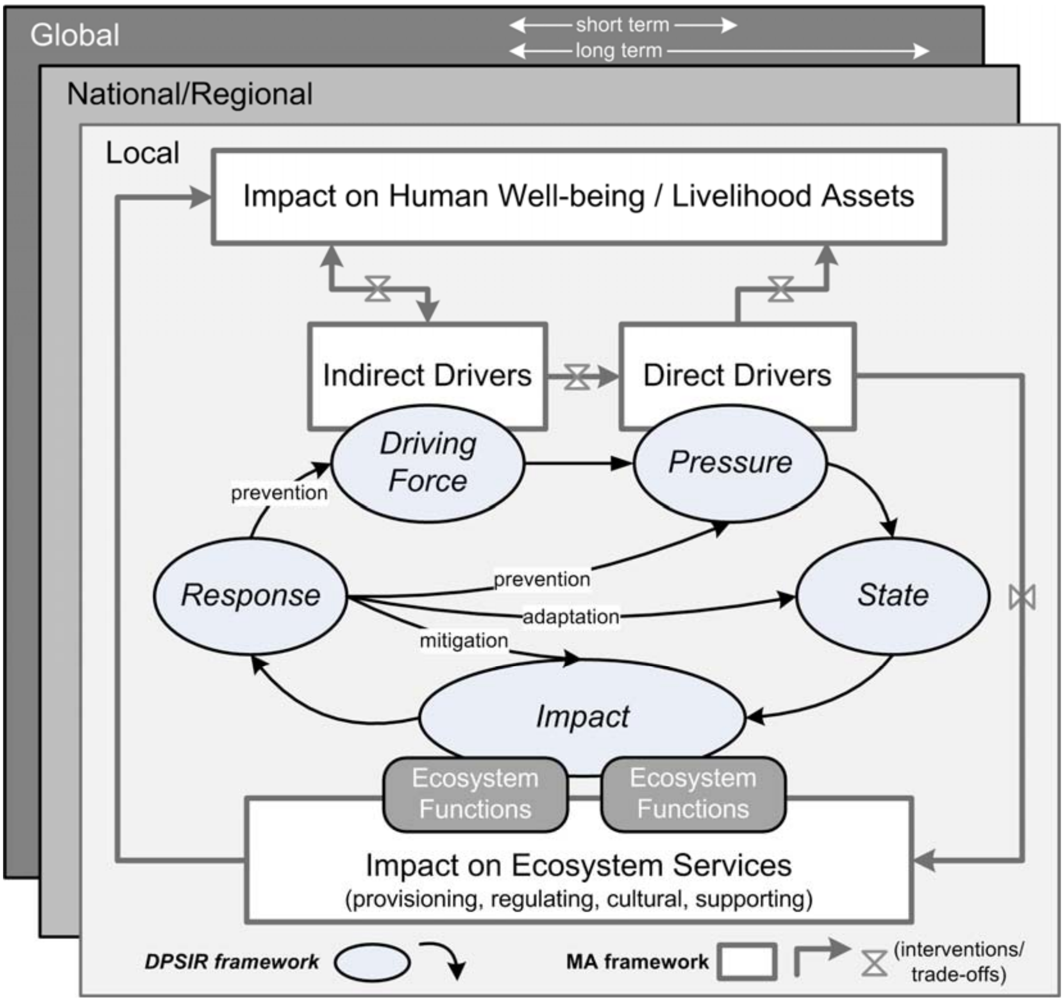
33. The MA conceptual framework includes characteristics that are central to the DPSIR conceptual framework. It accounts for indirect (driving force) and direct (pressure) drivers of change, and captures response. It differs in that it couches impacts from the perspective of human well-being — which is core to the mission of the Convention. It also visually accounts for interactions at more than one spatial and temporal scale and those that occur across scales.

34. Like DPSIR, the MA framework is commonly used in desertification research and practice. For example, the Drylands Development Paradigm, a synthetic approach to addressing the livelihoods of human populations in drylands via the study of coupled human-environment (H-E) systems, employs this framework,[62] as do GEF KM:Land and LADA.

E. Proposed amended DPSIR framework integrated with ecosystem services provision

35. The conceptual framework proposed for consideration by the UNCCD employs a combination of DPSIR and ecosystem services approaches to conceptualizing the indicator set and includes an MA-like visualization of the different spatial temporal scales of concern (figure 3).

Figure 3
Amended DPSIR framework integrated with ecosystem services provisions



Source: Adapted from GEF KM:Land 2010 & FAO LADA 2009.

36. The proposed framework is a refinement of the one used in the Initial Expert Review, with contributions from participants in the Technical Expert Workshop which followed. Those present proposed the framework be considered by the CST, as reflected in proposal (g) in section VII.B.

37. The proposed framework is similar in approach to that taken by two important synergistic efforts supporting the mission and objectives of the UNCCD, KM:Land and LADA. In the case of KM:Land, UNU-INWEH, together with the GEF Land Degradation Task Force, developed what they call the "SLM framework," where DPSIR operates at

different scale levels with the impact assessment focused on benefits to society and to biodiversity.[63] LADA integrates different parts of its land degradation assessment approach through DPSIR and ecosystem services frameworks, as well as a sustainable livelihoods framework. Together, these focus on the benefits people obtain from the environment in support of their livelihoods.[30]

38. The amended DPSIR framework integrated with ecosystem services provisions can guide and facilitate indicator set organization, use and communication. It has the potential to support the strategic objectives of the UNCCD and provides the opportunity to account for causality, interactions and trade-offs that are always present in land management, and which have to be taken into account if proper and feasible responses have to be identified in support of decision-making. This provides a first approximation of how well the causal chain associated with DLDD will be captured by the selected indicator set, helping to highlight gaps and cross-indicator interactions. While it is recognized that the UNCCD mandate for indicator development is focused on the national and global scales, it is important that the conceptual framework also highlights the need for eventual synergy between global, national and local information, and is amenable to a future mechanism that could support the use of locally-derived indicators in support of the global monitoring effort, such as that proposed by Oba et al., 2008.[64] In addition, the proposed framework provides specific emphasis on a number of monitoring and assessment priorities which the UNCCD is working to support in its approach to indicator refinement: (a) emphasis on impact on human well-being, (b) accommodation of an ecosystem services approach to integrated assessment, (c) consideration of spatial and temporal scalar issues, (d) emphasis on “response” indicators to help monitor policy and management influences ranging from implementation of the Convention to specific SLM or desertification mitigation efforts.

39. This approach has some weaknesses. Participants in the UNU-INWEH KM:Land effort have pointed out that changes in ecosystem services due to strategies or interventions (as measured by response indicators) may impact human well-being, but over a longer time frame than typical observation periods of 1–5 years. This can be in part mitigated through assessment of changes in state indicators.[29] While the approach highlights the issues of scale, it does not resolve them (in many cases, for instance, local-scale indicator data cannot be aggregated to national levels without risking exaggerated results). The approach also offers the opportunity to incorporate locally-derived indicators into the global monitoring effort, but it does not, as yet, define the mechanism that would make this operationally feasible.

40. Another challenge lies in how the framework is used to support reporting. Environmental assessments that are conducted using causal chain frameworks frequently do not capitalize on the entire set of indicators (interactions), but rather report on an indicator-by-indicator basis, with some comparisons across indicators.[39] This practice of compartmentalization of indicator data essentially defeats the purpose of having an indicator set working in concert. One solution to this is to make the framework itself part of the indicator development process so that it evolves with the decisions to embrace or adapt indicators and measurement methodologies into the future.

41. This could also include a more in-depth assessment of the interrelationships among the indicators in the set through casual network analysis, in a stepwise process corresponding to progress on indicator selection, development and testing. Casual networks visually resemble a process-based simulation model flowchart used in environmental systems analysis to depict interconnections between components and processes (but with less detail and less quantification of the relationships).[65] The causal network approach has an additional advantage in that it is even more flexible to regional variation, so that locally-derived indicators could be more readily incorporated, and more directly contribute to global assessment. Niemeijer and de Groot (2008b) document the steps necessary to build a

causal network conceptual framework, something that could be conducted by representatives of the major synergistic efforts working towards an integrated global monitoring and assessment approach to DLDD.

V. Provisional impact indicators: prior review results

42. Following the COP 9 request that the CST review the UNCCD-COP provisionally accepted set of eleven impact indicators (in decision 17/COP.9),[1] the UNCCD requested input which was provided in four parallel studies focused on the original provisional indictor set. Two of these, the GEF-STAP report (2009)[24] and a methods integration study by LADA (2010)[11] addressed all eleven provisional impact indicators relative to parallel indicator development work put in motion by KM:Land and LADA, respectively. Two others addressed, individually, the subset of two impact indicators that were identified in decision 17/COP.9 as the minimum required for reporting by affected countries beginning in 2012 (III Proportion of the population in affected areas living above the poverty line,[66] IX Land cover status).[67]

A. GEF-STAP review

43. In late 2009, GEF-STAP completed a review[24] of the 11 impact indicators provisionally approved by the UNCCD for refinement (table 1). This review focused primarily on the International Group of Experts Report, “UNCCD Minimum Set of Impact Indicators”.[7] The GEF-STAP review applied MA evaluation criteria[36] (which were originally developed by the United States National Research Council in 2000)[35] for identifying strengths and weaknesses in the eleven provisional indicators (see section III.C above). The review included a brief summary of the answers to each of these questions for all 11 indicators. The degree to which each indicator met these criteria (yes, no, partly or unknown) was then summarized, and is reproduced here in table 5.

Table 5
Results of the GEF-STAP indicator assessment using the Millennium Assessment indicator criteria

*Indicator**		*Information about important process*	*Sensitive enough to detect change*	*Detect change at appropriate scale*	*Generally accepted and understood*	*Reliable data available*	*Monitor system in place*	*Easily understood by policy makers*
I	Water availability per capita	±	±	–	+	+	+	+
II	Change in land use	–	–	–	–	–	–	–
III	Population above poverty line	+	±	–	+	+	+	+
IV	Childhood malnutrition	±	±	±	+	+	+	+
V	The HDI	±	±	**?**	+	+	+	±
VI	Level of land degradation	±	–	–	±	–	–	±
VII	Plant and animal biodiversity	+	+	**?**	+	+	±	+
VIII	The aridity index	+	±	±	+	+	+	+
IX	Land cover status	±	±	**?**	±	+	+	**?**
X	Carbon stocks	+	±	–	+	–	±	+
XI	Land under SLM	±	–	–	–	–	–	–

* For full indicator name see Table 1. Guide*: + = Yes; – = No;* ± *= partly;* **?** *= unknown.*
Source: GEF-STAP 2009.[24]

44. All eleven indicators were determined as needing refinement. The GEF-STAP summarized its findings as follows:

> *In summary, none of the discussed eleven impact indicators meet all the requirements as proposed by the MA. Overall, the human oriented indicators (I, III, IV, V) are more suitable than the others. Their main limitation is their applicability at the national to global level. However, most environmental indicators have severe conceptual and/or data limitations (especially II, VI, IX, X, XI). The shortcomings of these indicators include: insensitivity to detection of change, the lack of an appropriate scale for detecting change and various uncertainties about the nature of the indicator. The indicators on plant biodiversity and aridity are potentially the most robust of the proposed environmental indicators.*
>
> *… Only large impacts at national to global level over decades can be measured. Many of the proposed indicators are not sensitive enough to measure relevant impact.*
>
> *… It is clear… that there is a structural mismatch of the scale properties of the proposed indicators. There is no unifying resolution of the indicators though all can be reported at a resolution of country with a global extent. This is unfortunately far too coarse to approach the multi-scale levels where the actual land degradation and desertification processes take place.*[68,69] *This scalar mismatch severely limits the value of the proposed indicators. Additionally, the users of the proposed indicators are not discussed, nor are the scales that are used matched to the governance levels involved.*[70]

… When we map the UNCCD “core” indicators against the suggested impact indicators… some core indicators are served by three proposed indicators while others are served by one indicator. What could be done to improve the understanding of the relationship is to make a causal tracking diagram linking them. The current mapping suggests that there are too many overlapping biophysical indicators, such as indicators VII, VIII and IX. On the other hand, indicators II, IX and XI seem to overlap and could potentially be merged. This clearly indicates the need for a general systemic framework first, from where processes and impacts are derived, yielding, preferably, one impact indicator for each UNCCD “core” indicator.

B. LADA-NRD review

45. A second study, conducted by LADA members from Nucleo Ricerca Desertificazione (NRD) at the University of Sassari, focused mostly on exploring ways to use LADA data and methods of making the provisional set of indicators operational.[11] LADA was encouraged to provide this input as it is currently the only project working to produce an integrated assessment of dryland desertification at different scales, globally. As part of that effort, the authors conducted a brief analysis of the operability, specificity and data availability of each of the eleven indicators (table 6).

Table 6
A brief analysis of the present operability and specificity of the 11 UNCCD provisional indicators

Impact indicator		*Still need definition*	*Need greater specification**	*Operational***	*Datasets complete and available at subnational level****
I	Water availability per capita in affected areas	N	Y	Y	N
II	Change in land use	N	N	N	
III	Proportion of the population in affected areas living above the poverty line	N	N	Y	N
IV	Childhood malnutrition and/or food consumption/ calorie intake per capita in affected areas	N	N	Y	Y/N
V	The HDI as defined by UNDP	N	N	Y	N
VI	Level of land degradation (including salinization, water and wind erosion, etc.)	Y	Y	N	
VII	Plant and animal biodiversity	N	N	N	
VIII	The aridity index	N	N	Y	Y
IX	Land-cover status	N	Y	N	
X	Carbon stocks above and below ground	Y	Y	N	
XI	Land under SLM	Y	Y	N	

* In principle all indicators making reference to the affected areas would need better specification.

** Operational = datasets are already collected (and updated) with standard and common formats at the global level.
*** Applies only to “operational” indicators.
Source: Zucca and Biancalani, 2010.

46. The report concluded that some of the indicators can be satisfied by LADA products, but further refinement is necessary on all eleven indicators in how they are defined, specified and made operational for future implementation.

47. It is important to note that both studies point out that time and direct experience with the indicators had an influence on the assessment, particularly with regard to more complex indicators such as II Change in land use and XI Land under SLM. In addition, three indicators were essentially “placeholders” in the original report, as they were specifically requested but at the time of the report not defined at a higher operational level of detail (VI, X and XI).

VI. Indicator refinement: candidate metrics/proxies

Source and technical descriptions

48. Candidate metrics/proxies – how an indicator might be measured – have been proposed to the UNCCD for each of the provisional indicator categories by a number of synergistic activities. In particular, taken together, GEF KM:Land, LADA and CBD have 22 metrics/proxies for indicators under development that corresponded to the provisional indicator list. Their development efforts over the past few years have involved considerable input from the scientific community, and a considerable amount of documentation was available for each metric or proxy. Based on this background information, consistent technical descriptions for each were developed to provide to the Initial Expert Review, annex 2. They are ordered in annex 2 according to UNCCD strategic objectives 1, 2 and 3 and associated core indicators (S1–7). They are numbered to correspond with the original UNCCD provisional indicator (I–XI) they suited best, with the addition of a letter code (for example, KM:Land = KM; LADA = LA; CBD = CBD) to make it easier to track the source. Each refinement metric/proxy retains the name given by those who proposed it. A generalized reference to scale is also provided next to the indicator name. The information for each metric/proxy provided includes: purpose, description, source, spatial and temporal refinement, and noted strengths and weaknesses. Similar metrics/proxies of indicators relating to the same original UNCCD indicator were placed side by side in annex 2.

49. The metrics/proxies which were evaluated are listed in table 7. Table 8 maps these proposed metrics/proxies against the strategic objectives and core indicators, and the corresponding provisional indicator as originally defined in decision 17/COP.9, annex 1 (see table 1).

Table 7

The proposed metrics/proxies evaluated in support of the indicator refinement effort

1.	**I-KM-a**	Water stress
2.	**I-LA-a**	Pressure on water resources
3.	**I-KM-b**	Water availability
4.	**I-LA-b**	Water availability and use
5.	**I-KM-c**	Percentage of rural population with access to (safe) drinking water
6.	**I.LA-c**	Access to improved drinking water based on change in water quality
7.	**II-KM**	[see XI–KM below] LUS and SLM practices
8.	**II-LA**	LUS and change in land use
9.	**III-KM**	Rural poverty rate
10.	**IV-KM**	Proportion of chronically undernourished children under the age of 5 in rural areas
11.	**V-KM**	MMR
12.	**VI-LA-a**	Level of land degradation (via ecosystem-services provision capacity)
13.	**VI-LA-b**	Level of land degradation
14.	**VII-KM**	Crop and livestock diversity (agro-biodiversity)
15.	**VII-CBD**	Trends in abundance and distribution of selected species
16.	**VIII-KM**	Trends in seasonal precipitation
17.	**VIII-LA**	Aridity trend and rainfall variability
18.	**IX-KM**	Land cover
19.	**IX-KM&LA**	Land productivity
20.	**X-LA**	Above and below ground organic carbon stocks
21.	**XI-KM**	[see II-KM above] LUS and SLM practices
22.	**XI-LA**	Land under SLM

KM:Land = KM; LADA = LA; CBD = CBD

Table 8

Schematic of UNCCD objectives, core indicators, provisional indicators and revision metrics/proxies under consideration (part 1)

UNCCD Objective 1: To improve the living conditions of affected populations

UNCCD core indicator S-1 **Decrease in the number of people negatively impacted by the process of DLDD**	**UNCCD core indicator S-2** **Increase in the proportion of households living abovethe poverty line in affected areas**	**UNCCD core indicator S-3** **Reduction in the proportion of the population below the minimum level of dietary energy consumption in affected areas**

UNCCD Provisional indicator names:

I Water availability per capita in affected areas	**II Change in land use**	**III Proportion of the population in affected areas living above the poverty line**	**IV Childhood malnutrition and/or food consumption/ calorie intake per capita in affected areas**	**V The HDI as defined by UNDP**

Revision metric/proxy names:

1. **I-KM-a** **Water stress**	**2.** **I-LA-a** **Pressure on water resources**	**3.** **I-KM-b** **Water availability**	**4.** **I-LA-b** **Water availability and use**	**5.** **I-KM-c** **Percentage of rural population with access to (safe) drinking water**	**6.** **I.LA-c** **Access to improved drinking water based on change in water quality**	**7.** **II&XI-KM** **LUS and SLM practices**	**8.** **II-LA** **LUS and change in land use**	**9.** **III-KM** **Rural poverty rate**	**10.** **IV-KM** **Proportion of chronically under-nourished children under the age of 5 in rural areas**	**11.** **V-KM** **MMR**

(part 2)

UNCCD Objective 2: To improve the condition of ecosystems								*UNCCD Objective 3: To generate global benefits through effective implementation of the UNCCD*		
UNCCD core indicator S-4 Reduction in the total area affected by DLDD		**UNCCD core indicator S-5 Increases in net primary productivity in affected areas**						**UNCCD core indicator S-6 Increases in carbon stocks (soil and plant biomass) in affected areas**	**UNCCD core indicator S-7 Areas of forest, agricultural and aquaculture ecosystems under sustainable management**	
UNCCD provisional indicator names:										
VI Level of land degradation (salinization, water and wind erosion, etc.)		**VII Plant and animal biodiversity**		**VIII The aridity index**		**IX Land cover status**		**X Carbon stocks above and below ground**	**XI Land under SLM**	
Revision metric/proxy names:										
12. VI-LA-a Level of land degradation (via eco-system-services provision capacity)	**13. VI-LA-b Level of land degradation**	**14. VII-KM Crop and livestock diversity (agro-bio-diversity)**	**15. VII-CBD Trends in abundance and distribution of selected species**	**16. VIII-KM Trends in seasonal precipitation**	**17. VIII-LA Aridity trend and rainfall variability**	**18. IX-KM Land cover**	**19. X-KM&LA Land productivity**	**20. X-LA Above and below ground organic carbon stocks**	**21. XI&II-KM LUS and SLM practices**	**22. XI-LA Land under SLM**

VII. Conclusions

A. Refinement of the indicator set hierarchy

50. One of the critical needs identified in both of the reviews conducted prior to this effort and by the Initial Expert Review for this report was how the underlying logic (and in some cases, language) of the indicator set hierarchy needed to be fine-tuned in order to maximize the potential for the indicator set to meet the strategic objectives of the UNCCD. These issues were taken up in the Technical Workshop and led to proposals on (a) enhancing the linkages between the strategic objectives and core indicators, (b) distinguishing between necessary general indicators and the metrics/proxies and associated methodologies that might be used represent them, and (c) suggestions on metrics/proxies that are ready for testing or further development.

51. It is important to note that the suggested refinements detailed below are *not* intended to change the purpose and target of the indicators, but to simplify them in order to ease selection of the specific and operational indicators needed to allow for clear and effective reporting.

52. The next sections describe, step by step, these refinements. (To see the combined results of these steps, see table 12.)

1. Refine the indicator set hierarchical structure

53. The indicator set hierarchy as provided in decision 17/COP.9, annex I (table 1) involves three levels:

I. Strategic objectives
  a. Core indicators
    i. Provisional indicators

54. The proposed refinement to the *structure* of this hierarchy is to divide level 3 (provisional indicators) into two parts, namely general indicators (what should be measured) and metrics/proxies (methodologically defined measures to make the general indicators operational), so that the refined hierarchy would be as follows:

I. Strategic objectives
  a. Core indicators
    i. General indicators
      1. Metrics/proxies

55. This refinement essentially splits apart two, often confusing, aspects of the debate in indicator development and selection: what the indicator should measure, and the metric or proxy that should be used to measure it.

2. Refine the core indicator descriptions

56. The experts endorsed the approach defined by the core indicators and their relationship to the strategic objectives as listed in decision 17/COP.9, annex I (table 1), and suggested one aggregation and some minor refinements in wording to make them more effective.

57. The introduced changes depicted in *italics* and ~~strikethrough~~ in table 9 are:

- Merging and generalization of former core indicators S-1, S-2, S-3 to allow for more flexible and effective selection of the best indicators relating to poverty, nutrition and access to water, based on the most updated methods;
- Elimination of the repeated reference to "affected areas" in the core indicators definition, in conjunction with the proposal that the context of application of the indicators should be defined and clarified as a separate but parallel task, in order to avoid possible confusion and different interpretations by the UNCCD and affected country Parties (see proposal (g) in section VII.B).

Table 9
Proposed refinements to core indicators

Objective 1: To improve the living conditions of affected populations	
Core indicator S-1: Decrease in the number of people negatively impacted by the process of DLDD	**Core indicator S-1/2/3**: *Improvement in the livelihoods of people potentially* impacted by the process of DLDD
Core indicator S-2: Increase in the proportion of households living above the poverty line in affected areas	
Core indicator S-3: Reduction in the proportion of the population below the minimum level of dietary energy consumption in affected areas	
Objective 2: To improve the condition of ecosystems	
Core indicator S-4: Reduction in the total area affected by DLDD	**Core indicator S-4:** Reduction in the total area affected by DLDD
Core indicator S-5: Increases in net primary productivity in affected areas	**Core indicator S-5**: *Maintenance of or* increases in ecosystem function, including net primary productivity ~~*in affected areas*~~
Objective 3: To generate global benefits through effective implementation of the UNCCD	
Core indicator S-6: Increases in carbon stocks (soil and plant biomass) in affected areas	**Core indicator S-6**: Increases in carbon stocks (soil and plant biomass) ~~*in affected areas*~~
Core indicator S-7: Areas of forest, agricultural and aquaculture ecosystems under sustainable management	**Core indicator S-7**: Areas of forest, agricultural and aquaculture ecosystems under sustainable management

3. Generalize the provisional indicator system level, and refine the list

58. The convened experts are aware of the criticism raised in relation to the 11 provisionally accepted indicators. They are also aware that some of the 11 indicators were defined (by the original "minimum set" report) at a sufficient degree of operational specificity, but many others were just left open, to be intended as general indicators (or information categories, a sort of statement of information need) to be implemented by means of specific indicators to be defined in a later refinement phase. This aspect has often been neglected in such criticism.

59. With this in mind, the experts suggested that the provisional indicator list could serve an essential function of "general indicator" for what is determined must be measured in order to assess impact. (And, as noted in step 1 above, the operational definitions of these indicators would reside in the fourth level of the hierarchy, called "metrics/proxies".) Based on this, the experts proposed the name/definition changes in the general indicators list shown in table 10.

60. And, in the same way as for the core indicators, the experts suggested elimination of the repeated reference to "affected areas" in the general indicators definition, in conjunction with the recommendation that the context of application of the indicators should be defined and clarified as a separate but parallel task, in order to avoid possible confusion and different interpretations by the UNCCD and affected country Parties (see proposal (g) in section VII.B).

61. Next, the experts analysed the provisional indicator list for their relevance to the related core indicators. As far as they are considered as general indicators (as defined above) all the provisional indicators were considered as relevant to at least one of the core indicators and endorsed, with two exceptions:

- V Human development index, was *not* endorsed because it was determined to be redundant since it overlaps the other specific indicators proposed in relation to livelihood (indicators I–IV); and because of its complexity (it involves multiple underlying measures in its calculation), it would be the least sensitive to DLDD.
- VIII Aridity index was *not* endorsed as a general indicator relevant to the three core indicators in the sense that it must be used in conjunction with all the others to define the dryland areas, and thus will be used in support of their analysis rather than as an independent indicator (see proposal (g) in section VII.B).

Table 10
Proposed revisions to the indicator short names/definitions

The original 11 provisional indicators		*The retained general indicators*	
I	Water availability per capita in the affected areas	I	Water availability per capita ~~*in the affected areas*~~
II	Change in land use	II	Change in land use
III	Proportion of population in affected areas above poverty level	III	Proportion of population ~~*in affected areas*~~ above *the relative* poverty ~~*level*~~ line
IV	Childhood malnutrition and/or food consumption/caloric intake per capita	IV	~~*Childhood malnutrition and/or*~~ Food consumption~~*/caloric intake*~~ per capita
V	HDI	~~*V*~~	~~*Human Development Index (HDI)*~~
VI	Level of land degradation	*New V.*	*Capacity of soils to sustain agro-pastoral use*
VII	Plant and animal biodiversity	VI	~~*Level*~~ *Degree* of land degradation
VIII	Aridity index	VII	Plant and animal biodiversity
IX	Land cover status	VIII	~~*Aridity*~~ *Drought* index
X	Carbon stocks above and below ground	IX	Land cover status
XI	Land under SLM	X	Carbon stocks above and below ground
		XI	Land under SLM

4. Refine the relationship between core and general indicators

62. For some of general indicators it was suggested that the association with the specific core indicators be changed to ensure that each core indicator and its associated general indicators have a direct relationship, and that taken together they address the corresponding strategic objective. This is summarized in table 11 below (and is also reflected in the final results of the refinement process in table 12).

63. Specifically, two gaps were identified by the experts:

- A “drought index” indicator (for example, the Standardized Precipitation Index (SPI)) is necessary to cover fully the definition of core indicator S-4. In the refined hierarchy, this indicator was given the name “VIII Drought index”.
- A “capacity of soil to sustain agro-pastoral use” indicator (for example, the Global Land Degradation Information System (GLADIS) “Soil Health Status”) is needed in relation to both SO-2 (ecosystem provisioning services capacity) S-4 and SO-3 (sustainability of land use) S-7. In the refined hierarchy, this indicator was given the name “V Capacity of soils to sustain agro-pastoral use”.

64. The experts also noted that some indicators would play support roles for other indicators.

- The proposed “drought index” (new VII) was also considered necessary for (a) the assessment of drought, (b) the derivation of VI Degree of land degradation.
- The proposed “Capacity of soils to sustain agro-pastoral use indicator” (new V) (for example, GLADIS “Soil Health Status”) was considered necessary for the derivation and interpretation of VI Degree of land degradation, and for assessing sustainable land management, and XI Land under sustainable land management (SLM).

65. The experts noted that some indicators would serve as secondary indicators under a second core objective. One such example was:

> VII Plant and animal biodiversity is the primary general indicator under core indicator S-5. However, in relation to core indicator S-7, it should be considered as a secondary indicator because there are multiple aspects in the relationship between biodiversity and SLM, rather than just a single-faceted, unambiguous relationship.

66. In one case, an indicator originally addressed two strategic objectives, but with a core indicator associated with the second. Specifically, decision 17/COP.9, annex 1 (table 1) placed III Proportion of the population living above the relative poverty line, under SO-1, but also under SO-3 with no corresponding core indicator. This latter placement was deemed redundant and removed.

5. Refine the implementation scale

67. Because the provisional indicators listed in decision 17/COP.9, annex I (table 1) were both what was to be measured and, in some cases, the specific metric or proxy of how to measure that indicator, an attempt was made to reference the appropriate implementation scale (national, global or both), which subsequently engendered considerable debate. The proposed change in the structure of the indicator set hierarchy makes this no longer relevant at the general indicator level (as methodology and data set scale dependency is primarily an issue when the metric/proxy is defined) (table 11). Clearly, however, the implementation

scale issue will remain of concern when selecting metrics/proxies for testing or further development. To ensure clear guidance on this issue, and to document major concerns relating to scale, please see proposals (e) and (f) in section VII.B.

Table 11

Proposed revisions to the relationship between the core indicators and the underlying general indicators

	Original (provisional)		*Refined (general)*
	National	*Global*	*National and global*
STRATEGIC OBJECTIVE 1:			
Core indicator S-1/2/3:	I, II, III, IV	I, III, V	I, III, IV
STRATEGIC OBJECTIVE 2:			
Core indicator S-4:	II, VI		II, VI, new VIII, new V
Core indicator S-5:	VII, VIII, IX	IX	VII, IX
STRATEGIC OBJECTIVE 3:			
Core indicator S-6:	X		X
Core indicator S-7:	XI	XI	XI, new V, VII*
Not linked to a core objective	VII, III	III	

I Water availability per capita in the affected areas; II Change in land use; III Percentage of population in affected areas above poverty level; IV Childhood malnutrition and/or food consumption/caloric intake per capita; V Human Development Index (HDI); VI Level of land degradation; VII Plant and animal biodiversity; VIII Aridity index; IX Land cover status; X Carbon stocks above and below ground; XI Land under Sustainable Land Management (SLM); New VIII Drought index; New V Capacity of soils to sustain agro-pastoral use

*Note: VIII, Biodiversity in relation to core indicator S-7, should be considered as a secondary indicator because there are multiple aspects to the relationship between biodiversity and SLM, rather than just a single-faceted, unambiguous relationship.

6. Refine the metrics/proxies level

68. In all, 22 different “metrics/proxies”, the methodologically defined measures to make the general indicators operational, were evaluated. During the Initial Expert Review, 37 scientists provided comments on these measures, and of these, 17 completed an evaluation using the criteria (described in section III.C). The summary of the ratings for each indicator/criterion is available in annex III. The reviewers were also asked for their opinion on the role each metric/proxy under evaluation might play, with respect to the DPSIR and MA framework. Annex IV contains the summary of that assessment.

69. These results were discussed in both the plenary session and by the four working groups during the Technical Workshop. The metrics/proxies were then reassessed by the working groups of 10 scientists from different regions and disciplines (not all groups had time to address all metrics/proxies, but each was assessed in detail by at least two working groups). The working groups also rated these metrics/proxies on their “readiness” for testing as a separate issue, so that indicators deemed necessary but not yet ready to implement would remain under consideration (see proposal (n) in section 7.2).

70. All metrics/proxies that were recommended by both working groups to be moved forward for further consideration, as well as those with less agreement, are listed in table

12. There were several metrics/proxies that did not receive conclusive support as "independent" metrics or proxies within the indicator set. When considered in conjunction with another indicator or metric, however, they were considered essential. These included:

- No.3 I-KM-b and No.4 I-LA-b Water availability and use (in support of No.5 I-KM-c Percentage of population with access to (safe) drinking water
- No.7 II-KM/XI-KM and No.8 II-LA Land use (in support of deriving (a) VI Land degradation and (b) XI Land under SLM, and also in interpreting (c) IX Land cover status)

71. Finally, three new metrics/proxies were proposed and received strong support from the 10 scientists in the working group making the proposal. These included:

- SPI (under new VII Drought index), proposed because it was considered necessary for (a) the assessment of drought, (b) the derivation of VI Degree of land degradation, and the recent decision by the World Meteorological Organization (WMO) and other organizations to endorse SPI as a universal standard drought index.71
- GLADIS "Soil Health Status" (under new V Capacity of soils to sustain agro-pastoral use) was considered necessary for the derivation and interpretation of VI Degree of land degradation and for assessing sustainable land management and XI Land under Sustainable Land Management (SLM).
- Soil biodiversity (under VII Plant and animal biodiversity) was considered not ready for implementation today, but something which would be valuable, even essential, in the future. To ensure full consideration and to create a "place holder" this metric/proxy was proposed by the working group assessing this indicator.

72. These refinements are a culmination of the participatory, formative review process. The level of agreement among the experts varied from point to point, and this has been noted throughout the white paper and in table 12. In this way we hope to have reflected the views of the Technical Expert Workshop participants.

73. The refinements to Decision17/COP.9, annex I are based on the combined sources of technical expert feedback obtained throughout the formative, participatory evaluation process.

Table 12

Proposed refinements to decision 17/COP.9, annex I[1]

(*Impact indicators for reporting on strategic objectives 1, 2, and 3 of The Strategy*) (see table 1 in this white paper)

Proposed revisions to decision 17/COP 9, annex 1, including metrics/proxies to be considered for testing and/or further assessment/development

Core indicators (with proposed revisions)	*General indicators (revisions of 11 provisional indicators)*	*Metrics/proxies (operational approaches proposed for testing, where ready, and further assessment/development where not)*	*Degree of expert agreement*	*Readiness for testing*
Strategic objective 1: To improve the living conditions of affected populations				
Core indicator S-(1/2/3): Improvement in the livelihoods of people potentially impacted by the process of DLDD	**III Proportion of the population living above the relative poverty line**	No.9. III-KM Rural poverty rate*	High	Green
	I Water availability per capita	No.5. I-KM-c Percentage of population with access to (safe) drinking water	Medium	Yellow
		No.3. I-KM-b and No. 4 I-LA-b Water availability and use (in support of No.5 I-KM-c)	Low**	Yellow
	IV Food consumption per capita	No.10. IV-KM Proportion of chronically undernourished children under the age of 5 in rural areas*	High	Yellow
Strategic objective 2: To improve the condition of ecosystems				
Core indicator S-4: Reduction in the total area affected by DLDD	VI Degree of land degradation	A less complex version of No. 13 VI-LA-b Level of land degradation + No. 16 VIII-KM Trends in seasonal precipitation	High	Red
	VIII Drought index	SPI	(new)	Green
	V Capacity of soils to sustain agro-pastoral use	GLADIS "Soil Health Status"	(new)	Green
	II Change in land use	No.7. II-KM/XI-KM and No. 8 II-LA Land use (in support of deriving (a) VI Land degradation and (b) XI Land under SLM, and also in interpreting (c) IX Land cover status)	Low**	Yellow

Proposed revisions to decision 17/COP 9, annex 1, including metrics/proxies to be considered for testing and/or further assessment/development

Core indicators (with proposed revisions)	*General indicators (revisions of 11 provisional indicators)*	*Metrics/proxies (operational approaches proposed for testing, where ready, and further assessment/development where not)*	*Degree of expert agreement*	*Readiness for testing*
Core indicator S-5: Maintenance of or increases in ecosystem function, including net primary productivity	**IX Land cover status**	No.18. IX-KM Land cover*	High	Green
		No. 19. IX-KM&LA Land productivity	Medium	Green
	VII Plant and animal biodiversity***	No. 14. VII-KM Crop and livestock diversity (agro-biodiversity)	High	Yellow
		No. 15. VII-CBD Trends in abundance and distribution of selected species	High	Yellow
		Soil biodiversity	(new)	Red
Strategic objective 3: To generate global benefits through effective implementation of the UNCCD				
Core indicator S-6: Increases in carbon stocks (soil and plant biomass)	X Carbon stocks above and below ground	No.20a X-LA Above ground organic carbon stocks	High	Yellow
		No.20b X-LA Below ground organic carbon stocks	High	Red
Core indicator S-7: Areas of forest, agricultural and aquaculture ecosystems under sustainable management	XI Land under SLM	No.22 XI-LA Land under SLM + general indicator VII Plant and animal biodiversity (secondary role) + II Change in land use	High	Yellow
	V Capacity of soils to sustain agro-pastoral use	GLADIS "Soil Health Status"	(new)	Green

* Though named slightly differently, the operational definition of this indicator is very similar to that given by Berry et al., 2009.[7]

** As a stand-alone metric/proxy, there was limited or divided support for this metric/proxy. However, if used in support of another indicator, the agreement was much higher.

*** Also a secondary indicator under core indicator S-7.

B. Proposals

74. In addition to updating the proposed conceptual framework (figure 3) and the indicator set refinements proposed in section VII.A.3, the participants in the Technical Experts Workshop also debated and then drafted the following set of proposals for consideration by the CST designed to overcome barriers in the current approach to indicator set refinement, and to suggest where future emphasis may have greater impact. The proposals were debated and redrafted. After the meeting, most of the experts submitted additional feedback, helping resolve those points of discussion which remained open at the end of the meeting:

(a) We propose a clarification in the use of the term “impact indicators” to suggest that the complete set of indicators, when taken together, should provide insights into the progress made towards the achievement of strategic objectives 1, 2 and 3 of The Strategy. In this sense, some of the indicators in the set may not be, strictly speaking, “impact” indicators (they might be drivers, for instance). However, when considered with the other indicators, they are recommended for inclusion in the set as they would aid in understanding impact. This is particularly important for future efforts to measure the real impact of the UNCCD and associated interventions;

(b) We propose that a decision be taken concerning the use of the terms “harmonization” and “standardization” (as was done by the Global Terrestrial Observing System (GTOS)). Harmonization in this context means to make comparable (harmonize) the same variable measured in different ways. Standardization here means to only one agreed single common methodology for the same variable or indicator. Causes and consequences of dryland degradation have multiple characteristics and vary within space and scale. Hence, the indicator selection needs to accommodate these particularities while following coherent principles and criteria. We propose that the UNCCD pursues harmonization, with the potential for standardization when appropriate and feasible;

(c) We propose a clarification in the intent behind proposing a “minimum” or “limited” set of indicators. There is a demonstrable need for harmonized measures that are comparable across countries and regions. For reasons of practicality, feasibility, verifiability and capacity, these should be no more in number than is necessary to report impacts, so that each indicator contributes essential information, and that duplication (internal auto-correlation) among the indicators is minimized. However, it should be emphasized that this approach is not meant to limit monitoring, evaluation and assessment. To address this concern functionally, we propose that the UNCCD initiates the development of a mechanism where the minimum set of globally harmonized indicators can be systematically complemented by regionally, nationally and/or locally-relevant and developed indicators which, when combined with the global set, communicate impact more comprehensively and can provide support to the decision-making and planning processes;

(d) We support prior recommendations to the UNCCD that it is essential to have a scientific framework to support indicator set organization, use and communication. We propose that the framework selected helps to support the strategic objectives of the UNCCD and provides the opportunity to capture causality, interactions and trade-offs, so that the indicator set would further support decision-making. We propose as the initial framework an amended DPSIR framework integrated with ecosystem services provisions. We propose that the framework selected initially be regularly re-evaluated for appropriateness as monitoring and evaluation efforts mature, for its usefulness for the decision-making processes, and because needs may change;

(e) We propose that the UNCCD, in preparing reporting guidelines for the Parties, engages stakeholders (the scientific community, data providers and end users) in more clearly specifying their needs, and determines the desired data output resolution, particularly where the term "national monitoring"* is concerned (for example, to distinguish between single number national statistics versus measurements that would provide a sense of the variability within a nation);

(f) Indicators of land degradation and desertification are scale-dependent; that is, the resultant measurement depends on the area being considered and the process of land degradation being assessed. This is a particular concern when aggregating field, local and district information in support of national monitoring where exaggerated results could arise when an indicator is used at a small scale (detailed assessment) for estimating degradation at a large scale. In the UNCCD reporting guidelines, indicators and their scale of operation as measurements need to be carefully noted and precautions need to be taken if indicator measurements are aggregated to a wider landscape;

(g) In order to provide for effective use of the indicator set, we propose that the UNCCD clarifies the term "in affected areas", specifically where it is used in the definition of the core and provisional indicators. It is suggested that all the proposed indicators be measured in affected country Parties (as already mandated by the Convention); thus this term is not required in indicator definitions. However, the operational use of the term "affected areas" should be refined through input from the scientific community (determining how to delineate these areas in a scientifically sound manner) and used to interpret the impact indicator measurements (such as percentage of affected area). In this approach the related but different challenges of (a) defining, measuring and monitoring the indicators and (b) defining and delineating affected areas would be distinct and therefore more operationally viable;

(h) We propose that the UNCCD seeks further to develop, with other relevant conventions and organizations, synergies on the identification, development and use of indicators;

(i) We propose that the UNCCD establishes, and dedicates appropriate resources towards, an ad hoc technical expert group along the lines of a similar approach adopted by the CBD. Such a group would be tasked with continuing the iterative, participatory contribution from the science and technology community to the indicator selection, the development and refinement process, the subsequent monitoring and evaluation, and efforts to manage and make use of the information collected from the indicator set and contributions made locally and regionally. This technical group would be small and flexible enough to support the CST and the UNCCD, and yet be regionally and functionally representative, including participation by representatives of major synergistic efforts, and relevant conventions and organizations. Examples of topics that this group (or appointed ad hoc technical sub-working groups) would address are (a) indicator specifications in terms of underlying functions and explicit capacity to link with other indicators to increase effectiveness, reproducibility and understandability by users, (b) operational definition and measurement methodology refinements for the selected indicators, (c) indicator data requirements on quality, availability and cost, (d) indicator testing, (e) data harmonization and standardization, (f) development of a mechanism for the framework and indicator approach to accommodate regionally or locally specific inputs, (g) developing an operational definition of, and an approach to, identifying affected areas, (h) exploring ways to improve the "readiness" of selected indicators, including their sensitivity to DLDD, and (i) developing a communication strategy and associated information products for the outputs of the indicator set;

(j) We propose that the UNCCD encourages, and dedicates appropriate resources towards, the creation of an institutional partners group, along the lines of the

Biodiversity Indicators Partnership. This should be made up of the organizations which would be contributing to the generation and management of the data sets underlying the indicators of DLDD and the success of remedies to address it;

(k) We propose that the UNCCD dedicates appropriate resources towards encouraging the production/availability of statistical data at the subnational level to make possible an effective integration of biophysical and socio-economic information and, most importantly, to ensure that the socio-economic information be given proper weight to ensure that human well-being assessments (and associated indicators) are capable of determining the influence of DLDD. This process could be linked with efforts of the United Nations Statistics Division and national accounting;

(l) We propose that the UNCCD encourages the realization of tests in order to assess the feasibility of the proposed refinement impact indicators in meeting the objectives of the indicator set under the proposed hierarchy. The tests should include a review of available data, baselines and monitoring systems existing at national and local levels to use the UNCCD set of impact indicators currently under a scientific peer review process. Analysis of the gaps and review of capacities should be part of the testing. Testing should be part of both local engagement in the indicator development process and capacity-building. Testing should also evaluate whether the set of indicators, when taken together, cover all requirements for information necessary for assessing impact. The results of the tests should be presented to the CST before the next session of the COP (COP 10);

(m) We propose that the UNCCD (with input from the scientific community) carefully considers the sensitivity of indicators, particularly essential socio-economic measures of impact, where the contributive influence of DLDD and its remedies are, at least at present, difficult to distinguish. It is quite challenging, and in some cases impossible, to define the contribution of DLDD to some indicators (such as gross national product); for others, however, the degree of sensitivity to DLDD may improve as our capacity to define and delineate affected areas improves and the spatial resolution of corresponding indicator data sets is enhanced. This issue could be addressed by the 2nd UNCCD Scientific Conference, "Economic assessment of desertification, sustainable land management and resilience of arid, semi-arid and dry sub-humid areas";

(n) We propose that the UNCCD considers adopting a scheme for categorizing indicators based on their "readiness" for operational use (something like this was employed by the CBD and the UNFCCC). Such a scheme would ensure a place for indicators that are currently challenging to measure, but which are viewed as essential to monitoring impact. We propose, as an initial approach, the scheme used during the Technical Workshop: green = ready for testing, yellow = requires fine tuning, red = requires further development. Using such a scheme will prevent the elimination of essential indicators solely on the basis of our current capacity operationally to monitor them;

(o) We propose that the UNCCD (with input from the scientific community) reaches commonly agreed definitions for terms used for impact indicators and the potential associated metrics or proxies used to measure these indicators. For example, SLM is viewed by many technical and policy experts as a necessary indicator, but without a proper, consistent definition agreed upon in collaboration with major synergistic activities undertaking SLM activities locally, there will be confusion and disagreement which could be avoided with a consistent definition (as shown in the evaluation of this indicator and the subsequent discussion by experts);

(p) It is important that the realities of indicator development need to be fully acknowledged, including the time and financial resources required. It is an evolutionary process at the global, national and local levels, and thus the UNCCD should provide guidance on alternative approaches that may be adopted and encourage horizontal and inter-agency collaboration and data sharing, as well as on procedures for sufficient contextualization and a reporting review process (including the link between UNCCD performance and impact indicators).

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Annex I

Synthesis of recommendations from the scientific community made to the UNCCD prior to the refinement process[1-3]

This list synthesizes past recommendations from the scientific community to the UNCCD for consideration during the impact indicator refinement process:

(a) Ensure that the refinement of the indicator suite being developed to support monitoring and assessment of DLDD solicits and uses input from the scientific community;

(b) Ensure that the indicator refinement process is as representative as possible geographically and across disciplines, in order to assist the achievement of a final outcome which is indicative of the complexity (geographical, perceptions…) it captures;

(c) Maximize possible synergies with regional UNCCD efforts, and parallel relevant programmes, projects and institutions, including those associated with the other Rio Conventions;

(d) Identify a scientifically grounded, and systematically applied conceptual framework that can be used to support indicator organization, communication and use, has the capacity for supporting analysis of, and decisions based upon, complex DLDD information, and addresses not only the symptoms of DLDD (state, condition, impacts), but also the underlying drivers and processes;

(e) Employ an accepted, scientifically grounded and rigorous application set of criteria for refinement of the indicators;

(f) Ensure that the proposed conceptual framework has the capacity to support an operational link between the suite of indicators and the primary applications envisioned (that is, monitoring the impacts of the UNCCD and supporting management actions and policy decisions) in such a way that ecological and social issues are fundamentally interwoven, as are the options for livelihood support and ecological management. This would facilitate subsequent use of the data gathered in one or more accepted integrated assessment approaches (processes meant to treat complex issues through various scientific disciplines while incorporating local, regional and/or national social actors);

(g) Recognizing that a fixed "common denominator" indicator suite may be only a starting point for assessing the broad impacts of UNCCD implementation, select a conceptual framework that has the potential to be enhanced so that the common denominator of "standard" indicators can be readily augmented with indicators identified through participatory approaches involving all the actors affected, in order to capture the variation among regions, countries and sites, and even among different socio-environmental units within the sites. This would involve identifying a mechanism within or linkable to the conceptual framework so that such participatory processes that capture the variety of local perspectives and expertise (that is, land users, managers, decision makers, researchers) in the development of locally relevant indicators can contribute to global assessment and monitoring in a way that encourages stakeholder engagement and captures of essential local environmental knowledge;

(h) Provide a mechanism, within or connected to the refined indicator suite, for ensemble assessment ("triangulation" of information from multiple lines of evidence), recognizing the wide variety and disparity of information used to monitor and assess

DLDD, as well as the range of proven techniques for monitoring and assessment, and the variation in these at the regional and national levels;

(i) Refine the indicators in a way that helps to ensure that they are attributable to (correlate with) the primary processes of concern, DLDD and the performance of associated remedies;

(j) Anticipate, and work to enhance, the capacity for the refined indicator suite to account for the fundamental interrelationships within coupled H-E systems that cause DLDD, which includes scalar issues (multiple temporal and spatial scales, cross-scale links and hierarchical interactions, nesting vs independence, slow vs fast variables, and so on), recognizing that problems and solutions at one scale influence, and are influenced by, those at other scales;

(k) Consider that many DLDD processes are nonlinear, and that dryland systems are often not in equilibrium, have multiple thresholds, and thus often exhibit multiple ecological and social states;

(l) Work towards ensuring global measurability of the indicators where possible, and document where further development of the science, monitoring methods and/or data capture-management-reporting will be necessary;

(m) Consider the need for setting targets and reflecting progress through benchmarks based on a refined indicator suite that has the capacity to be assessed relative to socio-economic and biophysical baseline information;

(n) Ensure that the link between the refined indicator suite and policy/governance is established by providing the capacity within the conceptual framework and refined indicator suite to incorporate information necessary to aid in priority setting, including socio-economic factors (that is, economic, social and environmental costs of DLDD, the benefits of SLM, return on investment, pricing of ecosystem services provided/protected by successfully combating desertification) which are at the moment difficult to obtain but which will be vital in achieving the longer-term UNCCD objectives;

(o) Address the UNCCD request that monitoring and assessment meet both the needs of affected country Parties and global information needs by acknowledging that policy and institutional decision-making authority associated with DLDD is usually concentrated at national and subnational levels in most areas of the world. Thus the level of detail provided by the refined indicator suite must be commensurate with this need;

(p) Distinguish between indicator sets and scale of operation. While some of the global-level DLDD information desired by the UNCCD can be built from careful analysis of such national and subnational information, it is essential that compatible protocols and standards are used. Moreover, in many cases "scaling up" is not possible because levels of detail are different, measurement requirements vary and the users/uses of the information also vary. For this reason, it is necessary to distinguish between indicator sets and scale of operation;

(q) Capture the interconnections between DLDD, climate change and biodiversity loss in order to maximize (and leverage) the work of other multilateral environmental agreements (particularly the CBD and the UNFCCC) in the refinement of the indicator suite for DLDD assessment and monitoring;

(r) Encourage an approach to indicator development and use that maximizes multiple parallel efforts and the capacity to benefit from a common information repository and knowledge management system, such as the proposed GDOS;

(s) Ensure that SLM is carefully defined in collaboration with ongoing SLM initiatives, and that it is fully integrated into DLDD monitoring and assessment;

(t) Address the concern that monitoring and assessment should not only provide information about the risk of desertification and desertification impacts, but also about the performance of measures to combat desertification;

(u) Ensure that the conceptual framework proposed has the potential to be enhanced so that future indicator development, refinement and selection can be based on the analytical logic behind the interconnectedness of the indicators via a causal network/ model of the functioning of the system (developed in a participatory manner) rather than on individual indicator characteristics alone;

(v) Promote the endorsement of harmonization through compatible, scientifically-valid standards and protocols for monitoring and assessment across national and subnational levels, which will not only enhance the utility of the indicator suite, but permit appropriate analysis of national and subnational information at the global scale.

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Annex II

Technical descriptions of metrics/proxies for proposed refinement indicators (revised 13 December 2010)

Annex II is a table of technical descriptions of proposed refinements to the metrics/proxies of the provisional UNCCD impact indicators (see tables 1 and 4) proposed by groups of experts (KM:Land, LADA, the World Overview of Conservation Approaches and Technologies (WOCAT) and, in one case, the CBD) that have been working extensively on related indicator development. The indicators are ordered according to UNCCD strategic objectives 1, 2 and 3 and associated core indicators (S-1–S-7). They are numbered to correspond with the original UNCCD indicators I–XI, with the addition of a letter code (for example, KM:Land = KM; LADA = LA; CBD = CBD) to make it easier to track the refinement source. Each metric or proxy retains the name given by those who proposed it. A generalized reference to scale is also provided next to the indicator name. Global/national indicators are either national statistics (subnational data not available), or have the potential to be spatially explicit where some information on national boundaries is available (this is stated where relevant). Local (project) indicators listed here have the *potential*, based on input provided by KM:Land and LADA (verbal communication and reports), to be scaled up or otherwise aggregated to be reported at the national level (scaling methods are included or, if lacking, recommended). Indicators from more than one source relating to the same original UNCCD indicator are placed side by side in the table. In a few cases they may be very similar to each other, but in others they are quite different. Each indicator should therefore be assessed on its own merit. Whenever possible, text in each cell was copied verbatim directly from the primary references (listed in the first row in the table) used to generate a common technical description. However, the source documents varied considerably in format and approach, and so in many cases information was summarized for this table. Please do not hesitate to correct any errors and address any omissions.

Technical descriptions of proposed metrics/proxies for the refinement indicators

Primary reference(s) used for KM:Land- proposed refinement indicators metrics/proxies:	*Primary reference(s) used for LADA proposed refinement indicators metrics/proxies*
1. KM:Land Global indicators[1] 2. KM:Land Project indicators[2] 3: KM:Land Indicator measurement/reporting[3]	1. LADA Methodology Local Manual[4] 2. LADA Tool Box Local Manual[5] 3. LADA for UNCCD Guidelines[6] 4. LADA Land Use Systems Mapping[7] 5. WOCAT-LADA Framework[8-10] 6. GLADIS[11] 7. GLADIS Ecosystem Approach[12]
Use of primary references: Where possible, content below is taken verbatim from these reports in order to be as close as possible to what the authors intended. For more detail, please access the reports directly. In other cases, the content below is a summary of information extracted from one or more reports.	

LADA methodological note: LADA-proposed global/national indicators listed here can be derived from GLADIS data and/or LADA-WOCAT national assessment methodology, unless otherwise stated. Project indicators follow the LADA assessment methodology, which involves 2–6 geographic assessment areas per country, with 2–3 study areas in each. These areas range in size from a single watershed to a region of several hundred km^2 (up to several thousand in large contiguous regions). Study areas generally involve two transects. In addition, for each land-use type in the study area, three pairs of plots are measured (depending on complexity). Secondary data (maps, imagery etc.) and key respondent interviews are also used.

KM:Land methodological note: KM:Land-proposed indicators vary in source in methods at the global/national as well as the project level (and thus each is individually described below).

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UNCCD core indicator S-1: Decrease in the number of people negatively impacted by the process of DLDD

Current UNCCD indicator name:
I. Water availability per capita in affected areas

1. I-KM-a. Water stress (global/national)	**2. I-LA-a. Pressure on water resources** (global/national)
Purpose: To measure the stress/pressure on water resources	
Description: The ratio of water withdrawals to availability. Water stress is a measure of the amount of pressure put on water resources and aquatic ecosystems by the users of these resources, including domestic users, industries, power plants and agriculture. Water withdrawals are defined as the amount of water taken out of rivers, streams or groundwater aquifers to satisfy human needs for water.	*Description:* Percentage of total actual renewable freshwater resources withdrawn, as derived from the relationship between nationally reported statistics on total renewable water resources and water withdrawal (by water-user sectors and source of water). MDGs use this indicator, with the name "Proportion of total water resources used".[13]
Source: The mean annual relative water stress index (unitless ratio per grid cell) of the UNH WSAG..	*Source:* GLADIS includes these statistics from AQUASTAT,[14] the global information system on water and agriculture of the FAO, which has been collecting these national statistics since 1993.
Spatial and temporal refinement: National and sub-national analysis possible, based on a 0.5° grid (NB: the approximate area of a 30-minute grid cell at the equator is 3600 km^2). Models run on year 2000 data, but have not (at the time of the 2008 GEF report) been updated.	*Spatial and temporal refinement:* National statistic only. Some inputs are spatially explicit, such as the precipitation data set, 0.5° grid, while others are regional (for example, basin) or national aggregates. Trends can be calculated based on data going back to 1993.
Noted strengths and weaknesses: Spatially explicit, and available at a sub-national level. Not currently regularly updated (costs for updates estimated at $200,000 every two years).	*Noted strengths and weaknesses:* AQUASTAT has been used for global and national statistics reporting since 1993. This indicator was adopted by MDG as an indicator. Subnational data are not available, and thus can be used only as a national statistic. There are AQUASTAT data quality concerns relating to variation in reporting periods, variability in sources, interpolation issues, and potential over/under estimation bias. This raises concerns about accuracy, consistency and comparability.

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3. I-KM-b. Water availability (local level up to national)	**4. I-LA-b. Water availability and use** (local level up to national)
Purpose: To measure the impact of DLDD on water resources and its mitigation	
NOTE: KM:Land (I-KM-b) actually refers to LADA as a example of project-level methods (described in I-LA-b) that could be employed. They also refer to the LADA AQUASTAT approach to national statistics for the national context that LADA uses in GLADIS. Thus, both the KM:L and LADA descriptions for this indicator can be considered separately or in combination.	
Description: Proportion of total water resources used is defined as the total volume of groundwater and surface water withdrawn from their sources for human use (in the agricultural, domestic and industrial sectors), expressed as a percentage of the total volume of water available annually through the hydrological cycle. The terms water resources and water withdrawal are understood as freshwater resources and freshwater withdrawal.	*Description:* Current LADA-WOCAT indicators can be analysed to assess trends in water availability and the proportion of total water available that is in use. Per capita water availability indicators include: LADA-WOCAT-N: Hg Change in groundwater/aquifer level; LADA-WOCAT-N: Hs Change in quantity of surface water.
Source: Project level based on local assessment, such as the LADA methodology (see I-LA-b). Includes level of water resources, depth of water resources, water use and water withdrawal/extraction obtained through local measurement and key respondent interviews. Scale up to national level may be challenging; one approach would be to link this with data based on the MDG indicator “Proportion of total water resources used” (for which data are obtained through AQUASTAT – I.la).	*Source:* Project-level assessment of level of water resources, depth of water resources, water use, water withdrawal/extraction. Secondary information on water resources and climatic conditions and trends in the geographical assessment area are reviewed first. Local observations and measurements of water bodies (lakes, rivers etc.) and water points (boreholes and wells) in the field, backed up by secondary data and key respondent interviews including land users/households. Tested instruments for rapid assessment of water resources degradation (observations, measurements, key respondent interviews) are available to support data collection.
Spatial and temporal refinement: Project-level, and thus resolution dependent on local assessment implementation.	*Spatial and temporal refinement:* Project-level, and thus resolution dependent on local assessment implementation. See general note on LADA methods at the top of this table.
Noted strengths and weaknesses: DLDD happens locally; so capturing subnational variation is essential. However, scaling up from projects alone may not be spatially representative. Water quantity, especially in relation to water resources available, is difficult to assess. Care must be taken to account for inter-annual and seasonal variations in water availability. Short-term changes in water availability need to be carefully compared with longer-term trends in order to assess whether or not the observed trend is significant.	
5. I-KM-c. Percentage of rural population with access to (safe) drinking water (local-level up to national)	**6. I.LA-c. Access to improved drinking water based on change in water quality** (local-level up to national)
Purpose: Demonstrate that mitigation efforts remove or prevent the pollution of water resources associated with DLDD and/or enhance access to safe drinking water.	
Description: The percentage of the rural population with access to safe drinking water in a project’s intervention area. According to WHO, basic access to safe drinking water can be defined as the availability of at least 20 litres of drinking water per person per day within a distance of not more than 1 km of the dwelling, corresponding to a maximum water-hauling round trip of 30 minutes. Access to safe drinking water is measured by WHO and UNESCO as the “proportion of the population using an	*Description:* The LADA-WOCAT methodology has the potential to address safe drinking water access from the perspective of changes in water quality relative to overall water supply. It also includes the collection of contextual information on water allocations/access rules and arrangements, incidence and management of water conflicts, water policy, legislation and other institutional issues. Per capita water availability indicators include: LADA-WOCAT-N: Hg Change in groundwater/aquifer

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improved drinking water source”.	level; LADA-WOCAT-N: Hs Change in quantity of surface water. For water quality: LADA-WOCAT-N: Hp Decline of surface water quality; LADA-WOCAT-N: Hq Decline of groundwater quality.
Source: This indicator can be calculated by dividing the total population within a project area by the number of persons with access to an adequate amount of safe drinking water within the project area, and then multiplying this by 100 to obtain a percentage. Where available, the relevant data can be obtained through national data that is available from different sources such as WHO/UNICEF, AQUASTAT etc. The datasets of the WHO/UNICEF JMP for Water Supply and Sanitation[15] are based on national statistics but are completed by means of household surveys to improve the data quality. When national data are unavailable or insufficient, it will be necessary to conduct project-level assessments to obtain data. Two measurable indicators are proposed, to be assessed at the project level through household surveys: an indicator in relation to water access and availability as defined by WHO, and an indicator capturing information in relation to water quality for human consumption, animal water and/or irrigation, through simple categories.	*Source:* In the LADA methodology, the survey of water degradation is an assessment of level of water resources, depth of water resources, water use and water withdrawal/extraction, as well as groundwater and surface water quality obtained through observation and measurement of water bodies (lakes, rivers etc.) and water points (boreholes and wells) in the field, backed up by information from key respondents and land users/households.
Spatial and temporal refinement: JMP data are based on national statistics. (To capture subnational variability would require survey data at a finer spatial unit of analysis.) The data provided by JMP is updated every two years.	*Spatial and temporal refinement:* Mapping units in LADA-WOCAT products are associated with “land units” which are areas of land defined in terms of biophysical qualities and other landscape characteristics that may be demarcated on a map. They are the basis for the survey that produces the data for LADA-WOCAT indicators, which are then quantified (as an average) over each mapping unit. The resolution of spatially explicit national-level maps therefore varies from country to country, based on the landscape variation that exists and the intensity of sampling possible. However, the resolution is high enough for subnational analysis. The frequency of LADA-WOCAT surveys has yet to be determined, but is likely to be not more frequent than 5–10 years.
Noted strengths and weaknesses: DLDD happens locally, and so recording subnational variation is essential through project-level assessments. However, scaling up from projects alone may not be spatially representative. Changes in water quality can result from activities not directly related to land degradation, which reduces the sensitivity of this indicator in terms of attribution to land degradation. These factors need to be taken into account, therefore, when relating land degradation to changes in water quality. Improved drinking water sources are more likely to be protected from external contaminants than unimproved sources, either by intervention or through their design and construction. This indicator does not take actual drinking water quality into account, nor does it reflect the time spent on getting water from improved	*Noted strengths and weaknesses:* DLDD happens locally, and so capturing subnational variation is essential. However, scaling up from projects alone may not be spatially representative. Water quantity and water quality, especially in relation to water resources available, is difficult to assess. This approach is an indirect measure of drinking water access, but has the advantage that, in addition to measurements, contextual information on barriers to access is also gathered.

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sources which are not on the household premises. Both these determinants, however, are important parameters of access.

Current UNCCD indicator name:
II. Change in land use

Note: Both the KM:Land and LADA approaches to change in land use involve, as a first step, assessment of land cover and/or productivity. Please see IX Land Cover status (below) where this is detailed further. Both have approaches to obtaining information on SLM from land use (see XI).

7. II-KM and XI-KM Land-use system (LUS) and sustainable land management (SLM) practices (project level up to national)	**8. II-LA. Land-use system (LUS) and change in land use** (global/national with potential for project-level analogue) (See XI for the LADA SLM approach, which is project level.)
Purpose: This indicator is generated and used in conjunction with the land cover indicator (see IX). It provides information on the types of land use and SLM practices being used in DLDD intervention areas, and provides insights into the associated impacts. Good practices conducive to SLM (see XI) can contribute to the arresting and reversing of current global trends in land degradation, while improving human well-being.	*Purpose*: Measure land-use change to help understand impacts of land degradation on ecosystem function.
Description: This indicator shows the distribution/area coverage of LUS including SLM practices within intervention areas, which then have the potential to be scaled up for national-level reporting. Land cover (see IX) can be mapped in further detail to obtain LUS (categorized by cropland, grazing land, forest/woodland, mixed land, water surfaces, built/urban land, other). Further subdivision can be made on the basis of additional criteria such as physiography, administration, soil, slope, etc. The order of importance of these additional criteria depends on the local situation; for example, whether physiography or socio-economic criteria play a determining role. This is followed by mapping SLM practices in each LUS area.	*Description:* Land degradation can be defined as a long term loss of ecosystem functions over time as perceived by the beneficiaries. Its relation with land use is obvious as land use implicitly characterizes the way farmers and pastoralists use and manage the land and thereby inherently change it for the better and/or worse. Knowledge of local conditions, both biophysical and socio-economic, are needed to explain and relate the land use to land degradation and vice versa. The approach is based on a LUS) classification scheme focused on both production systems and the environmental services rendered.
Source: The mapping of LUS and SLM practices should be conducted through a participatory expert assessment. Further data for the delineation of the LUS and SLM practices can be obtained from various regional institutions involved in collecting and elaborating land management practices data. KM:Land suggests that the WOCAT[16]/LADA mapping questionnaires provide an elaborate method of assessing the area of degradation and SLM at the national level, which can also be applied at the project level. Participatory ground verification is recommended.	*Source:* The LADA-WOCAT approach to landuse mapping begins with a transformation of the global land cover dataset (GLC2000)[17] into major LUS that make up the LADA-WOCAT LUS scheme. This scheme is based on the sequence and combination of operations designed to obtain goods and services from the land. Apart from land cover, major ecosystems are mainly characterized by climate and terrain and by type of soils. Attributes include land use and landuse practices (dominant livestock and crop types, small-scale irrigation, and a crop index), biophysical aspects (temperature regime, length of growing period, dominant soil and terrain), and socio-economic aspects (population density and poverty). Change in land use can be obtained from LADA-WOCAT indicator LADA-WOCAT-N: Area trend of LUS available in GLADIS.

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Spatial and temporal refinement: The size of the intervention area and the variability within the area will determine the scale of the mapping exercise and the size of the mapping units. Measurement units include hectares of land, and percentage of different LUS and where SLM practices are applied in intervention areas.

Spatial and temporal refinement: The LADA-WOCAT methodology describes principles for mapping land use and inventory-related ecosystems and more detailed crop or livestock information at a the global and national scales. The database provided includes all individual characteristics aggregated to a five-arc-minutes grid. The approach can also be used at the local scale. Refinements of this methodology are required when applied at more detailed scales, but the linkage with the overall global LUS can be maintained. This allows a more reliable extrapolation of results from local to national and from national to global scale.

Noted strengths and weaknesses: Land use is a sensitive indicator, with the potential to show an impact after a short intervention period of 2–3 years. This indicator is one of the most important factors influencing land degradation; it is difficult, however, to evaluate the influence of land-use change on land degradation (and land-use change does not necessarily lead to land degradation). This indicator works within the overall set in that it requires land cover for its derivation, and it in turn contributes to measuring carbon stocks/sequestration. The LADA-WOCAT approach provides a national level indicator of land use that is spatially explicit. The methodology can be adjusted to be applied at the project level, allowing for scalar integration. The approach is being applied in current LADA-WOCAT countries, and there are plans to use it as LADA-WOCAT expands. However, both methods are dependent on the quality of land cover mapping, and the initial costs and workload for setting up land cover maps are high when compared with the assessment of other indicators. At the local level, the subsequent construction of a LUS and SLM map can be demanding of local expertise and knowledge. It is participatory, which engages stakeholders, but also requires strong organizational capacity. Getting data on land-use change at the national or global levels is challenging. Initial costs are high, but once a base map is obtained, updates are less demanding. Both the LADA-WOCAT and KM:Land approaches provide an option for project-level assessment that can be scaled up. National scale-up could be made feasible with this indicator, because it is spatially and intervention specific, if methods and maps have some common standards employed across interventions.

UNCCD core indicator S-2:
Increase in the proportion of households living above the poverty line in affected areas

Current UNCCD indicator name:
III. Proportion of the population in affected areas living above the poverty line

9. III-KM Rural poverty rate (global/national) (although differently named, this is identical to UNCCD III)

Note: LADA-WOCAT has a number of indicators which could be used as a proxy for this core indicator; however, since the UNCCD population/poverty indicator (which is identical in all but name to the KM:Land poverty indicator) has been approved, the LADA-WOCAT indicators are not included in this assessment.

Purpose: The rural poverty rate measures the percentage of the population in rural areas living in poverty. Individuals whose consumption (or income, when consumption is unavailable) falls below the rural poverty line are considered as poor.

Description: The rural poverty rate is the percentage of the rural population living below the national rural poverty line. The poverty rate is part of a suite of decomposable poverty measures referred to as the Foster, Greer and Thorbecke poverty measures, which also include the poverty gap and the poverty severity measure. The input required to produce these measures include a population estimate, a poverty line/threshold and a welfare estimate.

Source: National level rural poverty rates, based on national poverty lines, are in the public domain. For selected countries, data are also available at the subnational level.[18] The total population above/below the national poverty line is one of the MDG indicators.[13]

Spatial and temporal refinement: National-level statistics are available from the MDG database, with data available for 73 countries, from 1990–2004 (approximately two data points per country). For selected countries, data are also available at the subnational level. In its current form, it is a non-comparable indicator based on the national poverty

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line. However, there is an indicator in development which is comparable based on the international poverty line, which was set at $1.25 a day as of 2005.

Noted strengths and weaknesses: The total population above/below the national poverty line is an MDG indicator, is freely available and has a long time series. Because the national poverty lines vary, it is currently non-comparable, though an alternative indicator based on the international poverty line is in development. Although the poverty rate is one of the most widely-used indicators of poverty, it does not provide any details on how poor the poor are (i.e., how far below the poverty threshold). The income level does not take into account the multidimensional nature of poverty; it is therefore of limited value if it is used alone. This indicator may be insensitive to DLDD mitigation because it is linked to other human well-being indicators such as net migration rate, adult literacy rate, proportion of chronic undernourished children under the age of five in rural areas, and MMR. This linkage makes the relationship between the combat against desertification and the effect of economic policies aimed at decreasing poverty difficult to determine.[19]

UNCCD core indicator S-3:
Reduction in the proportion of the population below the minimum level of dietary energy consumption in affected areas

Current UNCCD indicator name:
IV. Childhood malnutrition and/or food consumption/calorie intake per capita in affected areas

10. IV-KM Proportion of chronically undernourished children under the age of five in rural areas (national with some local-level potential)

Note: There is no comparable LADA indicator.

Purpose: Measure long-term nutritional imbalance and malnutrition, as well as current under-nutrition within DLDD intervention areas.

Description: Prevalence of (moderately and severely) underweight children is defined as the percentage of children aged 0–59 months whose weights for age are less than two standard deviations below the median weight for age of the international reference population.

Source: Proportion of chronically undernourished children under five in rural areas is one of the indicators used within the MDG indicators. The data can be obtained through national data compiled by WHO,[20] UNICEF[21] and MDG[13] indicators. The national datasets are based on the following method of computation: the weights of children under five years of age are compared with the weights given in the WHO/United States National Center for Health Statistics standard reference population for each age group. The percentage of children whose weights are up to two standard deviations below the median weight-for-age are then aggregated to form the total percentage of children under the age of five who are underweight.

Spatial and temporal refinement: National statistic; however, this indicator can be calculated at the local level, allowing for cross-scale assessment.[22]

Noted strengths and weaknesses: This is an MDG indicator, which has increased efforts to collect, publish and analyse associated statistics. National data is available in most developing countries, although not on an annual basis in most countries. Additional data are therefore needed. Each country undertakes household surveys at different intervals, which typically take place every 3–5 years. This indicator can be sensitive to short-term changes in food supply. Although income level is the most commonly-used poverty indicator, a nutrition-based measure is a more appropriate measure of rural poverty since it takes into account the multidimensional nature of poverty. This indicator does not have to be adjusted for inflation and would not be affected by any gaps or distortions in price data. Although it is possible to assess this locally, the process can be demanding and complex, especially if based on household surveys conducted through projects. This indicator may be insensitive to DLDD, as there are other causes of childhood malnutrition.

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Current UNCCD indicator name:
V. The Human Development Index (HDI) as defined by UNDP

11. V-KM Maternal mortality ratio (or rate) (MMR)
(National with some local-level potential)

Note: The KM:Land indicator that is most similar to HDI is “rural poverty rate”, which is listed and described in III-KM as it addresses a different UNCCD core indicator objective. KM:Land proposed MMR as a second human well-being indicator.

Purpose: MMR is a proxy indicator which demonstrates that DLDD interventions contribute equally in both men and women to improvement of human well-being.

Description: Maternal health refers to the health of women during pregnancy, childbirth and the postpartum period. Maternal mortality is given through the ratio of maternal mortality per 100,000 live births. MMR measures maternal health and estimates the proportion of pregnant women who die from causes relating to or aggravated by pregnancy or its management. The MMR is expressed as follows:

[Maternal deaths (direct and indirect) x K]/Live births, for a specified year, where K = 1,000 or 10,000 or 100,000.

Source: Improved maternal health is a MDG, where MMR is one of the main indicators. National data are available in most developing countries; in most countries, however, data are not available on an annual basis. Additional data are therefore needed from clinics, hospitals, medical service centres etc., and from household surveys through projects. Data on maternal mortality and other relevant variables are obtained through databases maintained by MDG,[13] WHO,[20] and UNICEF[21]. Data available from countries vary in terms of the source and methods. Primary sources of data include vital registration systems, household surveys (direct and indirect methods), reproductive age mortality studies, disease surveillance or sample registration systems, special studies on maternal mortality, and national population censuses.

Spatial and temporal refinement: For some countries, MMR is a national annually-collected statistic, but others report less regularly. Adjusted MMR estimates are calculated every five years and published a year or two after the reference year to allow time for data compilation and analysis. Both the adjusted estimates from inter-agency work and the unadjusted estimates reported by governments are published annually by UNICEF.[23,24]

Noted strengths and weaknesses: Maternal mortality is difficult to measure, and a large sample size is required to address variability. Vital registration and health information systems are weak in most developing countries, and thus cannot provide an accurate assessment of maternal mortality. Even estimates derived from complete vital registration systems, such as those in developed countries, suffer from misclassification and under-reporting of maternal deaths. Because reporting of some countries is less frequent (or less regular) than annual reporting, pursuing this approach would require data extrapolation and/or supplementation by additional data from clinics, hospitals, medical service centres etc., as well as household surveys through projects. Such local assessment is challenging and resource-intensive. This indicator may not be suitable for assessing trends over time or for making comparisons between countries.

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UNCCD core indicator S-4:
Reduction in the total area affected by DLDD

Current UNCCD indicator name:
VI. Level of land degradation (including salinization, water and wind erosion)

Note: KM:Land does not have a direct proxy for this indicator. They recommend an analysis of two other indicators, Land cover (IX-KM) and Land use (II-KM).

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12. VI-LA-a Level of land degradation (via ecosystem-services provision capacity) (national, global)	**13. VI-LA-b Level of land degradation** (project level scaled up to national)
Purpose: Measure levels and trends in changes in the capacity of the land to provide ecosystem goods and services for its beneficiaries over a period of time.	*Purpose:* Measure the state of primary soil, vegetation and water degradation.
Description: Land degradation has been defined by LADA as a reduction in the capacity of the land to provide ecosystem goods and services for its beneficiaries over a period of time.[12] Ecosystem goods refer to absolute quantities of land produce having an economic or social value for human beings. They include animal and vegetal production, land availability and water quality and quantity. A decline in ecosystem services corresponds to a change in the state of these services due to pressures and resulting in various degradation processes. This suggests that an approach to assessing the level of land degradation could involve the integration of six parameters (biomass, soil health, water quantity, biodiversity and economic and social services) to describe the status of any ecosystem service in a semi-quantitative way. To visualize the status and/or changes in any of these parameters (also termed axes) for a given ecosystem, LADA uses a radar/spider diagram to visualize the strengths and weaknesses in providing goods and services of all six in combination. The value of each axis in the radar/spider diagram is determined according to parameters and indicators derived from global databases. These parameters can be displayed for each location in the world by clicking on a single pixel on the online map. In addition, averages can be displayed for wider areas by LUS in a country or for the whole country. This allows an easy and quick comparison between different areas, by point, country or land use, for any point on earth. Three aggregated indexes are also calculated. These are obtained by addition of the values (or the constraint classes) of each axis, divided by the maximum rating. –The Ecosystem Services Status Index (ESSI) considers the biophysical status of biomass, soil health, water quantity, biodiversity and socio-economics. ESSI describes the actual state of the ecosystem with regard to providing goods and services. The index is calculated by combining the four biophysical status axes and the two socio-economic ones in a single rating. –The Land Degradation Index (LDI) considers the combined trend of all six axes including the social and economic ones. LDI describes the overall processes of declining ecosystem services by considering the combined value of each process axis in the radar trend diagram. LDI is rated on a reduced scale where 0–50 indicates	*Description:* A second LADA solution for a “level of land degradation” indicator for the UNCCD is to combine soil, vegetation and water degradation assessments.[6] Soil degradation often impacts directly on provisioning and other key ecosystem services. A good understanding is thus required of the condition of the soil, the change dynamics and the processes involved. Vegetation degradation is an important aspect of land degradation, although more attention has been paid in the past to soil degradation and water shortage. Water resources, their management and degradation, will be important land resource components in most dryland assessment sites. More detail is provided here on the soil and vegetation degradation assessment processes. The overall sampling strategy for a LADA assessment is described at the top of this table. The water degradation assessment is described in I.la above. The approach includes assessment of soil biological properties (such as organic matter), chemical properties (nutrient or pH imbalance, salinization and so on), physical properties (crusting, compaction etc.) and hydrological properties (such as water logging, aridification), as well as water and wind erosion. The LADA project-level field methodology involves visual indicators of soil properties (such as soil depth, texture, structure, surface crusts, colour, earthworms and other biota, and roots) and erosion (for example, root exposure, tree mounds, armour layer, barrier build up, and soil depth change). Indicators for assessing vegetation degradation include: − Reduced vegetation cover (plant and litter) − Changes in vegetation structure and plant community composition − Decline in species and habitat diversity − Changes in abundance of indicator species (e.g. of high or low pasture quality or poor soil quality and invasive species). − Reduced productivity. Data come from key respondent interviews and focus groups, together with visual and imaging assessment of vegetation status and condition. These methods are well documented in the LADA Field Manual[4,5] and have been tested in LADA countries with success both at the project level and by scaling up to a national spatially-explicit assessment. Level of land degradation is the most complex (and the

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degradation; values more than 50 indicate improvements.

–The Land Degradation Impact Index (LDII) considers that land degradation does not have the same effect when it occurs in industrial relatively rich countries as compared to its effect in a poor rural society. It weighs the land degradation index according to the poverty levels and population density. To calculate LDII, poverty levels and the population class are multiplied by LDI.

In this LADA approach, the indicators used are relatively few. An effort has been made to focus on the most relevant ones and where possible to use geo-referenced indicators and therefore to obtain an idea of the sub-national situation and effect, which is easier for the biophysical indicators (except for the water resources). However, it is difficult at this small-scale level to go much beyond country statistics with regard to the social and some specific economic parameters.

The indicators used are quantitative or semi-quantitative. The former are those for which hard data exist, such as the decline in vegetation greenness, while the latter are secondary information derived through empirical algorithms such as the Universal Soil Loss Equation for the anticipated soil loss rates, or expert-based relationships such as the salinization effect in irrigated areas.

most basic and important) project-level indicator for LADA-WOCAT. Potentially, several LADA-WOCAT indicators (in principle all QM state indicators - termed QM indicators because they are obtained, in part, from a questionnaire for mapping) could contribute to defining it. The most relevant ones could be analysed in order to create a “level of land degradation” index.

LADA-WOCAT-N: Wg Gully erosion/gullying;
LADA-WOCAT-N: Wt Loss of topsoil/surface erosion (by water);
LADA-WOCAT-N: Ed Deflation and deposition;
LADA-WOCAT-N: Et Loss of topsoil (due to wind);
LADA-WOCAT-N: Ca Acidification;
LADA-WOCAT-N: Cn Fertility decline and reduced organic matter content;
LADA-WOCAT-N: Cp Soil pollution;
LADA-WOCAT-N: Cs Salinization/alkalization;
LADA-WOCAT-N: Pc Compaction;
LADA-WOCAT-N: Pk Sealing and crusting;
LADA-WOCAT-N: Hg Change in groundwater/aquifer
LADA-WOCAT-N: Hp Decline in surface water quality;
LADA-WOCAT-N: Hq Decline in groundwater quality;
LADA-WOCAT-N: Hs Change in quantity of surface water;
LADA-WOCAT-N: Bc Reduction of vegetation cover;
LADA-WOCAT-N: Bh Loss of habitats;
LADA-WOCAT-N: Bq Quantity / biomass decline;
LADA-WOCAT-N: Bs Quality and species composition / diversity decline.

An important feature of LADA-WOCAT QM pressure indicators are recorded as causal attributes in relation to state factors. For example, an area of land may be recorded as 15 per cent degraded (the state factor), and the QM survey may reveal an underlying cause associated with poverty. This permits a clear link between pressure and state indicators.

Source: GLADIS inventories changes in ecosystem goods and services by LUS in each country. GLADIS output is a series of global maps on the status and trends of the main ecosystem services that can be queried and downloaded. These are supplemented by a larger range of maps and databases which document the input data used to determine individual axis parameters. Ancillary maps such as a global LUS map with attributes are also included. These can be accessed in a beta version of the GLADIS database.[11]

Source: At national and subnational level, tools are available in LADA-WOCAT, including QM and LUS. In addition, GLADIS provides information at subnational level both on degradation processes and on the degraded status of the land. Most general types of land degradation are covered (soil erosion by water, salinization, compaction, nutrient decline, pollution, water, biomass and biodiversity decline).

Spatial and temporal refinement:

LADA, through GLADIS, provides a global assessment of

Spatial and temporal refinement:

Mapping units for LADA-WOCAT products are associated with “land units” which are areas of land

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land degradation: • per pixel on the map, at 5 ArcMin resolution • per global LUS units, subdivided by country. (Note that at national level, LADA evaluates land degradation similarly in national LUS units per province or district.) • per country, by averaging all pixels belonging to the country	defined in terms of biophysical qualities and other landscape characteristics that may be demarcated on a map. They are the basis for the survey that produces the data for LADA-WOCAT indicators, which are then quantified (as an average) over each mapping unit. The resolution of spatially explicit, national-level maps varies, therefore, from country to country, based on the landscape variation that exists and the intensity of sampling possible. However, the resolution is high enough for subnational analysis. The frequency of LADA-WOCAT surveys has yet to be determined, but is unlikely to be more frequent than 5–10 years.
Noted strengths and weaknesses: Measurement of the level of land degradation has direct relevance to the UNCDD mission, and is also very challenging to measure. The LADA approach, measuring level of land degradation from the perspective of the capacity of an ecosystem to provide services, links the human and environmental aspects of DLDD. The underlying parameters and calculated indexes have been generated for LADA countries, offering a spatially explicit means to assess land degradation for each country. Like all efforts to assess land degradation in a comprehensive manner, this approach is limited by the quality and frequency of data input. The effort to limit the number of input parameters makes the approach more feasible for participating countries. However, this approach might be considered an assessment (rather than an indicator). Moreover, there is a risk that this approach could confuse cause and effect.	*Noted strengths and weaknesses:* Measurement of the level of land degradation has direct relevance to the UNCDD mission, and is also very challenging to measure. The LADA-WOCAT field assessment methodology has been under development and testing in a variety of dryland environments across the globe, and there are plans to expand this significantly. The most important aspect of this assessment is directly correlated with desertification and land degradation. However, this strength brings with it some challenges. The focus of LADA-WOCAT is on drylands, while the UNCCD is also responsible for assessing impacts beyond the boundaries of drylands, particularly in this period of rising temperatures and associated environmental change. In addition, land degradation assessment is complex and is the most resource-intensive aspect of the LADA-WOCAT process. Although LADA's current primary focus is on drylands, its tools have the potential to be used in any other systems with amendments. LADA-WOCAT has made considerable progress in addressing local to national scalar issues in the assessment methodology. The frequency of reassessment has not been determined, but 5–10 years is a reasonable estimate. Particularly considering the expert assessment (with many not easily trained qualitative methods), it is not clear that this approach could be considered repeatable, or comparable across sites. This approach might be considered an assessment (rather than an indicator). Moreover, there is risk that this approach could confuse cause and effect.
UNCCD core indicator S-5: Increases in net primary productivity in affected areas	
Current UNCCD indicator name: **VII Plant and animal biodiversity**	Note: LADA assesses biodiversity globally but indirectly through a land-use proxy. LADA field methods mention the need to assess biodiversity degradation/improvement, but this is not a required part of the overall assessment (see page 99, LADA Field Manual Tool Box). LADA biodiversity indicators are therefore not described here. However, the CBD does provide an indicator which has been approved and which may meet UNCCD needs. It is described here.

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14. VII-KM Crop and livestock diversity (agro-biodiversity) (global/national)	**15. VII-CBD Trends in abundance and distribution of selected species** (global/national)
Purpose: The purpose of this indicator is to demonstrate the impact of DLDD interventions in terms of maintaining or enhancing the diversity of crops and livestock in agricultural systems within an intervention area. Crop diversity provides the source of the world's food and fibre production, including the basis for crop and livestock genetic resources. A monitoring and assessment of the development of agricultural diversity is therefore of great importance for ensuring food security. The impacts of climate change on agricultural land (including water availability) can be managed through diversification of crops and animal species in order to enhance agro-ecosystem resilience and risk mitigation, among other things.	*Purpose:* To measure trends in the abundance and distribution of indicative species in order to gauge impacts on biodiversity and, in so doing, on ecosystem services on which the human race depends for a multitude of purposes including the provision of food, medicines and basic materials.
Description: Agrobiodiversity is the variance in both crop and livestock diversity, including species and varieties. Crop diversity is the variance in genetic and phenotypic characteristics of plants used in agriculture, while livestock diversity is the number of livestock species used in the village territory and their relative share in the area, or the number of animals and plant species and varieties. The development of indicators for the genetic component of diversity is essential in order to obtain a clear picture of the current status of the extent and maintenance of native diversity in agricultural production systems. The following measurable indicators are recommended to be used for the assessment of crop and livestock diversity: - Number of crop and animal species in agricultural use - Share of main/key crop and animal varieties - (Optional: Number and share of crop and animal varieties that are endangered per area) The total number and share of main crop varieties are the indicators recommended for further consideration by the CBD in relation to agricultural crop diversity.	*Description:* This CBD indicator[25] is made up of two indices, the Living Planet Index (LPI),[26] and the Global Wild Bird Index (WBI).[27] The description below is taken from the Biodiversity Indicators Partnership website on the CBD indicators.[28] The LPI is an indicator of the state of global biological diversity, based on trends in vertebrate populations of species around the world. It is calculated using time-series data on more than 7,000 populations of over 2,300 species of mammal, bird, reptile, amphibian and fish from all around the globe. The changes in the population of each species are aggregated and shown as an index relative to 1970, which is given a value of 1. The LPI can be thought of as a biological analogue of a stock market index which tracks the value of a set of stocks and shares traded on an exchange. The results of the LPI are published biennially in the *Living Planet Report.* The WBI aims to measure population trends of a representative suite of wild birds, to act as a barometer for the general health of the environment and how it is changing. The WBI measures biodiversity change in a similar fashion to the LPI, the main difference being that the WBI incorporates trend data from formally designed breeding bird surveys only, in order to deliver scientifically robust and representative indicators.
Source: The assessment is based on the availability of national data, and needs to be broken down to project level through one of the following methods: - Agricultural statistics: Annual agricultural statistics for cropland - Household surveys: Diversification of farm production, number of crop varieties etc. - Local Markets: number of crop varieties and shares sold	*Source:* LPI data are collected by the World Wide Fund for Nature (WWF)[26] and maintained in the Living Planet Database (LPD) by the Zoological Society of London (ZSL). WBI data are collected by BirdLife International and the Royal Society for the Protection of Birds.[27]

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at local markets Some of these data are available through FAOSTAT[29] which provides time-series and cross-sectional data relating to food and agriculture for some 200 countries. The national version of FAOSTAT, CountrySTAT, is being developed and implemented in a number of target countries, primarily in sub-Saharan Africa.	
Spatial and temporal refinement: National data exist, but subnational assessment would not be possible unless projects obtained locally-specific data which were then scaled up.	*Spatial and temporal refinement:* Although both networks aspire to be global, monitoring is currently patchy. The LPI is not only a global index but can also be calculated for selected regions, nations, biomes or taxonomic groups, provided that there are sufficient data available. WBI data are generated at the local level and are thus amenable to changes of scale; they can be aggregated or disaggregated at the global, regional and national (subnational) level. WBIs can also be disaggregated by the habitat or guild in which a bird occurs, or by aspects of species' ecology, in order to aid interpretation. WBIs are particularly suited to tracking trends in the condition of habitats. The requirement for robust data, however, means that data coverage is currently patchy and the WBI is not at present applicable at the global scale.
Noted strengths and weaknesses: Crop and livestock diversity are related to net primary productivity and food security. This indicator does not address biodiversity outside agricultural systems. The number of crop varieties might be especially difficult to assess because available national data might not be accurate. Data which are not available from FAO or country databases would have to be obtained by projects through household surveys and local market analyses.	*Noted strengths and weaknesses:* Biodiversity is an essential service required for the survival of ecosystems in general. This is a CBD indicator and offers an excellent opportunity for direct collaboration between the two conventions. The indices used to generate this indicator are not yet ideal for DLDD needs, but are moving in the right direction. Ideally, trends in the diversity of selected species would cover all regions and species types evenly. However, this indicator is currently limited to vertebrate species, and of particular concern is the lack of vascular plant data. For LPI the LPD will ultimately provide greater coverage of species from under-represented taxonomic groups and regions. ZSL and WWF have recently begun forming partnerships to develop LPIs for invertebrates and plants.
Current UNCCD indicator name: **VIII The aridity index**	
16. VIII-KM Trends in seasonal precipitation (national with local-level potential)	**17. VIII-LA Aridity trend and rainfall variability** (local level scaled up to national)
Purpose: To measure rainfall water availability in project areas (or regional average) subject to drought.	*Purpose:* To measure changes in water balance and reliability of rainfall as driving forces of DLDD.
Description: Lack of precipitation, irregular rainfall distribution, non-seasonal rains etc. are the main climatic factors contributing to land degradation and affecting agricultural productivity. Assessing their seasonal trends can provide vital information on this climatic driving force. Trends can be generated from the national average (if possible, project area) of monthly station rainfall, weighted by the long-term station rainfall average. Ideally this would be based on 30 years of mean monthly rainfall	*Description:* The availability of water and the reliability of rainfall represent driving climatic forces that can result in increased pressure on resources in affected DLDD areas. LADA collects two indicators which could be used to capture this: LADA-G: Aridity trend

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(for near stations/gridded). Preferred measurement units would be departure from average in standard deviations.	LADA-G: Rainfall trend LADA defines these indicators as follows:[30] The aridity index is defined as the ratio between mean annual precipitation (P) and mean annual evapotranspiration: (ETP) $I_a = P_a / ET_o$, where ET_0: is the reference evapotranspiration in the period assessed. In the LADA approach, information for calculating the indicator is collected at local level (meteorological stations). At local level it may be possible to detect a trend (towards more or less aridity) if a sufficiently long time series is available, but such a trend may be validated only if more stations indicate the same trend, and this needs to be done by compilation at national level and beyond. The same is true for Rainfall variability. This indicator, instead of using the mere standard deviation of annual rainfall, is calculated by dividing the standard deviation of annual rainfall by the average annual rainfall (coefficient of variation); it expresses the standard deviation of annual totals as a percentage of average annual rainfall; the higher the coefficient, the more variable the rainfall from year to year. The advantage is that the coefficient of variation allows one to compare the variability of rainfall at any location, regardless of mean precipitation. Both indicators may be linked to agro-ecological zones through stratification.
Source: In order for this contextual indicator to be relevant, it will be necessary to obtain mean monthly rainfall statistics (from national statistics and, for local interventions, from stations situated in the area) based on a series spanning at least a 30-year period. This long period is necessary in order to provide an indication of the trend/development of the rainfall pattern in the area. Measurements will be based on data obtained from meteorological/climate services, possibly complemented with remote sensing data.	*Source:* GLADIS provides the trends of the aridity index and rainfall trends for various periods and the statistical significance levels of these trends. The data are obtained at the project level, through national and local databases. Data access could potentially be enhanced, in part, by supplementing the dataset from a global repository.[31]
Spatial and temporal refinement: National statistics with the potential to be spatially interpolated for subnational analysis. Temporal resolution involves 30 years of monthly averages.	*Spatial and temporal refinement:* Local-level and national data records obtained from national databases, where available, for stations in affected areas (monthly data, ideally with 30 years of data for trend calculations).
Noted strengths and weaknesses: This indicator is a direct measure of one of the climatic driving forces relating to DLDD. It is intuitively easy to understand. It is closely related to other social, economic and environmental measures important to dryland areas (i.e., population growth rate, net migration rate, human and economic loss due to natural disasters, gross domestic product per capita, groundwater reserves, land-use change, land affected by desertification, and arable land per capita). Data quality and the capacity to spatially interpolate can be issues.	*Noted strengths and weaknesses:* When assessed as trends, these are indicators of climatic driving forces related to DLDD. (They are not impact indicators however; in order to assess impacts, the context provided through information on driving forces is essential.). Their sensitivity depends strongly on the spatial density and temporal resolution of existing meteorological stations. The availability of complete series of temporal data at national level and a lack of homogeneity in data series are challenges.

UNCCD Objective 2: To improve the condition of ecosystems

Current UNCCD indicator name:
IX Land cover status

18. IX-KM Land cover (global/national)

Purpose: To measure current land cover, and especially the distribution of land cover types of greatest concern for land degradation (cropland, rangeland etc.).

Description: This indicator shows the distribution of 23 of the world's major land cover categories, as classified by the European Commission Joint Research Centre (JRC) Global Land Cover 2000 project (GLC 2000).[17] According to the JRC, who led the effort, "the general objective was to provide for the year 2000 a harmonized land cover database over the whole globe. The year 2000 is considered as a reference year for environmental assessment in relation to various activities, in particular the United Nation's Ecosystem-related International Conventions. To achieve this objective GLC-2000 makes use of the VEGA 2000 dataset: a dataset of 14 months of pre-processed daily global data acquired by the VEGETATION instrument on board the SPOT 4 satellite, made available through a sponsorship from members of the VEGETATION programme, including JRC."

Unlike previous global land cover mapping initiatives, the creation of GLC 2000 was participatory, involving the partnership of some 30 institutions across the globe, each with a team of regional experts who classified and mapped each region independently, assuring regional appropriateness. The regionally-defined classes were then aggregated into a thematically simpler global legend through the FAO Land Cover Classification System (LCCS), which is capable of cross-referencing regional differences in land cover descriptions.[32] The GLC 2000 data were included as a core data set in the MA.

Source: JRC GLC 2000 website.[17]

19. IX-KM&LA Land productivity (global/national)

Purpose: To identify regions with declining greenness as an early warning of possible land degradation in a particular area.

Description: The International Soil Resources Information Centre (ISRIC), under a subcontract with FAO LADA, has constructed a measure of greenness trend using the Global Inventory Modeling and Mapping Studies (GIMMS) normalized difference vegetation index (NDVI) time series (1981–2006) assembled by the University of Maryland. Where greenness is limited by rainfall, the index is adjusted for rainfall variability using rain-use efficiency (RUE), the ratio of NDVI to rainfall. First, correlation between annual rainfall and NDVI is calculated, pixel-by-pixel. For those pixels that show positive correlation, station-observed rainfall is used to create a rainfall surface, and annual integrated NDVI values for a given grid cell are divided by the rainfall amounts for the corresponding time-unit. Where RUE is positive, it is assumed that the greenness decline is caused by a declining trend in rainfall, and those areas are screened from the other areas of declining greenness. The remaining areas of declining greenness are expressed in terms of net primary productivity (NPP) to provide a single, tangible indicator: a long-term trend in declining productivity which may be summed up as loss of NPP in tones C/ha. The unit of measurement of the final product is sum NDVI, translated into absolute change in NPP.

Source: All required data sets are already available from the Global Assessment of Land Degradation and Improvement (GLADA).[33] GLADA used annual sums of NDVI from the GIMMS 16-day maximum at 8 km resolution. From this it is possible to create a five-year moving average (i.e., the 2005 average represents an average of the NDVI for the years 2003–2007). The GIMMS[34] data set is a NDVI derived from imagery obtained from the Advanced Very High Resolution Radiometer (AVHRR) sensor on board National Oceanic and Atmospheric Administration (NOAA) satellites. The GIMMS dataset was corrected for distortions due to instrument calibration, view geometry, volcanic aerosols and other effects unrelated to vegetation change (University of Maryland, undated). GIMMS is available globally for a 26-year period from 1981 to 2006 and is also updated annually. An Harmonic Analysis of NDVI Time Series algorithm has been applied in the GIMMS

UNCCD Objective 2: To improve the condition of ecosystems	
	dataset to remove cloud interference and to eliminate the influence of phenological shift between the northern and southern hemispheres. The rainfall-adjusted greenness indicator uses the greenness trends derived from the GIMMS dataset. It takes the ratio of sum of NDVI values and sum of annual rainfall values from a global repository.
Spatial and temporal refinement: GLC 2000 is a 1 km dataset for the year 2000. Change in land cover analysis will soon be possible, because the European Space Agency, through the GlobCover initiative, is generating a global land cover map for the year 2005–2006[35] using ENVISAT MERIS Fine Resolution (300m) data. It is being designed to be compatible with GLC 2000, and to have a thematic legend compatible with LCCS.	*Spatial and temporal refinement:* The spatial resolution of the resulting product is 8 km. Time series are possible for these date ranges: 2000–2007, 1981–2002, 1981–2006.
Noted strengths and weaknesses: GLC 2000 is a global land cover product that is regionally appropriate and which has been validated and shown to be reasonably accurate (as far as land cover classifications go, the overall accuracy of 68.6 per cent is good for a global product).[36] That accuracy, however, suggests that sub-national use should be accompanied by higher resolution land cover products, including ground verification. At present there are no globally comparable time series land cover data sets, but with GlobCover under development, the potential for land cover change analysis is possible. The cost of producing maps of this kind is substantial, but these GLC 2000 (and GlobCover) products are (and will be) freely available.	*Noted strengths and weaknesses:* The parameters used to create this indicator cannot be used to conclude definitively that land degradation has taken place, but they can help to identify areas which require more fine-scaled investigation. Although the rainfall-adjusted greenness trend controls to some extent for the impact of rainfall variability, the global indicator is unable to distinguish fully between changes in NDVI resulting from land-use change and those resulting from land degradation as ordinarily understood. This can be assessed only by following time series data for individual pixels, preferably at a higher resolution than the 8 km GIMMS data. Another weakness is the paucity of rainfall measurement stations in some regions. Any rainfall surface derived from widely-spaced observations will not capture fine-scale variability. Nevertheless, this indicator can signal areas requiring closer investigation and, as such, provides an early warning for land degradation. Beyond the trend measures, it is possible to generate state measures of current greenness (in a five-year moving average) for the most recent years for which NDVI data are available from the Moderate Resolution Imaging Spectroradiometer or AVHRR.

UNCCD Objective 3: To generate global benefits through effective implementation of UNCCD

UNCCD core indicator S-6: Increases in carbon stocks (soil and plant biomass) in affected areas

Current UNCCD indicator name:
X Carbon stocks above and below ground

20. X-LA Above and below ground organic carbon stocks (global/national)

Purpose: To estimate above and below ground organic carbon as an indirect measure of desertification control success and global significance in responding to climate change.

Description: At the global/national scale, LADA-WOCAT GLADIS and GLADA have developed two indicators to track organic carbon stocks: organic carbon above ground, defined as the status of above-ground biomass as a function of land cover in tons of C/ha, and organic carbon below ground, defined as topsoil and subsoil organic carbon in T/ha. Elaborated by ISRIC,[37] GLADA uses total biomass as an indicator for above-ground organic carbon accumulation (environmental service), based on GIMMS measurements of NDVI (see IX-LA). Trend analysis is conducted for 1981–2006. Topsoil and subsoil organic carbon is also estimated, based on soil type, using the Harmonized World Soil Database.[38]

Source: GLADIS stores both above and below ground carbon data from this analysis. For above-ground organic carbon, both trends and status are available. For the subsoil only the status is available.

Spatial and temporal refinement: Resolution 5 arc minutes. Using this approach it is possible to assess organic carbon losses/gains per year.

Noted strengths and weaknesses: The proposed datasets are available; the resolution is coarse, however, and accuracy/validation from this indirect method is an issue. The time series of above-ground estimates permits trend analysis; however, the below-ground data are collected over a number of years and are not a good basis for monitoring.

Note: A number of methods are now available for converting ground and remote sensing-based measurement into carbon stocks through allometric relationships that should be considered for this indicator.[39] Moreover, the UNFCCC recently released their ECV list[40,41] which includes above-ground biomass and soil carbon, and thus further development of this indicator could be pursued collaboratively. In addition, in May 2009 the GEF and UNEP launched a new focal area called the Carbon Benefits Project,[42] which aims to provide a cost-effective end-to-end estimation and support system for showing carbon benefits in the GEF and other natural resource management projects. Modelling will focus on estimation and forecasting of carbon stocks, flows and greenhouse gas emissions on cropland and grazing lands. Measurement and monitoring will focus on field measurement and monitoring of carbon changes across landscapes with the emphasis on agro-forestry and forestry.

UNCCD core indicator S-7: Areas of forest, agricultural and aquaculture ecosystems under sustainable management

Current UNCCD indicator name:
XI Land under SLM

21. XI-KM (see II-KM above) **Land-use system (LUS) and sustainable land management (SLM) practices** (global/national)

Note: This indicator, under KM:Land design, is both LUS and SLM. It is described in this table under II-KM. Thus one indicator addresses two UNCCD needs.

22. XI-LA Land under sustainable land management (SLM)
(local with the potential to be scaled up to national)

Purpose: Measure the impact of SLM on minimizing land degradation, rehabilitating degraded areas and ensuring the optimal use of land resources for the benefit of present and future generations.

Description: SLM is based on four common principles:

UNCCD Objective 3: To generate global benefits through effective implementation of UNCCD

– land-user driven and participatory approaches;
– integrated use of natural resources at ecosystem and farming systems levels;
– multilevel and multi-stakeholder involvement; and
– targeted policy and institutional support, including development of incentive mechanisms for SLM adoption and income generation at the local level.

LADA proposes a three-level approach for measuring the impact of SLM. GLADIS provides an estimate of the present land management level for agricultural cropped areas. This provides a first approximation of SLM at the national level, but would require subnational information for further development. Second, the land-use type mapping in the LADA methodology (see II-LA above) includes a SLM classification and mapping approach. There are 25 conversation measures tracked, including the full range of agronomic, vegetative, and management measures. This approach provides the base SLM map, which is then attributed using the same approach as for observations and interviews described in I-LA-a and I-LA-c above. SLM is conceptually complex, and thus several local-level LADA indicators could contribute to defining it. LADA-WOCAT QM, based on a participatory methodology that addresses the four common principles, provides two different kinds of input relating to SLM.

Primarily, the WOCAT response indicators (LADA-WOCAT-N: Extent and trends of Land Conservation; LADA-WOCAT-N: Effectiveness of Land Conservation) can contribute directly by estimating the extent and effectiveness of conservation practices.

Well-managed land can also be described as where anthropic pressure is limited or “sustainable”. Thus, indirect measures may be useful on impacted landscapes. Relevant LADA-WOCAT indicators would be: (LADA-WOCAT-N: c Crop management; LADA-WOCAT-N: e Over-exploitation of vegetation for domestic use; LADA-WOCAT-N: f Deforestation and removal of natural vegetation; LADA-WOCAT-N: g Overgrazing; LADA-WOCAT-N: o Over-abstraction / excessive withdrawal of water; LADA-WOCAT-N: s Soil management; LADA-WOCAT-N: w Disturbance of the water cycle). A combination of these indicators may better match the UNCCD requirement.

Source: GLADIS, LADA-WOCAT QM, and WOCAT databases, combined with LADA field methods as described in I-LA-c above.

Spatial and temporal refinement: Project level, and thus resolution dependent on local assessment implementation. See general note on LADA methods at the top of this table.

Noted strengths and weaknesses: DLDD happens locally, and so capturing subnational variation is essential. However, scaling up from projects alone may not be spatially representative. SLM is difficult to assess, and while LADA collects the aforementioned indicators, further development in integrating them will be necessary.

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Annex III

Summary frequencies of the 22 revision indicators (metrics/proxies) under evaluation (first 11) (n=17)

UNCCD Objective 1: To improve the living conditions of affected populations

Indicator evaluation criteria (NRC 2000;[1] MA 2003)[2]								UNCCD core indicator S-1	UNCCD core indicator S-2		UNCCD core indicator S-3
	No.1 I-KM-a	No.2 I-LA-a	No.3 I-KM-b	No.4 I-LA-b	No.5 I-KM-c	No.6 I.LA-c	No.7 II&XI-KM	No.8 II-LA	No.9 III-KM	No.10 IV-KM	No.11 V-KM
Does the indicator provide information about changes in important processes?	**100%**	**100%**	**85%**	**100%**	**75%**	**92%**	**92%**	**92%**	**100%**	**83%**	**50%**
Is the indicator sensitive enough to detect impact changes but not so sensitive that signals are masked by natural variability?	**85%**	**92%**	**67%**	**83%**	**40%**	**58%**	**67%**	**77%**	**85%**	**58%**	**30%**
Can the indicator detect changes at the appropriate temporal and spatial scale without being overwhelmed by variability?	**54%**	**58%**	**67%**	**83%**	**55%**	**50%**	**92%**	**77%**	**64%**	**55%**	**44%**
Is the indicator based on well-understood and generally accepted conceptual models of the system to which it is applied?	**93%**	**92%**	**92%**	**100%**	**83%**	**58%**	**67%**	**77%**	**77%**	**73%**	**67%**
Are reliable data available to assess trends and is data collection a relatively straightforward process?	**64%**	**69%**	**46%**	**54%**	**67%**	**100%**	**67%**	**77%**	**69%**	**64%**	**78%**
Are monitoring systems in place for the underlying data needed to calculate the indicator?	**50%**	**69%**	**62%**	**69%**	**67%**	**8%**	**67%**	**69%**	**62%**	**55%**	**56%**
Can policy makers easily understand the indicator?	**87%**	**69%**	**92%**	**92%**	**92%**	**92%**	**67%**	**85%**	**92%**	**82%**	**89%**

Figures in shaded boxes: ≥ 75% of respondents reported "Yes" moderately to mostly

NOTE: See last page for assessment rating scale and considerations for interpreting this table.

Summary frequencies of the 22 revision indicators (metrics/proxies) under evaluation (last 11) (n=17)

	UNCCD Objective 2: To improve the condition of ecosystems								*UNCCD Objective 3: To generate global benefits through effective implementation of the UNCCD*		
	UNCCD core indicator S-4						UNCCD core indicator S-5		UNCCD core indicator S-6		
Indicator evaluation criteria (NRC 2000;[1] MA 2003)[2]	No.12 VI-LA-a	No.13 VI-LA-b	No.14 VII-KM	No.15 VII-CBD	No.16 VIII-KM	No.17 VIII-LA	No.18 IX-KM	No.19 X-KM&LA	No.20 X-LA	No.21 XI&II-KM	No.22 XI-LA
Does the indicator provide information about changes in important processes?	**93%**	**100%**	**91%**	**80%**	**93%**	**87%**	**87%**	**100%**	**100%**	**100%**	**100%**
Is the indicator sensitive enough to detect impact changes but not so sensitive that signals are masked by natural variability?	**85%**	**85%**	**70%**	**67%**	**88%**	**88%**	**86%**	**80%**	**86%**	**83%**	**75%**
Can the indicator detect changes at the appropriate temporal and spatial scale without being overwhelmed by variability?	**77%**	**85%**	**78%**	**67%**	**80%**	**80%**	**86%**	**71%**	**69%**	**82%**	**73%**
Is the indicator based on well-understood and generally accepted conceptual models of the system to which it is applied?	**71%**	**86%**	**60%**	**70%**	**88%**	**88%**	**93%**	**80%**	**79%**	**75%**	**67%**
Are reliable data available to assess trends and is data collection a relatively straightforward process?	**29%**	**57%**	**60%**	**60%**	**94%**	**94%**	**87%**	**87%**	**43%**	**67%**	**50%**
Are monitoring systems in place for the underlying data needed to calculate the indicator?	**46%**	**43%**	**60%**	**44%**	**94%**	**94%**	**73%**	**73%**	**43%**	**50%**	**25%**
Can policy makers easily understand the indicator?	**71%**	**86%**	**80%**	**70%**	**88%**	**88%**	**93%**	**73%**	**86%**	**58%**	**58%**

Figures in shaded boxes: ≥ 75% of respondents reported "Yes" moderately to mostly

NOTE: See last page for assessment rating scale and considerations for interpreting this table.

Assessment rating scale:

- Sixteen reviewers contributed scores on indicators (metrics/proxies) where they felt they had sufficient knowledge/expertise to do so.
- Scoring was based on a Likert scale: (no, not at all) 0 <------> 5 (yes, very much).
- To create a summary (and help interpret the findings), the rating scale was collapsed into two over-arching levels of agreement with the assessment statements.

0 – 5 Rating Scale	*Interpretation key*
0 “No, not at all”	
1	
2	**Not at all to weakly**
3	
4	
5 “Yes, very much”	**Moderately to mostly**

This is an aggregated summary of the evaluation of these metrics/proxies.

Considerations:

- The reviewers were asked to assess the indicators individually, not relative to their role in a set or overall monitoring system.*
- These numbers encourage thinking and help understanding of the ranges of, and concurrence in, perspectives of the reviewers. The original scores and these percentages are illustrative and instructive but do not, in themselves, dictate an answer. Overall values indicate the “desirability” of the alternatives with respect to the preference information given by the respondents.
- Questions to consider when reviewing these results include:
  - (a) What was a realistic expectation for the above percentages?
  - (b) Should the tangible versus intangible nature of the 22 indicators above affect our expectations in terms of consensus and interpretation of the above feedback?

(c) Which of the above seven criteria are critical (go/no go variables) versus “preferable if they are present”?

(d) Where is the threshold for decision-making (for example, how do we proceed knowing that “perfect is the enemy of good enough”)?

(e) Which categorization (UNCCD strategic objectives, UNCCD core indicators, framework categories D, P, S, I-HWB, I-ES, R etc.) are priorities; do the strong performing variables above line up with these priorities?

* Some reviewers, in their comments, did discuss the issue of how the indicators would (or would not) function in a set.

References

[1] NRC (United States National Research Council). 2000. Ecological Indicators for the Nation. Chapter 3: A Framework for Indicator Selection. Washington D.C.: The National Academies Press. 180 pp. Available online: http://www.nap.edu/openbook.php?record_id=9720&page=51

[2] MA (Millennium Assessment). 2003. Millennium Ecosystem Assessment: Ecosystems and Human Well-being – A Framework for Assessment. Available online: http://www.maweb.org/en/Framework.aspx Chapter 1: Introduction and Conceptual Framework. Washington DC: World Resources Institute. Available online: http://www.maweb.org/documents/document.299.aspx.pdf.

Annex IV

Summary of the Initial Expert Review perspectives on the role each metric/proxy under evaluation might play in the updated DPSIR-MA framework

Indicator	*D*	*P*	*S*	*Impact* *I-ES*	*Impact* *I-HB*	*R*
Objective 1: To improve the living conditions of affected populations						
Core indicator S-1: Decrease in the number of people negatively impacted by the process of DLDD						
I-KM-a Water stress (No.1)	3	10	3	2	2	1
I-LA-a Pressure on water resources (No.2)	1	10	1	2	2	0
I-KM-b Water availability (No.3)	1	7	5	2	1	1
I-LA-b Water availability and use (No.4)	2	8	5	5	3	1
I-KM-c Percentage of rural population with access to (safe) drinking water (No.5)	2	7	7	5	4	0
I-LA-c Access to improved drinking water based on change in water quality (No.6)	1	1	5	2	7	1
II-KM and IX-KM Land-use system (LUS) and sustainable land management (SLM) practices (No.7)	5	6	5	1–2	1–2	6
II-LA Land-use system (LUS) and change in land use (No.8)	5	8	7	1–2	1	6
Core indicator S-2: Increase in proportion of households living above poverty line in affected areas						
III.KM Rural poverty rate (No.9)	6	4	5	0	9–10	1
Core indicator S-3: Reduction in the proportion of households living above the poverty line in affected areas						
IV-KM Proportion of chronically undernourished children under the age of 5 in rural areas (No.10)	2	0	5	0–1	10–11	2
V-KM Maternal mortality ratio (or rate) (MMR) (No.11)	2	0	3	0–1	9	2
Objective 2: To improve the condition of ecosystems						
Core indicator S-4: Reduction in the total area affected by DLDD						
VI-LA-a Level of land degradation (via ecosystem-services provision capacity) (No.12)	1	3	9	8–9	4–5	2
VI-LA-b Level of land degradation (No.13)	2	3	12	8–9	5–6	4
Core indicator S-5: Increase in net primary productivity in affected areas						
VII-KM Crop and livestock diversity (agro-biodiversity) (No.14)	2	1	8	3–4	1–2	1
VII-CBD Trends in abundance and distribution of selected species (No.15)	2	1	9	5–6	1–2	1
VIII-KM Trends in seasonal precipitation (No.16)	11	4	4	2	1	0
VIII-LA Aridity trend and rainfall variability (No.17)	7	5	4	3–4	1–2	1
IX.KM Land cover (No.18)	4	2	13	4	1	4
IX-KM&LA Land productivity (No.19)	1	3	10	5–6	2–3	3