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FRAMEWORK AND GUIDING PRINCIPLES FOR A LAND DEGRADATION INDICATOR TO MONITOR AND REPORT ON PROGRESS TOWARDS TARGET 15.3 OF THE SUSTAINABLE DEVELOPMENT GOALS, THE STRATEGIC OBJECTIVES OF THE RIO CONVENTIONS AND OTHER RELEVANT TARGETS AND COMMITMENTS

Note by the Executive Secretary

1. The Executive Secretary is circulating herewith, for the information of participants in the twentieth meeting of the Subsidiary Body on Scientific, Technical and Technological Advice, the report of an expert meeting to develop a framework and guiding principles for a land degradation indicator and to facilitate a standardized approach to reporting progress towards Target 15.3 of the Sustainable Development Goals and Aichi Biodiversity Targets 5, 7, 14 and 15.

2. The expert meeting, held in Washington D.C., United States of America, on 24 and 25 February 2016, was jointly organized by the Secretariat of the United Nations Convention to Combat Desertification, the Secretariat of the Convention on Biological Diversity, the Food and Agriculture Organization of the United Nations and the Scientific and Technical Advisory Panel of the Global Environment Facility to provide an input to the work of the Inter-Agency and Expert Group on SDG Indicators.

3. The report is presented in the form and language in which it was received.

[*] UNEP/CBD/SBSTTA/20/1/Rev.1.

UNCCD
United Nations Convention to Combat Desertification

Convention on Biological Diversity

STAP gef UNEP
Scientific and Technical Advisory Panel Of the Global Environment Facility

DRAFT FOR CONSULTATION

Framework and Guiding Principles for a Land Degradation Indicator

To monitor and report on progress towards target 15.3 of the Sustainable Development Goals, the strategic objectives of the Rio Conventions and other relevant targets and commitments

Outcomes of the Expert Meeting

Washington, DC

2/26/2016

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While retaining the flexibility to use other data/information and ensuring national ownership, this *Framework and Guiding Principles for a Land Degradation Indicator* outlines how countries can apply a standardized approach to reporting SDG indicator 15.3.1 **(Proportion of land that is degraded over total land area),** one which focuses primarily on the use of three sub-indicators **(land cover and land cover change, land productivity, and carbon stocks above and below ground)**. This Framework is also relevant to other reporting mechanisms and processes, such as those of the Rio Conventions (UNCCD, CBD, and UNFCCC), FAO and GEF, for monitoring the status and trends in land degradation, restoration and carbon stocks.

When consistently applied, the proposed definitions and methodologies for deriving SDG indicator 15.3.1 are considered practical even when using multiple data sources in a possible tiered approach. While monitoring and reporting should be based primarily, and to the largest extent possible, on comparable and standardized national official data sources, this Framework outlines options for using Earth observation, geospatial information and other global/regional data sources in the absence of, or to complement and enhance, national data sources.

1.0 Background and Purpose

In the last five years, a number of global and regional targets and commitments have been agreed to by national governments to halt and reverse land degradation and restore degraded land. Starting in 2010, these include the Aichi Biodiversity Targets, one of which aims to restore at least 15% of degraded ecosystems; the Bonn Challenge and related regional initiatives (e.g., 20x20, AFR100) to restore more than 150 million hectares; and most recently the Sustainable Development Goals (SDGs), in particular SDG target 15.3 where Member States agreed to restore degraded land and soil, and achieve land degradation neutrality.

> *By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land-degradation-neutral world*

On 11 March 2016, the 47th session of the UN Statistical Commission approved a draft global indicator framework[1] intended for the follow-up and review of progress towards the SDGs at the global level. The indicator, proposed by the Inter-Agency and Expert Group on SDG indicators (IAEG-SDGs) for SDG target 15.3, is the "***Proportion of land that is degraded over total land area***" (referred to as SDG indicator 15.3.1). This initial global indicator framework will next be submitted to the Economic and Social Council (ECOSOC) and the UN General Assembly for adoption.

However, many countries currently lack the necessary methods, data and expertise to monitor and report on land degradation. Building capacity in this regard would help decision-makers identify the significant opportunities for the conservation, rehabilitation, restoration and the sustainable management of land resources. The purpose of this document, *Framework and Guiding Principles for a Land Degradation Indicator* (hereto referred to as the "Framework"), is to provide consistent definitions and the best available methodologies as well as global/regional data options for the three sub-indicators[2]

> **i) land cover and land cover change,**
> **ii) land productivity, and**
> **iii) carbon stocks above and below ground**

that could be used to derive the indicator for monitoring and reporting progress towards SDG target 15.3 as well as other relevant targets and commitments.

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[1] http://unstats.un.org/unsd/statcom/47th-session/documents/2016-2-IAEG-SDGs-Rev1-E.pdf

[2] Progress indicators adopted by the United Nations Convention to Combat Desertification (UNCCD) at their 11th Conference of the Parties in 2013
http://www.unccd.int/Lists/OfficialDocuments/cop11/23add1eng.pdf

1.1 Target Audience

The definitions and methodologies presented in this document are applicable when using data from multiple sources, including statistics and estimated data for administrative or national boundaries, Earth observation, surveys, assessments and other ground measurements. The primary target audience is those countries with the capacity to use national official data sources, including Earth observations, to monitor and report on the indicator for SDG target 15.3.

Using these definitions and methodologies for the three sub-indicators would help ensure the consistent representation of the indicator over time, and promote harmonization and comparability among countries. For those countries without national data sets or seeking to complement them, UN organizations, agencies and other relevant partners could assist the appropriate national offices in reporting on the indicator using global and regional data sets.

1.2 Rationale

By leveraging the existing reporting mechanisms of UN organizations and agencies, the three sub-indicators currently provide a practical approach to monitoring and reporting progress towards SDG target 15.3. In the absence of national data, Earth observation represents the next best way to measure land degradation over large areas even though it is clear that significant challenges remain. The production of comparative quantitative assessments and corresponding mapping over large geographical zones would help many countries to set policy priorities among diverse land resource areas as well as compare and transfer their experiences. This Framework for monitoring and reporting provides policy-relevant information that will help decision-makers to:

- plan actions of redress, including through the conservation, rehabilitation, restoration and sustainable management of land resources,
- address emerging pressures and stresses to avoid future land degradation, and
- enact more sustainable land management policies and land use planning.

This Framework also promotes consistency and comparability when using multiple data sources (in a tiered approach) and is meant to complement ground-based methods by:

- using accurate, objective, comparable, frequent and cost-effective data,
- providing information at a variety of scales (e.g., land cover, administrative unit), and
- ensuring national ownership without increasing reporting burdens.

2.0 Indicator Framework

The SDG indicator 15.3.1 and the sub-indicators used in this Framework are recognized as suitable metrics for monitoring and reporting on restoration, combatting desertification and achieving land degradation neutrality, the primary aims of SDG target 15.3. When contextualized with information at the national and sub-national levels, areas with declining productivity and carbon stocks may be considered degraded while areas with increasing productivity and carbon stocks may be considered improving. A typical exception is bush and tree encroachment (i.e., land cover change from grassland to shrubland) which is considered to be land degradation, even though land productivity and carbon stocks may both be increasing. Such an assessment of this type of exception (i.e., "false positive") requires knowledge and interpretation at the local level.

The measurement unit for SDG indicator 15.3.1 is the spatial extent (hectares or km^2) expressed as the proportion (percentage) of land that is degraded over total land area. This indicator can be mapped and disaggregated by land cover type and/or other policy relevant units, such as agro-ecological, bio-cultural or administrative.

For the purposes of this Framework and in the context of the 2030 Agenda on Sustainable Development, the following definitions, adopted by the United Nations Convention to Combat Desertification (UNCCD), are considered generic and well-accepted globally:

Land degradation is the reduction or loss of the biological or economic productivity and complexity of rainfed cropland, irrigated cropland, or range, pasture, forest and woodlands resulting from land uses or from a process or combination of processes arising from human activities.[3]

Land degradation neutrality is a state whereby the amount and quality of land resources necessary to support ecosystem functions and services and enhance food security remain stable or increase within specified temporal and spatial scales and ecosystems.[4]

These definitions are coherent with the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) Land Degradation and Restoration (LDR) assessment which defines degraded land as "the state of land which results from the persistent decline or loss in biodiversity and ecosystem functions and services that cannot fully recover unaided within decadal time scales".[5]

2.1 Data from Multiple Sources

Quality, accessible, timely and reliable disaggregated data will be needed to help with the measurement of progress towards many of the SDG targets. Data and information from existing reporting mechanisms should be used where possible. They should build on existing platforms and processes, and minimize the reporting burden on national administrations by exploiting the

[3] http://www.unccd.int/Lists/SiteDocumentLibrary/conventionText/conv-eng.pdf
[4] Decision 3/COP12 http://www.unccd.int/Lists/OfficialDocuments/cop12/20add1eng.pdf
[5] http://www.ipbes.net/sites/default/files/downloads/Decision_IPBES_3_1_EN_0.pdf

contribution to be made by a wide range of data, including Earth observation and geospatial information, while ensuring national ownership in tracking progress.[6]

In the absence of, or as a complement to, national data, this Framework strongly advocates that global and regional data sets must be contextualized with information at the national and sub-national level. The most common approach involves the use of site-based data to assess the accuracy of the sub-indicators derived from Earth observation and geo-spatial information. Another approach uses site-based data to calibrate and validate Earth observation indices and measures where the remote sensing variable is used to predict the same biophysical variable on the ground. A mix-methods approach, which makes use of multiple sources of information and combines quantitative and qualitative data, can also be used.

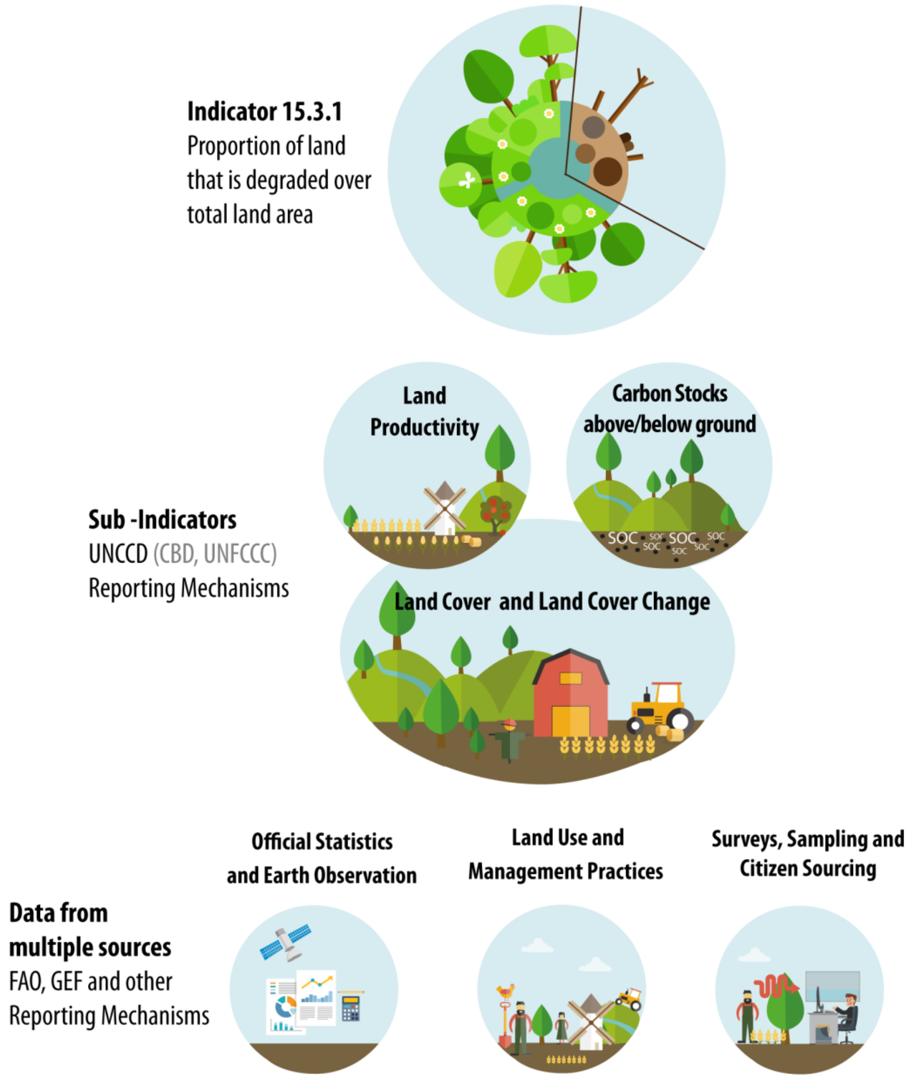
Stakeholder perspectives will play an important role in validating quantitative indicators. A range of methods exists to gather these perspectives, including surveys, workshops, in-depth interviews, consultations and the establishment of expert panels. These methods are often based on the principles of expert elicitation (i.e., the synthesis of opinions of technical and scientific experts). Ultimately, it is likely to be the task of the lead organization and its partners, who coordinate monitoring and reporting at national level, to interpret what this combination of quantitative and qualitative data reveals about land degradation and restoration trends.

[6] Resolution 70/1 adopted by the General Assembly on 25 September 2015
http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E

Framework for Monitoring and Reporting on SDG Target 15.3

Land Productivity refers to the biological productive capacity of the land, the source of all the food, fiber, and fuel that sustains humans. Land productivity can be calculated across large areas from Earth observation data on net primary productivity (NPP). Estimates of NPP, using vegetation indices, are influenced in the short-term by crop phenology, rainfall, nutrient fertilization and other variables which must be corrected for to accurately interpret trends. National authorities are best able to determine whether declining levels of land productivity are considered land degradation by taking into account local circumstances.

National Data is envisaged to be primarily used, to the greatest extent possible, to derive the sub-indicators and other relevant indicators and information at the country level, covering bio-physical, governance and socio-economic conditions as well as the status of land resources. National Data can be collected through existing sources (maps, databases, reports), including participatory inventories on existing land management systems and their characteristics



Carbon Stocks (Above and Below Ground) give an indication of the amount of carbon in living and decomposing biomass above and below ground, including soil organic carbon. Carbon stocks are elementary to a wide range of ecosystem services and reflect land use and management practices. These stocks, including for soil organic carbon, can be estimated by applying carbon density values from ground-based measurements or national inventories in conjunction with land cover maps derived from Earth observation data. National authorities are best able to estimate trends in carbon stocks that indicate land degradation by taking into account local circumstances.

Land Cover and Land Cover Change, most often derived from Earth observation, is a fundamental parameter that assists with the interpretation and stratification of the other two sub-indicators. It is also essential for monitoring and reporting on multiple SDG targets focused on natural resource management, food and water security, environmental health and rural/urban planning for sustainable development. For global comparisons, countries are encouraged to use standardized land cover classification systems. National authorities are best able to determine whether land cover change is considered land degradation by taking into account local circumstances.

UNCCD United Nations Convention to Combat Desertification
Convention on Biological Diversity
Food and Agriculture Organization of the United Nations
STAP Scientific and Technical Advisory Panel of the Global Environment Facility

2.2 Guiding Principles

The guiding principles in this Framework for monitoring and reporting on SDG target 15.3 are similar to the 2006 IPCC Guidelines[7] with regards to estimation methods at three levels of detail: from tier 1 (the default method) to tier 3 (the most detailed method). For example, one option would be the following:

Tier 1: Earth observation, geospatial information and modelling

Tier 2: Statistics based on estimated data for administrative or natural boundaries

Tier 3: Surveys, assessments and ground measurements

Each of the tiers may have a unique approach as to how driver (land management/use) and state (land resources) variables interact in a land degradation assessment[8] which depends primarily on the data and upscaling methods available. This approach would allow national authorities to use methods consistent with their capacities and resources. A decision tree would guide the selection of which tier to use for estimating the sub-indicators according to national circumstances, including the interpretation and availability of data.

From these guiding principles, more technical good practice guidance will need to be needed so that countries can:

1) Set Baselines to determine the initial status of the sub-indicators in absolute values. This would include: 1) the preparation of base land cover information which builds on standard land cover ontology (e.g., LCCS/LCML); 2) the establishment of a baseline for land productivity (e.g., NPP/NDVI); and 3) the establishment of a baseline for carbon stocks, above and below ground, with an emphasis on soil organic carbon below ground and building on the IPCC's work on carbon above ground.

2) Detect Change in each of the sub-indicators, including the identification of areas subject to change and their validation or evaluation by a participatory national inventory of land degradation, particularly where change in two or three of the sub-indicators coincide or overlap spatially.

3) Derive Indicator 15.3.1 by summing all those areas subject to change, whose conditions are considered negative by national authorities (i.e., land degradation) while using the Framework in their measurement and evaluation of changes within each sub-indicator and their combination.

4) Use National Data, to the greatest extent possible, to derive the sub-indicators and other relevant indicators and information at the country level covering bio-physical, governance and socio-economic conditions as well as the status of land resources. National data can be collected through existing sources (maps, databases, reports) and including participatory inventories on existing land management systems and their characteristics.

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[7] http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/0_Overview/V0_1_Overview.pdf
[8] http://www.fao.org/nr/lada/

As the sub-indicators will never fully capture the complexity of land degradation processes, there will always be a need for other relevant national or sub-national indicators, data and assessments to account for national circumstances and contexts. Ultimately, the expectation is that national capacities will be sufficiently increased so that each country can independently report on this indicator, as was envisioned in the UNCCD's Land Degradation Neutrality project.[9]

3.0 Definitions, Methodologies and Data Options

This section elaborates the definitions, methodologies and data options for the three sub-indicators that would enable global, regional and national bodies to derive a quantitative and spatially explicit (mapped) global indicator: "***Proportion of land that is degraded over total land area***".

3.1 Land Cover and Land Cover Change

Definition

Land cover refers to the observed physical cover of the Earth's surface which describes the distribution of vegetation types, water bodies and human-made infrastructure. It also reflects the use of land resources (i.e., soil, water and biodiversity) for agriculture, forestry, human settlements and other purposes.[10]

Meaning and Significance

Land cover is a fundamental land surface parameter that assists with the interpretation and disaggregation of the other two sub-indicators. Land cover change is also an important sub-indicator in its own right as it provides a first indication of a reduction or increase in the extent and degree of fragmentation in natural habitats/ecosystems as well as potentially adverse land conversions. Reliable land cover information has multiple applications for evaluating progress towards various SDG targets and is of crucial importance to: 1) understanding climate change and its impacts; 2) sustainable development; 3) natural resource management and land use planning; 4) biodiversity conservation; and 5) understanding of ecosystems and biogeochemical cycling.

The definition of adverse or desirable land cover changes is highly contextual and needs to take into account local ecological and socio-economic circumstances which require *in-situ* validation. However, at the most simple level, reductions and increases in particular land cover types could indicate progress towards land degradation neutrality. The area change, from one to another land cover type can indicate the loss of protective vegetative cover which may result from and further exacerbate land and soil degradation (e.g., natural forest to a plantation) or it can indicate improvements in land and soil protection or even restoration (e.g., agricultural to historical wetlands and forests).

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[9] http://www.unccd.int/en/programmes/RioConventions/RioPlus20/Pages/LDN-Project-Country-Reports.aspx

[10] http://www.fao.org/gtos/doc/ECVs/T09/T09.pdf

Changes in the distribution of vegetation types can provide a basis to identify high value areas for biodiversity and estimate changes in carbon stocks in biomass and soil, basic components of greenhouse gas inventories. Land cover change is understood as a significant driver of biodiversity loss and often alters the exchange of energy between the land and the atmosphere, affecting the concentrations of greenhouse gases. In general, land cover change modifies the quality and quantity of ecosystem services that directly benefit human society (e.g., provisioning and cultural services) as well as the less recognized supporting services (e.g., nutrient cycling) and regulating services (e.g., water purification) provided by both natural and managed ecosystems.

Finally, land cover is a primary input into mapping spatially-explicit land use types as well as the extent of biomes, ecosystems and habitats which assists decision-makers in the interpretation of the sub-indicators for land productivity and carbon stocks. Land cover and land cover change is thus an essential component for the assessment of trends in land degradation, restoration and carbon stocks as well as biodiversity, ecosystem services and resilience. This would help decision-makers to establish baselines and prioritize sustainable land management (SLM) and ecosystem restoration activities within and among land cover types. These activities would also help countries to sustainably intensify production activities and reduce the risk of future deleterious land cover changes that result in biodiversity loss, land degradation, increased emissions and reduced carbon sinks, and thus make progress towards the strategic objectives of the Rio Conventions (UNCCD, CBD and UNFCCC).

Methodology

Land cover and land cover change shows the distributions of major land cover categories and change over time. As with all SDG indicators, national reporting on land cover needs to be globally comparable. A consistently applied Land Cover Classification System (LCCS), based on a common ontology (i.e., the formal naming and definition of the types, properties, and interrelationships), can be derived from national data as well as global and regional land cover products that are available from Earth observation data sets.

Until now, land cover classes have been usually defined by country classification systems and are submitted to international entities that then need to harmonize national datasets and translate national land cover classes to a common global legend without losing information or detail. This can be very difficult if national land cover classes have been defined using fixed value ranges for a series of parametric values (e.g., cover, height). However, this challenge can be overcome if countries use the Food and Agriculture Organization’s (FAO) Land Cover Meta Language (LCML), an object-oriented land cover classification system that categorizes real world features with simple groups of elements that act as building blocks to describe the more complex semantic in any separate application ontology (legends). This LCCS/LCML is now being used by UN DESA to ensure consistent country reporting under a System of Environmental Economic Accounts (SEEA), and by the European Commission through the EU directive on spatial data and infrastructure (INSPIRE).

There are a number of options available for global and regional land cover data keeping in mind that an ideal data source is well-documented, of high quality, of high spatial resolution, thematically detailed, and available frequently, cheaply and consistently over at least two periods (e.g., 1990-2000, 2000-2010) in order to calculate land cover changes.

Global Data Options

While the choice of data sets will be a national decision, the criteria and basic requirements for harmonized methodologies and approaches are presented here. To the extent possible, global data sets should be freely available for open use, well documented in the scientific literature, made available in a consistent and calibrated non-stationary fashion, global in coverage, of a frequency of observation that is sufficiently dense to characterize seasonal and inter-annual dynamics, and consistent with spatial and spectral properties that enable the estimation of land degradation and restoration at national and sub-national levels. The three leading global data options that meet these criteria are:

1. The Food and Agriculture Organization's (FAO) has produced the GLC-Share database[11] which is the global reference layer for land cover endorsed by GEO, GEOGLAM, UN agencies, and NASA. It contributes to global land cover assessments through application of harmonization data fusion and standardization of various products[12] in accordance with the SEEA and LCCS.

2. The European Space Agency's (ESA) Climate Change Initiative Land Cover database[13] (CCI-LC) is available for three epochs centered around 2000, 2005 and 2010, and can be used to map land cover and analyze land cover changes. Version 2.0 is currently in preparation based on a reprocessing of all remote sensing data to provide annual land cover information till 2015 and this is expected to be completed in 2016.

3. GlobeLand30 refers to the land cover of the earth between latitude 80N to 80S. In 2010, China launched a Global Land Cover (GLC) mapping project, and finally produced this 30m GLC data product[14] with 10 classes for years 2000 and 2010 within a four year period.

Regional Data Options

1. Copernicus[15] is a European system for monitoring the Earth where data is processed to provide reliable and up-to-date information about six thematic areas: land, marine, atmosphere, climate change, emergency management and security. The pan-European component of Copernicus provides information about the land cover and land use (LC/LU), land cover and land use changes and land cover characteristics. The CORINE Land Cover is provided for 1990, 2000, and 2006, while the 2012 update is under production

[11] http://www.glcn.org/databases/lc_glcshare_en.jsp
[12] http://www.glcn.org/downs/prj/glcshare/GLC_SHARE_beta_v1.0_2014.pdf
[13] http://www.esa-landcover-cci.org/
[14] http://www.globallandcover.com/home/Enbackground.aspx
[15] http://land.copernicus.eu/

2. The mapping methodology[16] developed by the Sahara and Sahel Observatory (OSS) is based on the treatment of Landsat 5 and 8 data (2013, 2011 and 2009). The pre-processing phase included a set of operations consisting in making raw data fit to a thematic analysis. The Landsat images are produced, in most of the cases, with a radiometric and systematic geometric correction by integrating the control points and using a digital elevation model for a more topographical accuracy. When the data preprocessing implemented by the satellite data supplier is not adequate, a radiometric calibration could be applied by the project team, in a way that enables an efficient distinction between the land cover units.

National Data Options

For many countries, national land cover maps are available based on high resolution Landsat or SPOT-5 imagery. National land cover data are included in the UN-SPIDER database on data sources, which can be filtered by countries.[17] For many African countries, land cover data are available from FAO's Africover project.[18]

3.2 Land Productivity

Definition

Land productivity refers to the total above-ground net primary productivity (NPP) defined as the energy fixed by plants minus their respiration which translates into the rate of biomass accumulation that delivers a suite of ecosystem services.[19]

Meaning and Significance

Land productivity points to long-term changes in the health and productive capacity of the land and reflects the net effects of changes in ecosystem functioning on plant and biomass growth. Land productivity is also important for assessing changes in the carbon stocks of natural and managed systems, and thus their contribution to climate change mitigation efforts. Maintaining and enhancing the productivity of agro-ecosystems in a sustainable manner (SDG target 2.4) reduces the pressure for expansion and thus minimizes the conversion (loss) and degradation of natural ecosystems.

It is also essential to distinguish between land degradation resulting in long-term negative consequences, such as the persistent loss of ground cover due to overgrazing, or the one-time clearing of vegetation. Thus, a consultative approach is recommended for interpreting or validating estimates to address productivity changes in relation to land use objectives. For example, increased productivity in rangeland ecosystems can indicate shrub encroachment which in many regions is considered a land degradation process.

[16] http://www.oss-online.org/rep-sahel/index.php?lang=en&Itemid=139
[17] http://www.un-spider.org/links-and-resources/data-sources
[18] http://www.fao.org/geonetwork/srv/en/main.search?title=africover%20landcover
[19] http://www.millenniumassessment.org/documents/document.767.aspx.pdf

Methodology

Land productivity can be calculated from long-term time series of Earth observation data on net primary productivity to identify regions with declining greenness as an early warning of possible land degradation. Beyond trend measures, it is also possible to generate state measures of current greenness (in a five-year moving average) for monitoring and reporting.

Proxies to measure NPP, such as vegetation indices (e.g., NDVI), are influenced in the short-term by crop phenology, rainfall, nutrient fertilization and other variables which must be corrected for or processed to accurately interpret trends in land degradation and restoration. When using Earth observation data, the spatial resolution (ground resolution and image extent), spectral properties (number of bands, their width and location within the spectrum), temporal resolution (frequency of acquisitions) of the sensor, and annual variability also influence the vegetation features that can be detected.

Global Data Options

1. The Joint Research Centre (JRC) of the European Commission's Land Productivity Dynamics (LPD) dataset[20] has been derived from a 15-year time series (1998 to 2013) of global normalized difference vegetation index (NDVI) observations composited in 10-day intervals at a spatial resolution of 1 km.

2. NASA Vegetation Indices[21]: MODIS vegetation indices, produced on 16-day intervals and at multiple spatial resolutions, provide consistent spatial and temporal comparisons of vegetation canopy greenness, a composite property of leaf area, chlorophyll and canopy structure. Two vegetation indices are derived from atmospherically-corrected reflectance in the red, near-infrared, and blue wavebands; the normalized difference vegetation index (NDVI), which provides continuity with NOAA's AVHRR NDVI time series record for historical and climate applications, and the enhanced vegetation index (EVI), which minimizes canopy-soil variations and improves sensitivity over dense vegetation conditions.

3. ESA Vegetation Product[22]: The ESA vegetation product uses the VGT-S product, which takes into account some synthesis capability between successive orbits, either on the same day or on different days. Data is processed to extract the best possible measurement for a given period following carefully chosen criteria. Two types of standard products were defined: i) a daily synthesis (VGT-DS), with ground reflectance and NDVI computed from the ground reflectances; and ii) a 10 day period synthesis (VGT-PS) of NDVI maximum values.

4. The Copernicus Global Land Service contains a Normalized Difference Vegetation Index (NDVI) product[23], version 1 also known as GEOV1 NDVI [PUM-NDVI-V1], up to the end of the SPOT-VEGETATION mission (May 2014). This NDVI product is derived from directionally

[20] http://www.stapgef.org/stap/wp-content/uploads/2015/03/Michel-Cherlet-Remote-sensing-products-and-global-datasets.pdf
[21] http://modis-land.gsfc.nasa.gov/vi.html
[22] https://www.esa.int/SPECIALS/Eduspace_Global_EN/SEM6CFNW91H_0.html
[23] http://land.copernicus.eu/global/products/ndvi

corrected RED and NIR reflectances. The product is updated every 10 days, with a temporal basis for compositing of 30 days and delivered with a 12 days lag in Near Real Time (NRT).

3.3 Carbon Stocks (Above and Below Ground)

Definition

Carbon stock is the quantity of carbon in a pool (i.e., a system which has the capacity to accumulate or release carbon). Carbon pools are biomass (above-ground biomass and below-ground biomass), dead organic matter (dead wood and litter), and soil (soil organic matter).[24]

Meaning and Significance

Carbon stocks reflect the integration of multiple processes affecting plant growth and the losses/gains from terrestrial organic matter pools. These changes also reflect trends in soil health and ecosystem functioning as well as land use and management practices. Current carbon stocks are much larger in soils than in vegetation, particularly in non-forested ecosystems in the middle and high latitudes.

Methodology

Carbon stocks can be estimated by applying carbon density values from ground data or national inventories across land cover/vegetation maps obtained by Earth observation data. Spatial vegetation information from optical satellite sensors can be related to ground-based measurements to estimate carbon stocks. The IPCC provides a systematic approach for estimating carbon stock changes (and associated emissions and removals of CO_2) from biomass, dead organic matter, and soils as well as for estimating non-CO_2 greenhouse gas emissions from fire.[25]

On seasonal to decadal timescales, carbon stocks of natural and managed systems may be explained largely by changes in plant biomass ("fast variable") but, on longer time scales, soil organic carbon stocks ("slow variable") become a more relevant indicator of the functioning of the system, its adaptive capacity and resilience to perturbations (e.g., floods, drought), and thus its capacity to provide ecosystem services in a sustainable manner over the long term.

3.3.1 Soil Organic Carbon (SOC) Stocks

Definition

Soil organic carbon (SOC): a summarizing parameter including all of the carbon forms for dissolved (DOC: Dissolved Organic Carbon) and total organic compounds (TOC: Total Organic Carbon) in soils.[26]

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[24] http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_01_Ch1_Introduction.pdf
[25] http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_02_Ch2_Generic.pdf
[26] http://www.fao.org/3/a-bc607e.pdf

Meaning and Significance

SOC stocks are of local importance as they determine ecosystem and agro-ecosystem function, influencing soil fertility, water holding capacity and many other functions. They are also of global importance because of their role in the global carbon cycle and therefore, the part they play in the mitigation or worsening of atmospheric levels of greenhouse gases.

SOC (a proxy for soil organic matter) is an indicator of overall soil quality associated with nutrient cycling and its aggregate stability and structure, with direct implications for water infiltration, soil biodiversity, vulnerability to erosion, and ultimately the productivity of vegetation, and in agricultural contexts, yields. SOC stocks reflect the balance between organic matter gains (dependent on plant productivity and management practices) and losses due to decomposition through the action of soil organisms and physical export through leaching and erosion.[27]

SOC stocks are largely influenced by anthropogenic activities, such as land use change and management practices, which affect the productive potential of the soil. The SOC pool can be both a source and sink of carbon and thus fundamental to the estimation of carbon fluxes. Of particular relevance in the global carbon cycle are high carbon value ecosystems with organic soils such as peatlands and swamps.

Methodology

If countries have their own SOC data, they should ensure that analysis methods (i.e., depth) and measurement units (i.e., tons/ha) are standardized and fully documented. All new data should be compiled and shared in a consistent format and submitted to a central database so that digital soil mapping products such as SoilGrids may be regularly updated.

Regularly-updated global databases with spatially disaggregated information are not available to identify trends in SOC stocks. Therefore, a mechanism should be established through which SOC measurements derived from existing and emerging monitoring activities can be processed uniformly in a common server database[28] as quality-assessed input for automated digital mapping of changes in SOC stocks. Meanwhile, coarse estimates of SOC stock changes can be produced with the help of modelling techniques.

As part of its methods for greenhouse gas (GHG) inventories in the land sector[29], the IPCC offers a relatively simple approach to model stock changes in SOC, including a set of default values. It is a 3 tiered approach in which tier 1 foresees only the use of default values (no national data needed apart from area) whereas tier 2 and 3 require more detailed national or high resolution data. For estimations at the tier 1 level, the IPCC provides default reference values for SOC stocks under different climate/soil combinations for a reference depth of 30cm (see table 2.3 in IPCC 2006) as well as carbon stock change factors for different land use (6 IPCC land use/cover classes) and land management regimes. In the absence of

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[27] http://www.eoearth.org/view/article/156087/

[28] http://www.isric.org/data/wosis

[29] http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html

national data this allows for broadly estimating SOC changes on areas where land cover has changed. To a more limited extent, this approach also allows for estimating SOC changes on areas where the land cover class did not change but where there have been substantial management changes (e.g., restoration, irrigation, fertilization). This requires clear information on the spatial extent of the management practice.

<u>Global Data Options</u>

1. The International Soil Reference and Information Center (ISRIC) has updated the Harmonized World Soil Database (HWSD)[30,31] resulting in a database with higher resolution, more depth intervals and more parameters quantified. Currently a product is available with a resolution of 1*1km, containing SOC global estimates for different (adjustable) depth intervals. An entirely revised version will become available early 2016, with global SOC predictions at a resolution of 250*250m.

2. Under the Global Soil Partnership (GSP), the aim of Pillar 4[32] is to enhance the quantity and quality of soil data and information: data collection (generation), analysis, validation, reporting, monitoring and integration with other disciplines. The Global Soil Information System, which will be built under this Pillar, will also contain the monitoring of soil threats, among which soil organic matter is one of the most important indicators. It can be expected that the GSP will support countries to harmonize and more readily make national soil monitoring data available.

4.0 Deriving SDG Indicator 15.3.1

While there is no single indicator which could unambiguously report on land degradation and restoration, monitoring efforts are nevertheless feasible when considering a few sub-indicators in combination, given that they are measurable, compatible and faithful in capturing trends that are globally comparable. It should also be noted that the Essential Climate Variables (ECVs) proposed for observing land include land cover, albedo, leaf area index, fraction of absorbed photosynthetically active radiation, and above-ground biomass which can be measured with remote sensing.[33]

Good practice guidance for each of the sub-indicators would be essential to support countries in their measurement and evaluation of changes within each sub-indicator and their combination. By summing all those areas subject to change, whose conditions are considered negative by national authorities (i.e., land degradation), countries would be able to determine their pathway to deriving indicator 15.3.1.

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[30] http://webarchive.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/

[31] Batjes, N.H. 2016. Harmonised soil property values for broad-scale modelling (WISE30sec) with estimates of global soil carbon stocks. Geoderma 2016(269), 61-68.

[32] http://www.fao.org/globalsoilpartnership/the-5-pillars-of-action/4-information-and-data/en/

[33] http://remotesensing.usgs.gov/ecv/index.php

4.1 Building National Capacities

There are concerns about the ability of these sub-indicators to properly reflect the complex process of land and soil degradation. Even when the information that they provide is pooled, they still do not comprehensively address all quantitative and qualitative aspects of land degradation. Thus these sub-indicators can be regarded as a minimum set that would benefit from complementary metrics and indicators.

Likewise, monitoring should be accompanied by local and participatory initiatives that include a wide range of stakeholders. Participatory multi-stakeholder processes, taking into account traditional and local knowledge, are required to enhance the understanding of land degradation processes and their impact on local livelihoods. Linking global data to national data would thus blend a top-down with a bottom-up approach.[34,35] The ultimate goal should be to fully empower national authorities to regularly monitor and report on SDG indicator 15.3.1.

A transparent, country-driven process is required to apply the guiding principles of the Framework as outlined in section 2.2, including the use of multiple sources of data and information (e.g., Earth observation, statistical data, qualitative/quantitative surveys). For many countries, adequate capacity building can be achieved in a relatively short time frame. This would include:

- Data interpretation and validation at the national level using participatory approaches, when appropriate (e.g., for setting baseline and detecting change)
- The use of consistent methodologies and data sets over time
- Partnerships, technology transfers and capacity building required to use Earth observation data and geospatial information
- The use of data derived from the assessment of the sub-indicators to inform national land management and land use planning as well as international reporting.

4.2 Linkages within SDG Indicator Framework

This Framework would naturally link the monitoring of SDG target 15.3 to that of targets 2.4 (sustainable agriculture) and 15.2 (sustainable forest management) by providing useful information and mapping products for the evaluation of sustainable land (forest) management systems, their spatial extent and distribution as well as for integrated and sustainable land use planning at multiple scales.

The sub-indicators in this Framework are based on generally agreed upon definitions and methodologies that facilitate interoperability with other quantitative and qualitative indicators, including the SEEA. By using these sub-indicators to derive SDG indicator 15.3.1, countries would be able to complement and validate progress towards other SDG targets. In

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[34] http://www.iass-potsdam.de/sites/default/files/files/land_and_soil_indicators_proposal.pdf
[35] http://www.unccd.int/Lists/OfficialDocuments/cop11/cst2eng.pdf

this regard, the UNCCD is supporting the FAO in its efforts to refine and operationalize the indicators for:

- SDG target 2.4 which aims to "progressively improve land and soil productivity" using the indicator 2.4.1 "Proportion of land under productive and sustainable agriculture", and
- SDG target 15.2 which aims to "restore degraded forests and substantially increase afforestation and reforestation globally" using the indicator 15.2.1 "Progress towards sustainable forest management".

5.0 Work Plan

In order to operationalize this global indicator as defined in this Framework, further work is needed to provide a standardized approach and "good practice guidance" to derive the sub-indicators and help build monitoring and reporting capacities at the national, regional and global levels. A tiered approach, like that of the IPCC, would provide the structure of a future work plan and identify areas for priority attention. Good practice guidance would focus on:

- data collection, processing and interpretation, including the role of data of different spatial resolutions;
- the development of a land cover classification system that is consistent with other SDG indicators;
- the refinement of methodologies for estimating land productivity and carbon stocks, including establishing baselines and interfacing with ancillary data sources; and
- the production of quantitative estimates and mapping products.

In order to operationalize this global indicator, further work is needed to provide a standardized approach and "good practice guidance" to derive the sub-indicators and help build monitoring and reporting capacities at the national, regional and global levels. Significant work is now underway to develop a global partnership to train and build capacity at the national level, which for many countries can be achieved in a relatively short time frame.

The UNCCD, in close collaboration with the FAO and other relevant partners, would take the lead in compiling data for global reporting since i) the sub-indicators are already part of the UNCCD country reporting mechanism and ii) the UNCCD, with a number of funding and implementing agencies, is now building capacity in 60+ countries for implementing and monitoring SDG target 15.3. This role as custodian agency will include the development of "good practice guidance" for indicator 15.3.1 with well-defined methodologies and decision trees using a tiered approach to data use and validation.

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