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Advice on how best to measure progress on strategic objectives 1, 2 and 3 of The Strategy
The development and implementation of impact indicators relating to the measurement of strategic objectives 1, 2 and 3 of The Strategy

Methodological guide on the use of impact indicators to measure progress against strategic objectives 1, 2 and 3

Note by the secretariat

Summary

By decision 17/COP.9, the Conference of the Parties at its ninth session (COP 9) decided to provisionally accept the set of impact indicators attached to that decision to assist measurement, at the national and global levels, of progress made under national action programmes in implementing strategic objectives 1, 2 and 3 of The Strategy. The present document thus contains a methodological guide for using the subset of two impact indicators mandatory for reporting by affected country Parties beginning in 2012.

This document should be read in conjunction with document ICCD/COP(10)/CST/3, which contains the reporting templates for the subset of two impact indicators, and with the glossary contained in document ICCD/COP(10)/INF.9 which includes terminology and definitions used, inter alia, in the formulation of the subset of impact indicators. At its tenth session, the Committee on Science and Technology (CST) may wish to take note of the methodological guide contained in this document and to recommend that the COP should request the secretariat to make the guide available in all six official languages of the United Nations and to publish it on the UNCCD website.

Contents

List of abbreviations

AVHRR	Advanced Very High Resolution Radiometer
COP	Conference of the Parties
CST	Committee on Science and Technology
DLDD	desertification, land degradation and drought
EVI	Enhanced Vegetation Index
FAO	Food and Agriculture Organization of the United Nations
fPAR	Fraction of photosynthetically active radiation absorbed by vegetation
GIMMS	Global Inventory Modeling and Mapping Studies
GLADA	Global Assessment of Land Degradation
GLC2000	Global Land Cover 2000
GLCC	Global Land Cover Characterization
ISO	International Standards Organization
ISRIC	International Soil Resources Information Centre
JRC	Joint Research Centre
LADA	Land Degradation Assessment in Drylands
LCCS	Land Cover Classification System
LCML	Land Cover Macro Language
MA	Millennium Ecosystem Assessment
MDG	Millennium Development Goals
MERIS	MEdium Resolution Imaging Spectrometer
MODIS	MODerate – resolution Imaging Spectroradiometer
NASA	National Aeronautics and Space Administration
NDVI	Normalised Difference Vegetation Index
NOAA	National Oceanic and Atmospheric Administration
NPP	Net primary productivity
OECD	Organisation for Economic Co-operation and Development
PELCOM	Pan-European Land Cover Monitoring project
RPR	Rural Poverty Rate
RUE	Rain-use efficiency
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNSD	United Nations Statistics Division
VASClimO	Variability Analyses of Surface Climate Observations

I. Introduction

1. By decision 17/COP.9,[1] the Conference of the Parties (COP) decided to provisionally accept the set of impact indicators attached to that decision to assist with the measurement, at the national and global levels, of progress made under national action programmes in implementing 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). A subset of impact indicators[2] was identified as the minimum required for reporting by affected countries, beginning in 2012:

(a) Proportion of the population in affected areas living above the poverty line;

(b) Land cover status.

2. The remaining impact indicators listed in annex I to decision 17/COP.9, although recommended, are considered optional for inclusion in reports by affected countries.

3. By the same decision, the COP requested the Committee on Science and Technology, "with the support of the secretariat, to continue work on methodologies for collecting data and baselines and for an effective use of the agreed set of impact indicators and to prepare a glossary in order to clarify the terminology and definitions used in the formulation of the set of impact indicators for consideration at the tenth session of the Conference of the Parties"[3] (COP 10).

4. The work on methodologies has been carried out in the framework of the iterative process and scientific peer review for the refinement of the set of impact indicators. A progress report on this process is contained in document ICCD/COP(10)/CST/2.

5. The present document contains the methodological guide templates for the subset of two impact indicators that are mandatory for reporting by affected country Parties. In particular, this document presents detailed reporting guidelines for the metrics associated with the two mandatory impact indicators (see table 1). One of the critical outputs of the scientific peer review was the refinement of the structure of the indicator set into a hierarchy, making it possible to distinguish what to measure (general indicators) and how it should be measured (metrics/proxies). The rural poverty rate and land cover/land productivity were recommended by the experts involved in the scientific peer review as metrics to measure the proportion of the population living above the poverty line and the land cover status, respectively. The reporting guidelines contain the relevant background information pertaining to each metrics, including, among other things, the relevance of the indicators, the data needed, sources and limitations, computation methods, and the presentation and interpretation of the indicators.

6. This document should be read in conjunction with document ICCD/COP(10)/CST/2, which contains the reporting templates for the two mandatory impact indicators and their associated metrics.

7. The terminology and definitions used in the formulation of the subset of impact indicators are contained in document ICCD/COP(10)/INF.9.

[1] For the full text of decision 17/COP.9, see document ICCD/COP(9)/18/Add.1.
[2] See decision 17/COP.9, annex I.
[3] Decision 17/COP.9, paragraph 2.

8. A draft template and reporting guidelines for the remaining impact indicators are being developed and tested in the framework of the pilot impact indicator tracking exercise.[4]

Table 1
The subset of impact indicators and related metrics/proxies
(adapted from table 1 of document ICCD/COP(10)/CST/2)

Strategic objectives	*Core indicators*	*General indicators*	*Metrics/proxies*
SO.1: To improve the living conditions of affected populations	S-(1/2/3): Improvement in the livelihoods of people potentially impacted by the process of desertification/land degradation and drought	III. Proportion of the population living above the relative poverty line	Rural poverty rate
SO.2: To improve the condition of ecosystems	S-5: Maintenance of or increases in ecosystem function, including net primary productivity	IX. Land cover status	Land cover Land productivity

II. Proportion of the population living above the poverty line

9. For the reasons explained in chapter II. section A of document ICCD/COP(10)/CST/3, the experts involved in the scientific peer review suggested the elimination of repeated references to affected areas in the definition of general indicators, in conjunction with a recommendation that the context of the application of the indicators should be defined and clarified as a separate, parallel task, in order to avoid possible confusion and different interpretations by affected country Parties and other UNCCD stakeholders. The title of the mandatory indicator “Proportion of the population in affected areas living above the poverty line” was therefore amended to “Proportion of the population living above the poverty line”.

10. The recommended metric to measure this general indicator is the “rural poverty rate”, which is defined as the percentage of the rural population living below the national rural poverty line.

11. A detailed reporting template for this indicator is contained in document ICCD/COP(10)/CST/3.

[4] Document ICCD/COP(10)/CST/INF.2.

Rural poverty rate

Strategic objective	SO.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 desertification/land degradation and drought
General indicator	Proportion of the population living above the relative poverty line
Metric/proxy	Rural poverty rate

1. Introduction

a. Purpose

12. The indicator makes it possible to measure progress in reducing the number of people living under extreme poverty. It is used to make an accurate estimate of poverty that is consistent with the country's specific economic and social circumstances.

b. Global relevance

13. The total population living above the national poverty line is one of the Millennium Development Goals (MDG) indicators.[5] Individuals whose consumption (or income, when consumption data are is unavailable) falls below a certain threshold are considered poor. The inputs required to calculate this metric include a population estimate, a welfare estimate and a poverty line/threshold. As of 2005, an international poverty line was set at USD 1.25 a day.[6] This indicator correlates with other indicators of human well-being such as net migration rate, adult literacy rate, proportion of chronically undernourished children under the age of 5, and maternal mortality ratio.

c. Relevance to the UNCCD

14. Measures of poverty are a very significant consideration of assessing the impact of actions against desertification due to the centrality of poverty as a root cause, and at the same time consequences, of land degradation and desertification. In the affected areas, where people's incomes are strongly dependent on ecosystems services, it is worth mentioning that poverty is linked to the state of ecosystem services. Several determinants of human well-being are directly dependent on ecosystem services.

d. National context

15. Poverty lines are often adjusted to reflect the economic and social circumstances of a country. National poverty lines tend to have higher purchasing power in rich countries, where more generous standards are used, than in poor countries. In some case, the national poverty line is adjusted within a country for different areas, especially when prices or availability of goods and services differ, for example the urban poverty line can have a higher real value—meaning that it allows the purchase of more commodities for consumption—than does the rural poverty line.

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[5] Millennium Development Goals indicators database. Statistics Division. United Nations, NewYork. Available at . <http://unstats.un.org/unsd/mdg/Host.aspx?Content=Indicators/About.htm>.

[6] World Bank, 2008, 2008 World Development Indicators Poverty data; A supplement to World Development Indicators 2008 The World Bank Washington, D.C., 26 pages. Available at <http://siteresources.worldbank.org/DATASTATISTICS/Resources/WDI08supplement1216.pdf>.

e. Status of development of the indicator

16. The methodology is considered well developed and the indicator is considered ready for testing.[7] However the majority of countries do not have rural poverty data.[8] The indicator may therefore not be as ready in practice as suggested in theory.

2. Implementation

a. Definition

17. The rural poverty rate (RPR) is the percentage of the rural population living above the national poverty line (or in cases where a separate, rural poverty line is used, the rural poverty line). Individuals whose consumption (or income, when consumption is unavailable) falls below the rural poverty line are considered poor.

18. The poverty rate is part of a suite of decomposable poverty measures referred to as the Foster, Greer, and Thorbecke Poverty Measures, that also include the poverty gap and the poverty severity measure.

b. Unit of measurement

19. The unit of measurement of the rural poverty rate is the percentage (%).

c. Data needs to compile the indicator

20. Data required include size of population, an estimate of the individual economic welfare and the poverty line.[9] Finding data disaggregated by rural areas may be a challenge. Other organizations facing similar data constraints with estimating rural poverty have opted to use rural population as a proxy for vulnerable populations.

d. National and international data sources

21. National level rural poverty rates, based on national poverty lines, are in the public domain. For selected countries data are also available at the sub-national level.[10]

22. Data for developing countries may come from the World Bank's Poverty Assessments. The World Bank periodically prepares poverty assessments of countries in which it has an active programme, in close collaboration with national institutions, other development agencies and civil society groups, including poor people's organizations. Since 1992 the World Bank has conducted about 200 poverty assessments.[11] Total poverty estimates are available for approximately 87 countries; rural poverty estimates are available

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7 Orr, B.J. 2011. Scientific review of the UNCCD provisionally accepted set of impact indicators to measure the implementation of strategic objectives 1, 2 and 3. White Paper . Version 1, 145p. Available at <http://www.unccd.int/science/docs/Microsoft%20Word%20-%20White%20paper_Scientific%20review%20set%20of%20indicators_Ver1_31011%E2%80%A6.pdf>.

8 World Bank, 2011. World Development Indicators 201. The World Bank, Washington, D.C., 460 pages. Available at <http://data.worldbank.org/news/WDI-2011-database-and-publication-available>.

9 <http://mdgs.un.org>.

10 Socioeconomic Data and Applications Center (SEDAC). 2010. Global Distribution of Poverty. Poverty Mapping Project of the Center for International Earth Sciences Information Network (CIESIN). Available at <http://sedac.ciesin.columbia.edu/povmap/>.

11 Summaries of poverty assessments are available at <www.worldbank.org/povertynet>, by selecting "Poverty assessments" from the left side bar. Poverty assessment documents are available at <www-wds.worldbank.org>, under "By topic," "Poverty reduction," "Poverty assessment."

for approximately 77 countries and urban poverty estimates are available for approximately 72 countries.

23. Poverty assessments report the extent and causes of poverty and propose strategies to reduce it. The poverty assessments are the best available source of information on poverty estimates using national poverty lines. They often include separate assessments of urban and rural poverty. Data are derived from nationally representative household surveys conducted by national statistical offices or by private agencies under the supervision of government or international agencies and obtained from government statistical offices and World Bank Group country departments. The lag between the reference year and actual production of data series depends on the availability of household surveys and frequency of the World Bank's poverty assessment for each country. Household budget or income surveys are undertaken at different intervals in different countries. In developing countries they typically take place every three to five years. World Bank poverty assessments usually coincide with the availability of these surveys.

24. Consumption data may be better than income data for this indicator. For many countries, data of the United Nations Development Programme (UNDP) relating to the MDG might be more accessible, better known and amenable for use.[12] UNDP does, of course, have a core mandate to reduce poverty and its country offices should be a primary source of information; if the information does not exist, for whatever reason, UNDP has the resources and commitment to gather the information on behalf of national governments, but only on request. Internet sources should generally be treated with caution.

e. Data references

25. Some internet sources are (but not limited to):

(a) United Nations data:[13] the United Nations Statistics Division (UNSD) of the Department of Economic and Social Affairs has an internet based data service for the global user community. It brings United Nations statistical databases within easy reach of users through a single entry point. Users can search and download a variety of statistical resources of the United Nations system. For the concept of "poverty" the tool identifies a set of indicators relating to poverty, from different sources, such as the MDG Database of the UNSD, the World Development Indicators 2009 of The World Bank and data of the World Health Organization;

(b) Millennium Development Goals indicators:[14] this site presents the official data, definitions, methodologies and sources for more than 60 indicators to measure progress towards the MDG produced by the Inter-agency and Expert Group on MDG Indicators, coordinated by the UNSD. In order to measure the progress of the first millennium goal (to eradicate extreme poverty and hunger), there is a set of useful indicators relating to poverty, such as: Population below USD 1 (per day, in percentage); Population below national poverty line (total, percentage); Population below national poverty line (urban, percentage); and Population below national poverty line (rural, percentage);

(c) Statistics of the Organisation for Economic Co-operation and Development (OECD):[15] this database includes data for all 30 OECD member States. In addition, some

[12] Available at <http//www.undp.org/poverty/focus_poverty_assessment.shtml>.
[13] See <http://data.un.org> and search for poverty.
[14] Available at <http://mdgs.un.org>.
[15] Link: <http://stats.oecd.org> and search for poverty in the left hand side menu. The result of the query will be highlighted in yellow.

data are provided for non-member States (see especially data for the five candidate countries, Chile, Estonia, Israel, Slovenia and the Russian Federation) and Brazil, China, India, Indonesia and South Africa.

f. Data limitations

26. To be useful for poverty estimates, surveys must be nationally representative. They must also include enough information to compute a comprehensive estimate of total household consumption or income (including consumption or income from own production) and to construct a correctly weighted distribution of consumption or income per person.

27. Despite these quality standards, there are numerous potential problems associated with household survey data. Some warrant more detailed discussion.[16]

28. Consumption is measured by using household survey questions on food and non-food expenditures as well as on food consumed from the household's own production, which is particularly important in the poorest developing countries. This information is collected either through recall questions using lists of consumption items or through diaries in which respondents record all expenditures daily. But these methods do not always provide equivalent information and, depending on the approach used, consumption can be underestimated or overestimated. Different surveys use different recall or reference periods. Depending on the true flow of expenditures, the rate of spending reported is sensitive to the length of the reporting period. The longer the reference period, the more likely that respondents will fail to recall certain expenses — especially food items — thus resulting in underestimation of true expenditure.

29. Best practice surveys administer detailed lists of specific consumption items. These individual items collected through the questionnaires are then aggregated afterwards. But many surveys use questionnaires in which respondents are asked to report expenditures for broad categories of goods. In other words, specific consumption items are implicitly aggregated by virtue of the questionnaire design. This shortens the interview, reducing the cost of the survey. A shorter questionnaire is also thought to reduce the likelihood of fatigue for both respondents and interviewers, which can lead to reporting errors. However, there is also evidence that less detailed coverage of specific items in the questionnaire can lead to underestimation of actual household consumption. The reuse of questionnaires may cause new consumption goods to be omitted, leading to further underreporting.

30. Invariably some sampled households do not participate in surveys because they refuse to do so or because nobody is at home. This is often referred to as "unit non-response" and is distinct from "item non-response," which occurs when some of the sampled respondents participate but refuse to answer certain questions, such as those pertaining to consumption or income. To the extent that survey non-response is random, there is no concern regarding biases in survey-based inferences; the sample will still be representative of the population. However, households with different incomes are not equally likely to respond. Relatively rich households may be less likely to participate because of the high opportunity cost of their time or because of concerns about intrusion in their affairs. It is conceivable that the poorest can likewise be underrepresented; some are homeless and hard to reach in standard household survey designs, and some may be physically or socially isolated and thus less easily interviewed. If non-response systematically increases with income, surveys will tend to overestimate poverty. But if

[16] This section draws on World Bank, 2008 "2008 World Development Indicators Poverty data; A supplement to World Development Indicators 2008".

compliance tends to be lower for both the very poor and the very rich, there will be potentially offsetting effects on the measured incidence of poverty.

31. Consumption is the preferred welfare indicator for a number of reasons. Income is generally more difficult to measure accurately. For example, the poor who work in the informal sector may not receive or report monetary wages; self-employed workers often experience irregular income flows; and many people in rural areas depend on idiosyncratic, agricultural incomes. Moreover, consumption accords better with the idea of the standard of living than income, which can vary over time even if the actual standard of living does not. Thus, whenever possible, consumption-based welfare indicators are used to estimate the poverty measures reported here. But consumption data are not always available: for instance, in Latin America and the Caribbean the vast majority of countries collect primarily income data. In those cases there is little choice but to use income data.

32. Even if survey data were entirely accurate and comprehensive, the measure of poverty obtained could still fail to capture important aspects of individual welfare. For example, using household consumption measures ignores potential inequalities within households. Thus, consumption- or income-based poverty measures are informative but should not be interpreted as a sufficient statistic for assessing the quality of people’s lives.

3. Analysis

a. Calculation

33. The formula for calculating the percentage of the rural population living below the national poverty line (or in cases where a separate, rural poverty line is used, the rural poverty line) is as follows:

$$P_0 = \frac{1}{N}\sum_{i=1}^{N} I(y_i \leq z) = \frac{N_p}{N}$$

34. Where *I*(.) is an indicator function that takes on a value of 1 if the bracketed expression is true, and 0 otherwise. If individual consumption or income (*yi*) is less than the poverty line (z), then *I*(.) is equal to 1 and the individual is counted as poor. *Np* is the total, rural number of poor. *N* is the total, rural population.

35. Consumption or income data are gathered from nationally representative household surveys, which contain detailed responses to questions regarding spending habits and sources of income. Consumption, including consumption from own production, or income is calculated for the entire household. In some cases, an “effective” household size is calculated from the actual household size to reflect assumed efficiencies in consumption; adjustments may also be made to reflect the number of children in a household. The number of people in those households is aggregated to estimate the number of poor persons.

36. National poverty rates use a country specific poverty line, reflecting the country’s economic and social circumstances. In some cases, the national poverty line is adjusted for different areas (such as urban and rural) within the country, to account for differences in prices or the availability of goods and services. Typically the urban poverty line is set higher than the rural poverty line, reflecting the relatively higher costs of living in urban areas. In principle, global and national poverty figures cannot be compared because they are based on different poverty lines.

b. Other considerations

37. Regarding the definition of "affected areas", at the meeting of the CST, held in Bonn from 16 to 18 February 2011, it was recommended that the UNCCD secretariat should continue work on methodologies for measuring, monitoring and reporting on the "proportion of the population in affected areas living above the poverty line" ICCD/CRIC9/15, addressing the topics related to the establishment of the poverty line and to the spatial disaggregation of the data in line with the outcomes of the scientific peer review of the provisionally accepted set of UNCCD impact indicators.

38. Based on the findings of the scientific peer review process, the need to clarify the term "in affected areas", specifically where it is used in the definition of the core and provisional indicators, was emphasized. It was recommended that all the proposed indicators be measured in affected country Parties and that the operational use of the term "in affected areas" should be refined through input from the scientific community and used to interpret the impact indicator measurements. 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. It was recommended that the secretariat should further work on this issue in collaboration with the scientific community in view of CST 10.

4. Presentation and interpretation

a. Formats and narratives

39. Data can be presented as a graph of rural poverty against time. Consider error bars/uncertainty.

b. Meaning and causes of trends

40. It is important to present results of the rural poverty rate with sufficient contextual information to enable users to interpret them. Poverty is recognized as a root cause, and also as a consequence, of desertification, land degradation and drought (DLDD) because the well-being of populations in the affected areas is strongly dependent on environmental goods and services.[17] A reduction in the rural poverty rate suggests an improvement in aspects of the living conditions of rural populations. Populations outside urban areas are those most likely to be affected by DLDD. However, 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 5 in rural areas, and the maternal mortality ratio. This linkage makes the relationship between combating desertification and the effect of economic policies aimed at decreasing poverty difficult to determine.

c. Implications for policy and management

41. The eradication of poverty remains a major challenge for policy decision makers. The rural poverty rate makes poverty comparisons possible. These are required for an overall assessment of a country's progress in poverty alleviation and/or the evaluation of specific policies or projects. Poverty comparisons are also made over time, in assessing overall performance from the point of view of the poor.

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[17] See <http://www.un.org/esa/sustdev/natlinfo/indicators/isdms2001/isd-ms2001socialA.htm>.

d. Limitations

42. The following limitations should be considered:

(a) An income and consumption based poverty indicator does not fully reflect the other dimensions of poverty such as inequality, vulnerability, and lack of voice and power of the poor;

(b) An income and consumption based poverty indicator does not provide any details on how poor (i.e. how far below the poverty threshold) the poor are. It does not capture income inequality among the poor or the depth of poverty. For instance, it fails to account for the fact that some people may be living just below the poverty line, while others experience far greater shortfalls. Policymakers seeking to make the largest possible impact on the headcount measure might be tempted to direct their poverty alleviation resources to those closest to the poverty line (and who are therefore the least poor);

(c) 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 5 in rural areas, and the maternal mortality ratio. This linkage makes the relationship between the combat of desertification and the effect of economic policies aimed at decreasing poverty difficult to determine;

(d) National poverty lines and rural poverty lines are used to make more accurate estimates of poverty consistent with the country's specific economic and social circumstances and are not intended for international comparisons of poverty rates;

(e) National poverty lines tend to increase in purchasing power with the average level of income in a country.

5. Agencies involved in the production of the indicator

43. The lead agencies are the World Bank and UNDP.[18]

6. References

44. See box 1 for some suggested readings, databases and websites.

Box 1
References

Readings
Coudouel, A., J. Hentschel, and Q. Wodon. 2002. "Poverty Measurement and Analysis." In J. Klugman, editor, *A Sourcebook for Poverty Reduction Strategies, Volume 1: Core Techniques and Cross-Cutting Issues.* Washington, D.C.: The World Bank. Available at <http://siteresources.worldbank.org/INTPRS1/Resources/383606-1205334112622/5467_chap1.pdf>
Duraiappah , A.K. and Roy, M. 2007. *Poverty and Ecosystems: Prototype assessment and reporting method, Kenya case study; July 2007*; Available at < http://vww.iisd.org>
ECLAC. 1991. *Magnitud de la pobreza en América Latina en los años ochenta*. Estudios e Informes de la CEPAL. ISSN 0256-9795.
Leon A., 2010 *The subset of UNCCD impact indicators - Proportion of the population in affected areas living above the poverty line*. Report prepared for the UNCCD 25 pages. Available at <http://www.unccd.int/science/docs/report%20poverty%20-%20version%20for%20the%20web%5B1%5D.pdf>

[18] Contact points: data@worldbank.org and demostat@un.org.

Ravallion, M. 1998. *Poverty lines in theory and practice*. The World Bank Washington, D.C.
The World Bank, *World Development Report* 1990, 2000, 2001, and 2006 editions
The World Bank, Word Development Indicators, various years
Databases
Data and metadata on the official MDG indicators, Available at <http://mdgs.un.org/unsd/mdg/Default.aspx>
Internet sites
The World Bank: www.worldbank.org/poverty
World Development Report: www.worldbank.org/wdr
World Development Indicators: www.woridbank.org/data
United Nations. Millennium Indicators Database. Statistics Division Internet site: <http://data.un.org>.

III. Land cover status

Strategic objective	SO.2: To improve the condition of ecosystems
Core indicator	S-5: Maintenance of or increases in ecosystem function, including net primary productivity
General indicator	Land cover status
Core metric/proxy	Land cover
Additional metric/proxy	Land productivity/production

45. Based on the work conducted on methodologies for the effective use of the subset of impact indicators (see document ICCD/CST(S-2)/7) as well as on the preliminary findings of the scientific peer review on the refinement of the set of impact indicators (see document ICCD/CST(S-2)/INF.1), the CST at its second special session noted that two main alternatives had been identified for reporting on land cover status: (a) those based on indicators derived from land cover/land use maps; and (b) those that use biophysical indicators, which are also known as ecosystemic indicators. The use of biophysical indicators was recommended. Nevertheless, taking into account the different levels of technical capacity in affected country Parties and that the deadline for compliance by 2012 was very tight, the provisional adoption of a stratified approach to reporting on land cover status was recommended. This approach would allow a start to be made using readily available data on land cover. As technical capacity improves, countries can provide more detailed reports and mapping, reflecting the other classifiers, such as land utilization types and vegetation cover measurements along with production and biomass data, as appropriate to the type of cover.

46. Therefore, where possible and according to their capacities, countries should report on both suggested metrics: land cover and land productivity/production. Where capacity is more limited, reporting could be limited to the core metric: land cover.

A. Land cover

1. Introduction

a. Purpose

47. The land cover indicator is intended to contribute to monitoring progress in maintaining or improving the condition of ecosystems, that is, reducing land degradation. As ecosystems are degraded the extent of different land cover classes changes. In the first instance, this indicator measures the current distribution of vegetation and other classes of land cover, for example, grass, rangeland, water, open woodland, closed forest, built-up areas and bare soil. These land cover classes are determined by the technical feasibility of detecting them and their relevance to DLDD assessments (e.g. in relation to vegetation density). These measures are either in terms of specific cover classes or as spectral indices from remote sensing analyses that relate to cover classes through their productivity or ‘greenness’.

b. Global relevance

48. Land cover change is a pressing environmental issue. Reliable observations are crucial to monitor and understand the ongoing processes of deforestation, desertification, urbanization, land degradation, loss of biodiversity, ecosystem functions, water and energy management, and the influence of land cover changes on the physical climate system itself.

c. Relevance to the UNCCD

49. Change in land cover is an important result of DLDD over the medium to long term. Furthermore, particular land cover classes differ in their susceptibility to DLDD. Assessing land cover can therefore aid in the identification of areas that are potentially affected by DLDD and changes in land cover over time will reflect DLDD impacts.

50. Change in land cover relates to the UNCCD core indicator S-5 “Maintenance of or increases in ecosystem function, including net primary productivity (NPP)” in terms of different land covers having different levels of NPP. A forest usually has higher primary productivity than a grassland over an annual cycle, and obviously a grassland will have higher productivity than bare soil. Land cover is a very broad indicator of the condition of an ecosystem and its productivity for people and their livelihoods.

d. National context

51. This indicator summarizes measures of current land cover, and especially the distribution of land cover classes of greatest concern for land degradation (forest, rangeland, agricultural crops, etc.). Analysing trends in land cover can help to identify changes in a nation’s land resources, and assist decision-making for sustainable land management.

e. Status of development of the indicator

52. Land cover is well established as an indicator and its methods are ready for testing and use at national and site scales.

2. Implementation

a. Definition

53. Land cover is defined as the observed (bio)-physical cover on the Earth’s surface, and is usually summarized in terms of classes that reflect this (e.g. bare ground, water,

grassland, shrubland, forest, cropland). It is distinct from, but often confused with, land use, which is concerned with how people utilize the land, that is, the socio-economic function (agriculture, environmental protection, urban), which may or may not be associated with a specific land cover at any given time. For example, the land cover of an agricultural area may be bare soil at one time and annual crop cover at another; similarly an area designated as forestland may have no tree cover if it has recently been harvested. Land cover is amenable to assessment using remote sensing, but many forms of land use and change in land use are not. Sustainable agricultural or other land management is an aspect of land use that may affect land cover, but it is not in itself a land cover.

b. Unit of measurement

54. Land cover, as a spatial measure, and its units of measurement are usually hectares (ha) or square kilometres (km2).

c. Data sources and limitations

55. An initial assessment of land cover change can be implemented using time series of either statistical or mapped data on the location and extent of different land cover classes. Such data may come from a variety of sources, including traditional cartography, aerial photography and various forms of remote sensing. However, assessing the maintenance of ecosystem condition requires evaluating change in land cover over time, and therefore requires time series of comparable data. As data from different sources are processed using different methods to identify land cover classes and may also use different classes and definitions, they are rarely directly comparable. Therefore, compiling valid and comparable time series data that can be used to assess land cover change can be a major challenge.

d. National and international data sources and references

56. A few countries have monitoring systems in place that generate comparable data on land cover at different points in time. These include both aerial survey and satellite remote sensing approaches. However, both are much more commonly employed to detect changes in forest cover (see, for example, PRODES at <http://www.obt.inpe.br/prodes/index.html> that monitors forest cover change in the Brazilian Amazon) than for quantifying change in other land cover classes.

57. Similarly, most countries report to the Food and Agriculture Organization of the United Nations (FAO) on both their forest and their agricultural land use, based on various forms of national inventory, and the resulting databases[19] are one international source of harmonized data on trends in some land uses. In addition, the FAO Global Forest Resources Assessment provides information on the extent of forests at national level and has recently incorporated an assessment based on remote sensing of a subsample of the world’s forests.[20]

58. However, the range of data sources and quality in the global databases is large and less productive ecosystems, such as those most subject to DLDD, are poorly represented. Nevertheless, individual countries may have appropriate survey data, for example, from agricultural census, to provide a basis for assessment of land use and associated land cover.

59. There are several sets of global land cover data that potentially provide useful context information and possibly baseline data for national efforts to monitor land cover change. These include: the Global Land Cover 2000 (GLC2000) database, produced by the

[19] <http://faostat.fao.org/>.

[20] <http://www.fao.org/forestry/fra/remotesensingsurvey/en/>.

Global Vegetation Monitoring Unit of the Joint Research Centre (JRC) of the European Union in collaboration with a network of partners around the world, databases produced by the University of Maryland, University of Boston and NASA, the Global Land Cover Characterization (GLCC) database, developed by the U.S. Geological Survey (USGS) and collaborators and the Pan- European Land Cover Monitoring project (PELCOM Due to their global and regional nature, these are mostly at spatial resolutions of 500 metres or greater and therefore cannot be used as a basis for assessing finer scale differences in pattern or changes with time. Of these, the GLC2000 may have the widest acceptance; it is a 1 km resolution global land cover product based on data from the SPOT VEGETATION sensor, which is regionally appropriate and has been validated by regional experts and been shown to be reasonably accurate (as far as land cover classifications go, the overall accuracy of 68.6% is good for a global product). The GLC2000 data was included as a core data set in the Millennium Ecosystem Assessment (MA).

e. Data limitations

60. The lack of a source of appropriate global land cover data that has been derived using consistent data sources and methods and shown to be comparable at successive time periods is a major barrier to change detection based on global data sets to date. Nonetheless, historical land cover data can provide both a form of baseline assessment and useful context for interpreting recent changes.

61. Recently, a new product from the MODerate – resolution Imaging Spectroradiometer (MODIS) has become available that provides information on the global extent of 17 land cover classes at 500 metre resolution on an annual basis, processed in a consistent manner.[21] However, initial investigations have identified difficulties in using this data to track change in land cover.[22] The European Space Agency has plans to provide comparable time series of data based on satellite data derived from the MEdium Resolution Imaging Spectrometer (MERIS) (300-metre resolution) using the GlobCover processing approach.[23] However, questions have been raised about the accuracy of the GlobCover product, especially for sparser vegetation and more arid parts of the world. Both GLC2000 and GlobCover are freely available and use land cover classes derived from the Land Cover Classification System (LCCS), but they are not directly comparable.

62. Another approach to measuring long-term change in land cover status at broad geographical scales is the use of spectral indices, such as the Normalised Difference Vegetation Index (NDVI), which reflect changes in the nature and extent (and potentially productivity) of vegetative cover. However, this approach is more appropriate to the additional metric land productivity/production. Two useful, relevant and publicly available data sets based on MODIS imagery are NDVI and Enhanced Vegetation Index (EVI) which are compiled as biweekly mosaics, reducing problems from cloud cover.[24] The data can be downloaded at no charge from NASA’s Earth Observing System Data Gateway.

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[21] Friedl, M. A., Sulla-Menashe, D, Tan, B., Schneider, A., Ramankutty, N., Sibley, A., & Huang, X. (2010) MODIS Collection 5 global land cover: algorithms refinements and characterization of new datasets, Rem. Sens. Env. 114, 168–182.

[22] Scharlemann, J.P.W. and Kapos, V. (2011). Tracking change in the extent of selected ecosystems using global 500 metre resolution MODIS land cover data. United Nations Environment Programme World Conservation Monitoring Centre, Cambridge, UK.

[23] <http://postel.mediasfrance.org/en/PROJECTS/Preoperational-GMES/GLOBCOVER/>.

[24] Huete A,Didan K.,Miura T., Rodriguez E.P., Gao X., Ferreira L.G. (2002). Overview of the radiometric and biophysical performance of the MODIS vegetation indices. Remote sensing of environment 83: 195–213.

63. The coarse resolution of the global datasets and the lack of classified global data sets that are comparable over time means that national assessment of land cover status and change is likely to be dependent on analysis of higher resolution remotely sensed data, such as Landsat, SPOT, Ikonos, and Quickbird (table 2). These are well reviewed and guidance for their use is provided in a publication in the Convention on Biological Diversity's Technical Series,[25] which includes a section devoted to remote sensing in dry and sub-humid lands and presents several case studies relevant to the UNCCD context. More information, including experiences of measuring degradation in case study countries can be found on the website of the Land Degradation Assessment in Drylands project (LADA).[26]

Table 2
Satellite sensors commonly used for assessing land cover (adapted from Annex 3 of Strand et al 2007, where more detail can be found; additional detail via CEOS)[27]

Satellite sensor	*Characteristics*	*Internet site*
NOAA KLM/AVHRR	Spatial resolution: 1.1 km image coverage: 3000 km wide Repeat frequency: 1 day launch date: 1978	http://www2.ncdc.noaa.gov/docs/klm/index.htm
SPOT VEGETATION	Spatial resolution: 1.15 km at nadir repeat frequency: 1 day launch date: 1986	http://www.spotimage.com/
Terra/MODIS	Spatial resolution: Bands 1 and 2: 250 metre, bands 3–7: 500 metre, and bands 8-36: 1km repeat frequency: near daily launc date: 2000	http://modis.gsfc.nasa.gov/
Terra/ASTER	Spatial resolution: 15 metres (Visible and near-infrared) to 90 metres (thermal infrared). Repeat frequency: 16 days; acquisitions are scheduled launch date: 2000	http://asterweb.jpl.nasa.gov/
Landsat/TM and ETM+	Spatial resolution: Panchromatic: 15 metres (panchromatic) or 30 metres (multispectral) repeat frequency: 16 days launch date: Landsat TM 4 and 5 1982 and 1984, Landsat ETM+ 1999	http://edc.usgs.gov/guides/landsat_tm.html
IR-MSS/CBERS2, 2b	Spatial resolution: 20 metre repeat frequency: 26 days launch date: 2003, 2006	http://www.cbers.inpe.br/?hl=en&content=index
Landsat/MSS	Spatial resolution: Landsat 1–3: 5 6metres x 79 metres, Landsat 4–5: 68 metres x 82 metres repeat frequency: Landsat 1–3: 18 days, Landsat 4–5: 16 days launch date: 1972, 1975, 1978, 1982, 1984	http://edc.usgs.gov/guides/landsat_mss.html
ENVISAT-1/MERIS	Spatial resolution: Land and coast: 260 metres x 300 metres repeat frequency: 3 days launch date: 2002	http://earth.esa.int/dataproducts/
SPOT 5/HRG	Spatial resolution: 2.5 metres (panchromatic) or 10 metres (multispectral); Repeat frequency: 2–3 days launch date: 2002	http://www.spotimage.com/

25 Strand, H., Höft, R., Strittholt, J., Miles, L., Horning, N., Fosnight, E., Turner, W., eds. (2007). Sourcebook on remote sensing and biodiversity indicators. Secretariat of the Convention on Biological Diversity, Montreal, Technical Series no. 32, 203 pages. Available at: <http://www.cbd.int/doc/publications/cbd-ts-32.pdf>.

26 <http://www.fao.org/nr/lada/>.

27 <http://www.eohandbook.com/eohb05/pdfs/miss_inst_2005.doc>.

Satellite sensor	*Characteristics*	*Internet site*
SPOT 4/HRVIR	Spatial resolution: 10 metres (panchromatic) or 20 metres (multispectral); Repeat frequency: 2–3 days launch date: 1998	http://www.spotimage.com/
IKONOS-2	Spatial resolution: 1 metre (panchromatic), or 4 metres (multispectral) image coverage: 11.3 km swath width Repeat frequency: 1–3 days launch date: 1999	http://www.geoeye.com/CorpSite/products-and-services/Default.aspx
QUICKBIRD	Spatial resolution: Pan: 61 cm; MS: 2.44 metre image coverage: 16.5 km spectral bands: Pan: 725, 479.5, 546.5, 654, 814.5 nm repeat frequency: 1–3 launch date: 2001	http://www.digitalglobe.com/
RESOURCESAT	1 IRS/P6 (three instruments LISS-3, LISS-4, and AWiFS) Spatial resolution: 23.5 metres (LISS-3), 5.8 metres (LISS-4), or 56 metres (AWiFS). Repeat frequency: 5 days (LISS-4), or 24 days (LISS-3 and AWiFS.) launch date: 1996, 2003	http://www.isro.org/satellites/irs-p6resourcesat-1.aspx
ENVISAT/ASAR C-band	Spatial resolution: 150 metres x 150 metres repeat frequency: 35 days; acquisitions are scheduled launch date: 2002	http://earth.esa.int/dataproducts/
Radarsat-1/ SAR (Synthetic Aperture Radar) C-band (HH polarization)	Spatial resolution: Standard: 100 km Wide: 150 km, Fine: 45 km, Repeat frequency: 24 days launch date: 1995	http://www.asc-gc.ca/eng/satellites/radarsat1/
ALOS (Advanced Land Observing Satellite)/ Phased Array type L-band Synthetic Aperture Radar (PALSAR)	Spatial resolution: Hi-res: 7–44 metres or 14–88 metres (depends on polarisation and looks), Repeat frequency: 3 days Launch date: 2006	http://www.jaxa.jp/projects/sat/alos/index_e.html

64. Recently, NASA has released a large archive of Landsat data and has made it available free of charge. This is potentially a valuable resource for national land cover assessments. However, it is important to recognise that processing such data is a resource-intensive undertaking requiring both financial resources and technical capacity. It is also potentially quite time consuming.

65. The costs of national land cover assessments based on remote sensing are further increased by the need for extensive programmes of field work to support the analysis. It is essential that, field observations and knowledge must be used to ground truth and validate classification and assessment of land cover using remote sensing.

3. Analysis

66. In addition to consistently sourced and processed land cover data, analysis of land cover status and change requires agreement on which land cover classes are both of interest and feasible to measure. The classes most likely to be of interest in the UNCCD context includes: closed forest, open or sparse forest, closed and open shrubland, grassland, cropland (perhaps divided into annual and perennial crops), rangeland and bare soil. However, these classes are defined in many different ways and it is important that the definitions used are made clear. The LCCS, which is designed to increase consistency and comparability across space and time, can help clarify and use appropriate definitions. Many existing global, regional and national land cover datasets make use of this classification system. Ideally it would be possible to detect degradation within each land cover class, but the feasibility of this is limited. As methods improve, it will likely become possible to

quantify the extent of degraded grassland as well as grassland in good condition. It may be possible to do the same for forest. Specific methods are needed to address the status of other ecosystems in land cover terms. Other classes may well be of interest, but the feasibility of assessing them will depend on the data sources used and the ability to detect and delineate the classes.

67. When classes and data processing methods have been agreed, the source data can be processed to provide a simple table of the area of each land cover class at each time period. Based on this, the differences between time periods can be calculated and expressed either as absolute gains or losses for each class (in square kilometres) or as a percentage of the extent of that land cover at the beginning of the time series, or both. In somewhat more complex analyses, it will be possible to generate a transition matrix (table 3) showing the exact area that has changed from each land cover class to each of the other classes.

Table 3
Example of transition matrix

		Land cover class Time 2			
		Forest	Grassland	cropland	Bare soil
Land cover class Time 1	Forest	Km^2 or percent of forest remaining forest	Km^2 or percent of forest converted to grassland	Km^2 or percent of forest converted to cropland	Km^2 or percent of forest converted to bare soil
	Grassland	Km^2 or percent of grassland remaining forest	Km^2 or percent of grassland remaining grassland		Km^2 or percent of grassland converted to bare soil
	Cropland	Km^2 or percent of cropland becoming forest	Km^2 or percent of cropland becoming grassland	Km^2 or percent of cropland remaining cropland	Km^2 or percent of cropland converted to bare soil
	Bare soil	...	...	...	Km^2 or percent of bare soil remaining as bare soil

4. Presentation and interpretation

a. Formats and narratives

68. Presentation of the land cover status indicator can usefully include maps, tables and graphical summaries. Maps are most useful for making clear the basic distribution of the different land cover classes and providing context for the statistical patterns. Tables of summary statistics provide a more objective basis for assessment by the indicator users of both the absolute and relative extent of each land cover class, although for some audiences graphical summaries may do this more effectively. For example, pie charts of total national land area divided into land cover classes can be very effective. For presenting change in land cover over time, line graphs for each land cover class are more useful and an area graph that shows changes in all classes simultaneously is useful where there are not too many land cover classes.

69. It is essential that maps, tables and graphs be accompanied by text explaining the patterns and highlighting their most important features. This text would need to relate patterns of change to the context of other changes in the country, including actions taken to

achieve the objectives of the Convention. Ideally it would also address the question of how the trends differ, at least qualitatively from previous patterns.

70. It is also very important to know where to find information on the data sources and analysis methods used to generate the indicator; i.e. metadata or links to them are provided.

b. Meaning and causes of trends

71. The meaning of particular trends in land cover depends significantly on national context. However, in general, decreases in the area of closed or natural vegetation and increases in the area of open vegetation and bare soil are likely to reflect processes of degradation or difficulty in maintaining ecosystem condition. The trends need to be viewed in the context of other information such as tends in population, climatic fluctuations and changes in land management regimes.

c. Implications for policy and management

72. Where particular land cover classes decline rapidly, it will be important to review land management and development policies and seek opportunities for halting or reversing degradation.

d. Limitations

73. The principal limitations of this indicator result from the inability of most available methods to detect subtle changes in land cover. Therefore, the classes quantified may not provide enough meaningful detail to support informed decision making. For example, many of the methods available are unable to distinguish between degraded forest and forest in a good condition. As mentioned earlier, the challenges associated with assembling valid time series mean that for many countries, an initial assessment of land cover is all that will be possible. While this potentially provides useful context for the other indicators and a useful baseline for future work, it gives little information on how the condition of an ecosystem may be changing.

74. Another limitation derives from the compatibility and comparability of the datasets. Although extensive information on land cover has been produced in many regions of the world, the varying purposes, data sources, accuracies, spatial resolutions, and thematic legends of these efforts have resulted in a suite of more or less incompatible land cover datasets. The lack of consistency has triggered the need for harmonization and standardized land-cover monitoring. Information on land cover has to be compatible and comparable for multi-temporal analysis and map updates within and among countries, within and between applications, disciplines and agencies and at local to global scales (vertical and horizontal harmonization). Harmonization efforts should first address the terminology, or classifiers, used for the description of land cover and, once applied to systems and legends, the individual criteria used for creating land cover categories should be harmonized and applied in operational observing programmes.[28] The LCCS[29] and the related ontology specified in Land Cover Macro Language (LCML) currently is the most comprehensive, internationally applied and flexible framework for land cover characterization. It defines a system of diagnostic criteria (land cover classifiers) that provides standardization of terminology and not categories. At this level, existing land cover data can be compared much better. The LCML is undergoing approval to become an ISO standard.

[28] Global Terrestrial Observing System, 2009. Assessment of the status of the development of the standards for the terrestrial essential climate variables. Land, land cover. 25p.

[29] Di Gregorio, A., 2005, United Nations Land Cover Classification System (LCCS) – classification concepts and user manual for Software version 2. [online] URL: <www.glcn-lccs.org>.

5. References

75. See box 2 for some suggested readings, databases and websites.

Box 2
References

Readings
Fisher, P.F., Comber, A.J. and Wadsworth, R.A., 2005. Land use and Land cover: Contradiction or Complement. Pp. 85-98 in Re-Presenting GIS, (eds. Peter Fisher, David Unwin), Wiley, Chichester. Ramachandra, T. V. & Kumar, U., 2004. Geographic Resources Decision Support System for land use, land cover dynamics analysis. Proceedings of the FOSS/GRASS Users Conference, Bangkok, Thailand. Squires,V.R, 2010 “The subset of UNCCD impact indicators – Land Cover status.” Report prepared for the UNCCD, 38pp. Available at: http://www.unccd.int/science/docs/Report%20Land%20Cover%20Status%20-%20version%20for%20the%20web%5B1%5D.pdf Tappan, G. C., M. Sall, E. C. Wood, and M. Cushing. 2004. Ecoregions and land cover trends in Senegal. Journal of Arid Environments 59(3):427–62.
Databases
The GLC2000 database: http://bioval.jrc.ec.europa.eu/products/glc2000/glc2000.php Global Land Cover Facility: http://glcf.umiacs.umd.edu/ MODIS Land Cover: http://www-modis.bu.edu/landcover/ NASA Global Land Use database http://gcmd.nasa.gov/records/GCMD_SAGE_IAMDATA.html The Global Land Cover Characterization (GLCC) database,: http://landcover.usgs.gov/landcoverdata.php The Pan- European Land Cover Monitoring project (PELCOM): http://afoludata.jrc.ec.europa.eu/index.php/dataset/detail/6 FAO Global Forest Resources Assessment (http://www.fao.org/forestry/fra/remotesensingsurvey/en/) Earth Resources Observation System (EROS) Data Center (EDC) (http://edcsns17.cr.usgs.gov/EarthExplorer/) The Global Terrestrial Observing System (GTOS, www.fao.org/gtos/) http://www.fao.org/nr/lada/ http://apdrc.soest.hawaii.edu/datadoc/gpcc_1.htm http://www.landcover.org/data/gimms/
Internet sites
GLC 2000 or POSTEL’ product GLC2008 based on MODIS imageries, 300-metre spatial refinement. http://postel.mediasfrance.org/breve.php3?id_breve=29 http://www.fao.org/nr/lada/index.php?/Documents/View-category.html http://nrd.uniss.it/dis/index.php http://apdrc.soest.hawaii.edu/datadoc/gpcc_1.htm http://www.landcover.org/data/gimms/ CORINE Land cover – Part 1: Methodology http://www.eea.europa.eu/publications/COR0-part1 GLCN www.glcn.org FAO LCCS software manual LCCS manual: http://dwms.fao.org/lccs/index_en.asp

B. Land productivity/production

1. Introduction

a. Purpose

76. The purpose of this indicator is to identify regions with declining or increasing NPP as an early warning of possible land degradation or land improvement respectively in a particular area.

b. Global relevance

77. Demand for land-based products is greater than supply and is growing. Aside from providing more food, other factors are, inter alia, increasing the productivity of land-influence prospects for poverty reduction, economic growth, income distribution and savings, labour migration.

c. Relevance to the UNCCD

78. Land productivity relates to the UNCCD core indicator S-5: “Maintenance of or increases in ecosystem function, including net primary productivity”. Land degradation may be defined as a long-term decline in ecosystem function and productivity, which may be measured by change in NPP. Deviation from the norm may be taken as an indicator of land degradation or improvement.[30] A persistent reduction of NPP below its potential, which does not disappear during wetter periods, could identify areas that are experiencing desertification.[31] To this end, an index of greenness is commonly accepted as a proxy of NPP.

d. National context

79. Greenness trends help to identify areas in which there has been either an increase or decrease in vegetative cover or biomass productivity, net of the effect of rainfall. The indicator cannot be used definitively to conclude that land degradation has taken place, but it can help to identify hotspots, and bright spots of significant change that need subsequent detailed investigation on the ground.

e. Status of the indicator development

80. The indicator is still under development. It is currently the object of international debate and its interpretability has been questioned.[32] However, the basic approach adopted is considered to be most promising and is being explored by large research projects such as DeSurvey.[33]

81. As a proxy indicator, NDVI, calculated from the reflected near-infrared and red wavebands measured by earth-orbiting satellites, has been shown to be related to leaf area

[30] Dent, D., and R. Scholes. (2008). “Greenness Indicator.” Methodological note provided to the KM:Land project on 3 March 2008.

[31] Prince, S.D., 2002: Spatial and temporal scales of measurement of desertification. In: Global desertification: do humans create deserts? M. Stafford-Smith and J. F. Reynolds (eds.), Dahlem University Press, Berlin, pp. 23–40.

[32] Wessels K.J.,2009. Letter to the editor. Comments on ‘Proxy global assessment of land degradation’ by Bai et al. (2008) Soil Use and Management, March 2009, 25, 91–92.

[33] Del Barrio,G., Puigdefábregas,J., Sanjuán, M. E., Stellmes, M., Ruiz, A. 2010. Assessment and monitoring of land condition in the Iberian Peninsula, 1989–2000. Remote Sensing of Environment, 114: 1817–1832.

index and the fraction of photosynthetically active radiation absorbed by vegetation (fPAR), which control vegetation productivity and land/atmosphere fluxes, and to NPP. It compensates for some sensor drift, view angle, illumination and atmospheric effects. Shortcomings include saturation at high leaf cover, soil interference with the signal at low leaf cover, unreliable measurements for cloudy areas, and variable, empirical calibration in terms of NPP. Consistent time-series data at resolutions from 20 metres to 8 km are available from 1983 and, for this reason, it is the recommended indicator for immediate use (i.e. when looking at conditions in the past).[34]

82. fPAR has the advantage of being a physically-defined quantity directly related to NPP. It is calculated from the same wavebands as NDVI using further, independent measurements and it does not become saturated at high leaf areas. Consistent time series data is available from the JRC (MERIS ENVISAT) and NASA (MODIS) at 500 metre to1 km resolution from year 2000. This is the preferred indicator for use in the future.[35]

83. The indicator is considered ready for testing.[36]

2. Implementation

a. Definition

84. 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) NDVI time series (1981 to 2006) assembled by the University of Maryland.

b. Unit of measurement

85. Units of measurement are:

(a) Sum NDVI;

(b) NPP: kgC ha-1 year-1;

(c) RUE mm-1 (it also be measured as kg-1mm-1year-1).

c. Data needs to compile the indicator

86. Processing of the indicator requires:

(a) NDVI calculated for time series (at least multi-annual) of high temporal resolution satellite data;

(b) Annual rainfall for corresponding time series.

d. National and international data sources

87. All required data sets are already available from the Global Assessment of Land Degradation (GLADA). Data sources used by GLADA are GIMMS and Variability Analyses of Surface Climate Observations (VASClimO) 1.1.

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[34] See footnote 27.

[35] See footnote 27.

[36] Orr, B.J. 2011. “Scientific review of the UNCCD provisionally accepted set of impact indicators to measure the implementation of strategic objectives 1, 2 and 3. White Paper – Version 1, 145p. [online] URL: <http://www.unccd.int/science/docs/Microsoft%20Word%20-%20White%20paper_Scientific%20review%20set%20of%20indicators_Ver1_31011%E2%80%A6.pdf>.

88. The GIMMS data set is a NDVI derived from imagery obtained from AVHRR sensor onboard 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.[37] The spatial resolution of the resulting product is 8 km. Time series are possible, for these date ranges: 2000–2007, 1981–2002; 1981–2006. The VASClimO comprises the most complete monthly precipitation data for 1951–2000, compiled from long, quality-controlled station records, gridded at a resolution of 0.5°, from 9343 stations. For 2001–2003, these were supplemented by the full data re-analysis product of the Global Precipitation Climatology Centre (GPCC)[38] to produce monthly rainfall values matching the GIMMS NDVI data.

e. Data limitations

89. The 8 km resolution of the GIMMS data is a limitation in two senses. First, an 8 km pixel integrates the signal from a wider surrounding area. Many symptoms of even very severe land degradation, such as gullies, rarely extend over such a large area. They must be very severe to be seen against the signal of the surrounding unaffected areas. More detailed analysis is possible for those areas that have higher resolution time-series data, in particular South Africa.[39] Secondly, an 8 km pixel or even a 1 km pixel cannot be checked by a windscreen survey and a 23-year trend cannot be checked by a single snapshot.

3. Analysis

a. Calculation

90. Areas of land degradation and improvement are identified by a sequence of analysis of remotely sensed data.

91. Simple NDVI indicators can be computed for the period of time considered. The annual sum NDVI (sumNDVI), which is the aggregated of greenness over the growing season, is commonly used as the standard surrogate for annual biomass productivity.

92. Values of NDVI can be translated to NPP by using correlation methods with ground measurements or remotely sensed estimation. GLADA uses MODIS data:

$$NPP_{MOD17}\ [kgC\ ha_{-1}\ year_{-1}] = 1106.37 * sum\ NDVI - 564.55$$
$$(r = 0.83,\ n = 3\ 128\ 207)$$

93. Where NPP $_{MOD17}$ is annual mean NPP derived from MODIS MOD17 Collection 4 data and sum NDVI is the four-year (2000–2003) mean annual sum NDVI derived from GIMMS, there is uncertainty about the slope ± 3.818 and the intercept ± 16.364.

94. The major obstacle to detecting a land-productivity trend in drylands is the strong dependency of NPP on rainfall and the high inter-annual variability of precipitation. Where greenness is limited by rainfall, the index is adjusted for rainfall variability using rain-use

[37] University of Maryland. (undated). Global Land Cover Facility. Available at: <http://glcf.umiacs.umd.edu/data/gimms/>.

[38] Schneider U, T Fuchs, A Meyer-Christoffer & B Rudolf 2008 Global precipitation analysis products of the GPCC, full data re-analysis product version 4. Global Precipitation Climatology Centre, Deutscher Wetterdienst, Offenbach available at: <ftp://ftp-anon.dwd.de/pub/data/gpcc/html/fulldata_download.html>.

[39] Wessels, K. J., S. D. Prince, P. E. Frost, and D. van Zyl. 2004. Assessing the effects of human-induced land degradation in the former homelands of northern South Africa with a 1 km AVHRR NDVI time-series. Remote Sensing of Environment 91(1): 47–67.

efficiency (RUE). RUE is calculated as the ratio of the annual sum of NDVI and annual rainfall. To distinguish between declining productivity caused by land degradation, that caused by other factors, false alarms must be eliminated. Rainfall variability and irrigation have been accounted for by:

(a) Identifying each pixel where there is a positive relationship between productivity and rainfall, i.e. where rainfall determines NPP;

(b) For those areas where rainfall determines NPP, Rainfall Use Efficiency (RUE has been considered: where NPP declined but RUE increased, we may attribute declining productivity to declining rainfall. Those areas are masked;

(c) For the remaining areas with a positive relationship but declining RUE, and also for all areas where there is a negative relationship between NDVI and rainfall, i.e. where rainfall does not determine NPP, NDVI trend has been calculated; this is called RUE-adjusted NDVI;

(d) Land degradation is indicated by a negative trend of RUE-adjusted NDVI and may be quantified as RUE-adjusted NPP.

95. The reliability of using RUE has been questioned by finding a strong negative correlation between RUE and total amount of rainfall. To get around this correlation, Wessels et al., (2007) have suggested the alternative use of residual trends – the difference between the observed NDVI and that predicted from the local rainfall-NDVI relationship.[40]

b. Limitations

96. The parameters used to create this indicator cannot be used to definitively conclude that land degradation has taken place, but they can help to identify areas that require more fine-scaled investigation.

97. A negative trend in NDVI does not necessarily indicate land degradation, nor does a positive trend necessarily indicate land improvement. Biomass depends on several factors including: climate, especially fluctuations in rainfall, sunshine and length of growing season, land use, large-scale ecosystem disturbances such as fires and the global increase in nitrate deposition and atmospheric carbon dioxide. To interpret NDVI trends in terms of land degradation or improvement, we have to eliminate false alarms, in particular those arising from climatic variability and changes in land use. Although the rainfall-adjusted greenness trend controls to some extent for the impact of rainfall variability, the global indicator is unable fully to distinguish between changes in NDVI resulting from land-use change and those resulting from land degradation as ordinarily understood. This can only be assessed by tracking time-series data for individual pixels, preferably at a higher resolution than the 8 km GIMMS data. Only when placed in the context of land use systems or land use changes, can NPP-related indicators provide an indication of where problems occur. This underlines the fact that there is a general lack of data on changes in land cover and land use, necessary correctly to interpret detected changes in NPP (Vogt J.V., 2011).[41]

[40] Wessels, K.J, S.D. Prince, J.Malherbe, J.Small, P.E. Frost D.VanZyl, 2007 Can human-induced land degradation be distinguished from the effects of rainfall variability? A case study in South Africa. Journal of Arid Environments 66:271–297.

[41] Vogt, J. V., U. Safriel, G. Von Maltitz, Y. Sokona, R. Zougmore, G. Bastin and J. Hill, 2011. Monitoring and assessment of land degradation and desertification: Towards new conceptual and integrated approaches. 2011. Land Degradation & Development, 22:150–165.

98. 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.

99. Despite the above-mentioned criticisms, the general approach of modelling NPP using a combination of satellite-based inputs and weather data is the only option for assessing vegetation production per unit rainfall across vast geographic areas (Vogt J.V., 2011).[42]

4. Agencies involved in the production of the indicator

100. The FAO is the lead agency.

101. Other contributing organizations include: UNDP Dryland Development Centre, UNEP, Consultative Group on International Agricultural Research (CGIAR), International Fund for Agricultural Development (IFAD) and World Soil Information (ISRIC).

5. References

102. See box 3 for some suggested readings and databases.

Box 3
References

Readings

Bai ZG, Dent DL, Olsson L. and Schaepman, M E. 2008 Global assessment of land degradation and improvement - 1. Identification by remote sensing. Report 5 2008/01, GLADA - ISRIC World Soil Information, Wageningen

Bai, ZG, Dent, DL, Olsson, L & Schaepman, ME. 2008. Proxy global assessment of land degradation. Soil Use and Management, 24, 223–234

Berry. L., E. Abraham, and W. Essahli. 2009. The UNCCD Recommended Minimum Set of Impact Indicators. Draft Report. Consultancy report (1) for the CST of the UNCCD. 99 pp. Available at: http://www.unccd.int/regional/rcm/docs/UNCCD%20Min%20Set%20of%20Impact%20Indicators%20Final%20Report%20June%204.pdf

JRC. 2010. Development of a new “World Atlas on Desertification”. Information available at: http://edo.jrc.ec.europa.eu/php/index.php?action=view&id=105

Shoshany, M. 2000. Satellite remote sensing of natural Mediterranean vegetation: a review within an ecological context. Progress in Physical Geography 24(2):153–178

Smith, M. O., S. L. Ustin, J. B. Adams, and A. R. Gillespie. 1990. Vegetation in deserts: I. A regional measure of abundance from multispectral images. Remote sensing of environment 31:1–26.

Squires,V.R, 2010 “The subset of UNCCD impact indicators - Land cover status.” Report prepared for the UNCCD, 38pp. Available at: http://www.unccd.int/science/docs/Report%20Land%20Cover%20Status%20-%20version%20for%20the%20web%5B1%5D.pdf

Tong, C., J. Wu, S. Yong, J. Yang, and W. Yong. 2004. A landscape-scale assessment of steppe degradation in the Xilin River Basin, Inner Mongolia, China. Journal of Arid Environments 59:133–49.

Verstraete, MM, CF Hutchinson, A Grainger, M Stafford Smith, RJ Scholes, JF Reynolds, P. Barbosa, A. Léon, and C. Mbow. Towards a global drylands observing system: Observational requirements and institutional solutions. 2011. Land Degradation & Development, 21:1–16. doi: 10.1002/ldr.1046

[42] See footnote 38.

Databases
VASClimO: http://apdrc.soest.hawaii.edu/datadoc/gpcc_1.htm; GIMMS: http://www.landcover.org/data/gimms/

IV. Conclusion and recommendation

103. The CST may wish to take note of the methodological guide contained in this document and to recommend that the COP request the secretariat to make it available in all United Nations languages and to publish it on the UNCCD website.