VIEW FROM THE SKY

THE CONTRIBUTION OF EARTH OBSERVATION TO THE SUSTAINABLE DEVELOPMENT GOALS AND INDICATORS

POLICY BRIEF

The 2030 Agenda for Sustainable Development

On 27 September 2015, the United Nations General Assembly adopted the Agenda 2030 for Sustainable Development.

The 2030 Agenda is a plan of action for people, planet and prosperity. It builds on the progress made under the Millennium Development Goals, by extending the nature of the goals and recognising their interdependencies. The

2030 Agenda is a data and evidence driven agenda, containing a framework of 17 Sustainable Development Goals (SDGs) and 169 targets, supported by 232 indicators. Countries have been requested to define their own targets, guided by the global level of ambition, whilst taking into account their national circumstances and specificities.

This policy brief is a resource for National Statistical Offices (NSOs), and all stakeholders involved in the various international and national processes, linked to the production of data and statistics for the SDG indicators.

The Inter Agency Expert Group on Sustainable Development Goals

To enable countries to monitor their progress towards achieving the 2030 Agenda, the UN Statistical Commission endorsed in 2017 a Global Indicator Framework comprised of 232 indicators. The indicators are intended as a management tool for countries to implement evidence-based development strategies and report on their progress towards the SDG Targets, to the United Nations High Level Political Forum on Sustainable Development (HLPF).

The Inter-Agency Expert Group on the Sustainable Development Goals Indicators (IAEG-SDGs), was set up by the UN Statistical Commission with a remit to develop the Global Indicator Framework, to provide technical support for its implementation, and regularly review the methodological developments and the data availability. It is made up of representatives of NSOs from Member States and includes regional and international agencies as observers.

The SDG Monitoring Framework

The SDG monitoring framework underlines the importance for countries to set targets to demonstrate their commitment to the goals, in addition to regular and routine monitoring to evaluate progress in achieving them.

The ambitious nature of the indicator framework, committing countries to develop gender and spatially disaggregated statistics, represents a challenge for all countries, but especially low and middle-income countries. During the development of the statistical framework, countries identified a number of challenges. These included access to data, a lack of technical expertise and capacity in their NSOs, especially in processing geospatial data. Furthermore, the systems needed for production of disaggregated and multi-sectoral statistics were lacking.

BOX 1: The 17 Sustainable Development Goals (SDGs) of the 2030 Agenda

During its meetings, the IAEG has specifically referenced the need for streamlining efforts in data collection and reporting, improved access to the internet and a reliable electricity supply, investment in hardware and software, and capacity building.

Through the UN Statistical Division, the UN family established custodian agencies for each indicator to support the technical work of the IAEG and of countries in their delivery of data for the indicators. In addition, the UN Statistical Commission recommended that the UN's existing regional statistical mechanisms be used where possible to report on the SDG indicators. This should avoid duplication between the national, regional and global levels of reporting and reduce the reporting burden on countries. However, countries still require objective monitoring tools to complement these statistics and to assist them in their reporting at both national and regional scales.

Therefore IAEG has recognised the potential for geospatial information in defining some of the indicator methodologies. In particular, satellite-based Earth Observation (EO), although not yet fully exploited in indicator methodologies, has the ability to generate data that underpin reporting on a number of SDG indicators as will be demonstrated in this policy brief. There is thus an urgent need to increase awareness of EO products and EO-derived data which meet the requirements of NSOs and custodian agencies, and to highlight how these data can be used in the generation of national statistics and in their spatial disaggregation. Guaranteeing the supply of EO data and ensuring capacity to use such data through adequate resourcing, is thus a critical step in helping countries set SDG targets and routinely monitor progress.

IAEG-SDG Working Group on Geospatial Information (WGGI)

At its 3rd meeting in April 2016, the IAEG-SDGs formed a Working Group on Geospatial Information (WGGI) to help countries realise the full potential of geospatial information and Earth Observation in the Global Indicator Framework. This includes a technical guidance to NSOs on how to work with their counterpart mapping agencies in order to disaggregate spatially the indicators to have a far clearer picture of progress on the ground. To expedite its activities and ensure adequate geospatial and EO expertise, the WGGI benefits from a secretariat provided by the Global Geospatial Information Management (GGIM) section of the UN Statistical Division, and has amongst his members representatives from the UN Committee of Experts on Global Geospatial Information Management (UN-GGIM), the UN Global Working Group on Big Data for Official Statistics, the UN Expert Group on the Integration of Statistical and Geospatial Information (EG-ISGI), the Group on Earth Observations (GEO) and its EO4SDG initiative, and the Committee on Earth Observation Satellites (CEOS) and its Ad-hoc Team on SDGs.

Custodian Agencies

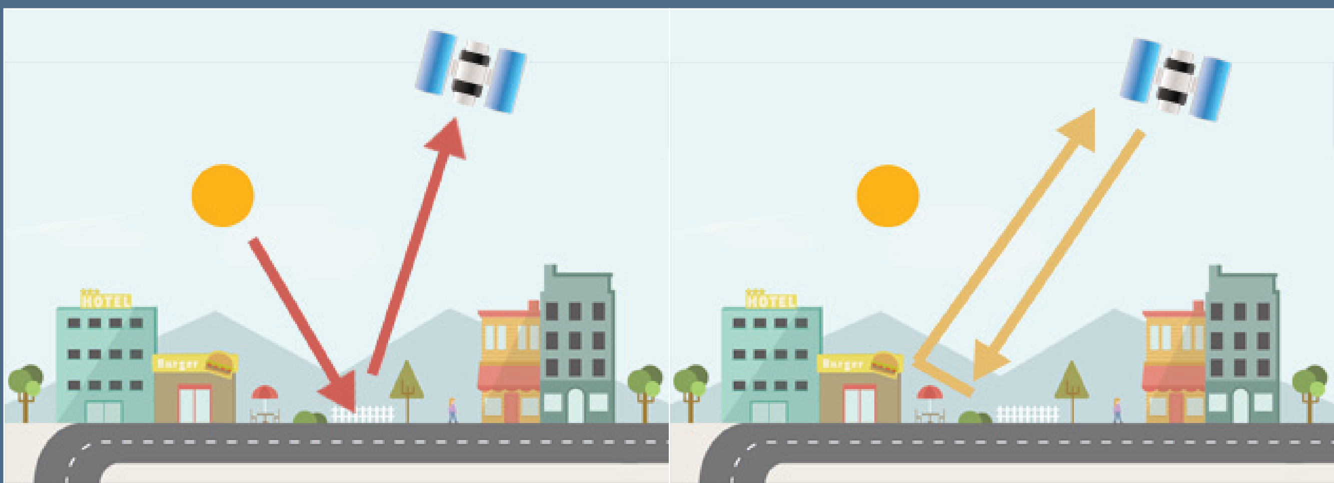
Custodian agencies are UN specialised agencies and programs (and in some cases other UN affiliated agencies), that have the mandate for defining the detailed indicator methodological guidelines for countries. The custodians have also the mandate to facilitate access to existing global and regional datasets than can complement national data. These datasets help countries to strengthen their national capacities to monitor and report on the indicators, and in some instances, to generate national, regional and global statistics. The custodians also assist in compiling and verifying country data and metadata, submitted to the United Nations Statistics Division (UNSD). Custodian agencies have a responsibility to support countries to generate the statistics and data required by the framework of indicators. The allocation of custodian agencies to the different indicators is based on their area of expertise.

EO potential and advantages for the SDG monitoring framework

EO from satellite remote sensing can help to meet the growing demand for bulk environmental information from the local to the planetary scale. Information derived from EO has the advantage to be less subjective than many other sources of data. With the expanding number of satellites with free and open data policies and global observation scenarios, EO can now be considered as a reliable, systematic and affordable source of monitoring data for countries to use in reporting on the SDGs. EO is also playing an important role in the wider context of technology development and Industry 4.0, a term coined to describe the current trend of automation and data exchange in manufacturing technologies but increasingly being used in the context of the transformation of information technologies by Big Data, cloud computing and artificial intelligence.

There are many features of EO capabilities that make it an indispensable source of data for a number of Sustainable Development indicators, and a supporting source of data for many others:

- **Objectivity:** Satellite observations derive from the satellite instrument's measurements. They exist within a known and controlled range of error, and are thus less susceptible to many of the biases detected in other measures of the same phenomena.
- **Repeatability:** The nature of satellite observations, being collected along a periodic orbit of the Earth's surface, means that they are repeatable and comparable over time.
- **Coverage:** EO satellites have a range of configurations which enable them to provide global coverage. In some cases, such as along near polar orbits, they can cover the entire planet in one cycle, however with some observational gaps at polar extremes. Gaps in coverage also occur where orbits do not overlap or in certain weather conditions. Nevertheless, observations can be retrieved over remote and inaccessible areas which would otherwise be difficult to monitor through ground-based techniques.



BOX 2: What is Earth observation?

Earth observation is an all-encompassing term for planetary scale, satellite observations of the Earth's surface and atmosphere. Satellite sensors gather information by remote sensing, collecting and analysing data about an object without the instrument used to collect the data being in direct contact with the object. Therefore satellite sensors observe the Earth remotely and in a synoptic fashion, gathering consistent and comparable information on a global scale. There are two major pathways to gather information remotely from space; (i) passively, where a sensor measures reflected sunlight emitted from the sun (left) or (ii) actively, where the sensor generates its own source of light or illumination (right). Source: www.gisgeography.com.

Sentinel-1, the first in the family of Copernicus satellites; Source: ESA

- **Data continuity:** The continuity of EO satellite data streams is an increasingly important aspect of their missions. Landsat is the longest running EO satellite program, while Copernicus demonstrates the European Commission's commitment to long term data continuity up until 2030 and beyond (see box 3). This allows the scientific community time to build experience with the systems, to develop and refine approaches for indicator methodologies with EO data
- **Affordable:** Along with the rise in the numbers of commercial satellites, there is also an increase in satellites, such as the Copernicus Sentinel missions, which have free and open access to data, thus making it affordable for countries to use these data for monitoring and progress reporting.
- **Thematic detail:** Satellite sensors can view the Earth's' surface and its atmosphere in ways the human eye cannot. Thus they can record unique information about its physical, biological and chemical nature and their changes.
- **Density of observations:** The number of EO satellites in operation and the sensors they carry are constantly increasing as space agencies and commercial operators respond to demand. This means that there are multiple sensors offering the same type of observations, which diminishes the risk for data gaps and improves the spatial and temporal coverage of observations.
- **Link to Industry 4.0:** The growing trend for automation and bulk data exchange, has given rise to the use of artificial Intelligence in industry and increasingly in civil society. Coupled with this trend is a demand for big data and machine learning to extract meaning from these data. EO, which itself generates large and complex datasets, is part of the emerging big data global architecture.
- **Link to Industry 4.0:** The growing trend for automation and bulk data exchange, has given rise to the use of artificial Intelligence in industry and increasingly in civil society. Coupled with this trend is a demand for big data and machine learning to extract meaning from these data. EO, which itself generates large and complex datasets, is part of the emerging big data global architecture.

In summary, EO provides a unique source of information for the production of national statistics at the various scales required for SDG monitoring and reporting. In addition to the technical benefits of EO, some programmes not only provide free and open access to EO data (see Box 3), but also to processing infrastructure for data analysis. Other geospatial data and statistics are becoming increasingly free and open, in line with the GEO principles of sharing of data, information, knowledge, products and services. These advances together with data cubes, which are simplified data structures that allow different types of geospatial data to be integrated with EO, are an important part of this data integration principle. In future, the principle of data integration and harmonisation will be key to the measurement of many indicators.

BOX 3: The European Commission's Copernicus and United States Geological Survey Landsat programmes

The Copernicus programme of the European Commission has made data from its Sentinel satellite programme (left) free for all. The United States Geological Survey liberated the vast archive of Landsat data in 2012 (right), dating from 1978 onwards, making it free for all to use.These progressive initiatives set a precedent for future data continuity from all EO programmes.

Images: Free and open EO data programmes: Sentinel 2 over Semarang, Indonesia (left) and operational Land Imager on Landsat 8 over Georgia, USA (right). Credit: ESA; USGS/NASA.

How many SDG targets and indicators can benefit from EO?

The contribution of EO to the SDG indicators was reviewed based on literature review and expert consultation. A "traffic light" system of red, amber, green (RAG) colours was applied across the indicator suite to flag EO relevance. The overall EO relevance was deduced from eight criteria describing the readiness and adequacy of EO to the indicator methodology (Table 1).

The final RAG ratings for each indicator were deduced by analysis of these criteria through scrutinising the available methodological guidelines and comparing them against expert opinion as well as available scientific literature. The final rating per indicator can be summarised as follows:

- **Green:** SDG Indicators for which EO has been identified as a main source of information, or would make a definite contribution to their methodological development
- **Amber:** SDG Indicators for which EO has not been currently identified as a source of information, but could potentially contribute
- **Red:** SDG indicators where EO cannot contribute to the indicator methodology

The results of this analysis, show that there are 17 green, 17 amber and 193 red indicators (not listed here for conciseness). A schematic of the 34 indicators in the green and amber categories is given in figure 1.

In order to facilitate the implementation of the global indicator framework, all indicators are classified by the IAEG-SDGs into three tiers. The tier classification and their definitions are described in BOX 4. Figure 2 illustrates the distribution of amber and green indicators by tier level as demonstrated by this analysis.

The EO contribution does not vary substantially by tier level, except for tier III indicators, where only 1 indicator currently stands to benefit directly from EO data (indicator 14.1.1 on coastal eutrophication and plastic debris). As EO continues to develop, efforts should be focused on those indicators where there is a definite contribution to be made (green), especially amongst the tier II and III indicators where methodologies are still under development. For example, there are 8 tier II and 1 tier III indicators (constituting 11% of tier II

Table 1: Criteria used to assign the RAG colours to assess overall contribution of earth observation to the indicator methodology

Readiness			
Maturity of earth observation technologies	Status of earth observation in indicator guidelines	Technical capacity required	Availability of global earth observation data
Adequacy			
Compliance with reporting calendar of indicator	Sensitivity to change	Is it scalable (spatial)?	Is there a substitute for gaps in the earth observation record?

1.5.2 Disaster damage
2.4.1 Sustainable agriculture
6.3.2 Ambient water quality
6.4.1 Water use efficiency
6.4.2 Water stress
6.6.1 Water-related ecosystems
7.1.1 Access to electricity
9.1.1 All-season roads
11.1.1 Informal settlements
11.3.1 Land consumption
11.6.2 Urban air quality
14.1.1 Coastal marine pollution
14.3.1 Ocean acidification
15.1.1 Forest areas
15.2.1 Sustainable forest management
15.3.1 Land degradation
15.4.2 Mountain green cover

1.1.1 International Poverty Line
1.2.1 National Poverty Line
1.4.1 Access to basic services
2.3.1 Agricultural productivity by sector
3.3.3 Malaria incidences
3.9.1 Mortality due to air pollution
4.a.1 School facilities
6.1.1 Safe drinking water
6.3.1 Safe waste water treatment
3.4.1 Diseases induced mortality
11.2.1 Access to public transport
11.5.2 Damage to infrastructure
11.7.1 Public access to green space
13.1.1 People affected by disasters
14.4.1 Sustainable fishing
15.1.2 Terrestrial biodiversity
15.4.1 Mountain biodiversity

Figure 1: Categorisation of the sustainable development indicators based on the identification of EO as a relevant data source; green: highly relevant; amber: potentially relevant.

indicators and 2% of tier III indicators) for which this analysis shows there is a direct contribution to be made from EO to the indicator methodology. These methodologies should be the focus of community efforts to integrate EO as much as possible in order to strengthen their methodologies.

In figure 3, the contribution of EO to each SDG (x-axis) is illustrated by the corresponding number of indicators within each SDG where EO can make a contribution to the methodology (y-axis). The proportion of green and amber indicators per goal is also illustrated.

Under the current indicator tiers (per 31 December 2018), Goals 6 (water), 11 (cities) and 15 (life on land), have been identified as having the most

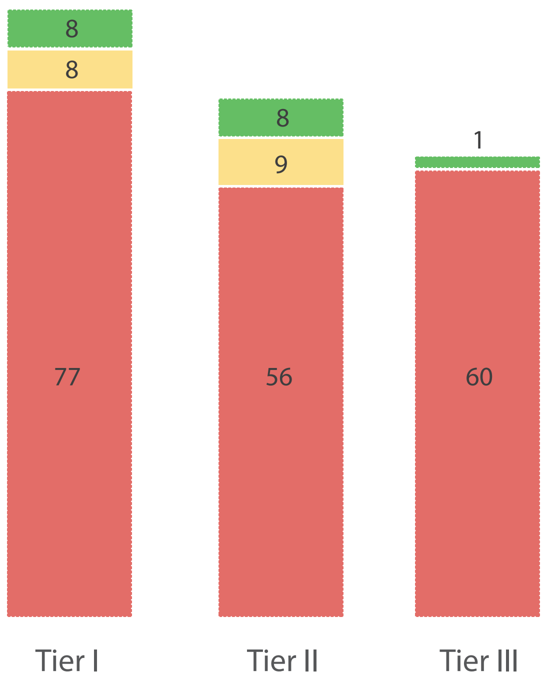


Figure 2: Contribution of EO to the SDG indicators, by tier level (x-axis) and number of indicators (y-axis) where EO has a definite (green), minor (amber) or negligible (red) contribution.

BOX 4: Tier Classification for Global SDG Indicators

In addition to defining the indicators for each target and goal, the IAEG have grouped the SDG Indicators into three different Tiers based on their level of data availability and methodological development. The tier classification criteria are described below.

Tier 1: Indicator is conceptually clear, has an internationally established methodology and standards are available, and data are regularly produced by countries for at least 50 per cent of countries and of the population in every region where the indicator is relevant.

Tier 2: Indicator is conceptually clear, has an internationally established methodology and standards are available, but data are not regularly produced by countries.

Tier 3: No internationally established methodology or standards are yet available for the indicator, but methodology/standards are being (or will be) developed or tested.

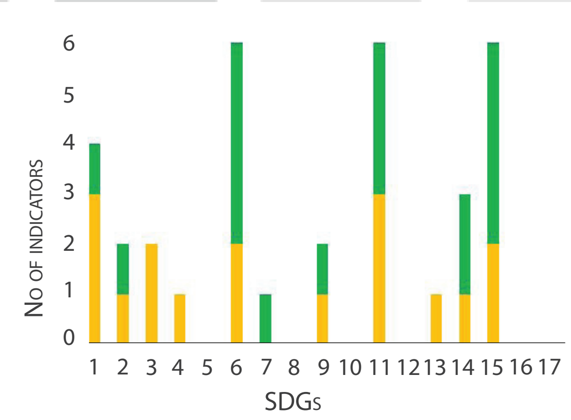


Figure 3: Contribution of Earth observation to the SDGs, illustrated by the number of green and amber indicators per goal where EO can contribute to the indicator methodology.

indicators which can benefit from EO, with 6 indicators each. The following goals have none: 5 (gender), 8 (decent work), 10 (inequality), 12 (consumption and production patterns), 16 (peace and justice) and 17 (Global Partnership). Of all the indicators, 15 Tier I and II indicators have published methodologies which explicitly mention EO approaches and data, while 18 published methodologies don't include EO as a source of information, while this analysis suggests there is potential to do so.

Case studies for selected targets

While this brief has so far examined the role of EO in supporting the Indicator Framework, EO also has a direct contribution to helping countries set their targets as well as planning for implementation. In terms of a supply of reliable and routine global observations, EO is a growing and increasingly important source that countries can use provided that they have access to the tools, capacity and expertise needed to integrate them with national statistics. As many SDG targets are more qualitative than quantitative, there is an opportunity for countries to set time bound targets in line with their level of national ambition, internal capacity and development needs. The following three case studies document examples of where EO can contribute to an SDG indicator under each target. There is one example each for water-related ecosystems (target 6.6), terrestrial ecosystems (target 15.3) and urban areas (target 11.1).

Coastline of Guinea-Bissau and the Bissagos island; Source: USGS/ESA

Earth observation for water-related SDGs

TARGET 6.6

INDICATOR 6.6.1: CHANGE IN THE EXTENT OF WATER-RELATED ECOSYSTEMS OVER TIME

By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes

With the advent of high performance cloud computing infrastructures and data analysis techniques, complex environmental monitoring problems are beginning to be solved with EO data. Below are two examples of regularly produced global datasets on the extent of water related ecosystems which can directly support countries in their reporting requirements for SDG 6.6.1 (extent of water-related ecosystems). These are regularly updated and continuous data products at high spatial resolution (30m). They can also be used by countries for planning at the national and sub-national levels, and at the scale of the water catchment, to establish baselines of water-related ecosystem condition, and therefore to set targets for the protection of wider water catchments.

The Global Surface Water Explorer – an example of EO for SDG 6.6.1

An important element of SDG 6.6.1 is the extent of open surface water. The Global Surface Water Explorer (GSWE), produced by the European Commission's Joint Research

Centre (JRC), has mapped the extent of the world's surface water including their temporal dynamics over the last 32 years. The 30m resolution water products within the Explorer tool could have a wide range of uses in the SDG framework, not least for indicator 6.6.1 where it is now the official indicator methodology for global sub-indicator 1 on the spatial extent of water-related ecosystems. The global sub-indicator is based on globally available data from earth observations which will be validated by countries against their own methodologies and datasets. In addition to directly supporting SDG 6.6.1, the GSWE supports applications other SDG targets including sustainable management of water and sanitation (target 6.6.), biodiversity conservation (target 15.3) and food security (target 2.4). However Indicator 6.6.1 benefits directly from the information contained in the GSWE. Examples of the surface water occurrence and transitions maps produced by the Explorer tool are shown in Figure 4.

Global Mangrove Watch – an example of EO for SDG 6.6.1

The SDG 6.6.1 requests countries to report on the extent of water-related ecosystems over time, which includes vegetated wetlands. One of the most important vegetated wetlands in the Tropics is mangrove. A time-series of maps of the global mangrove extent has been generated within the framework of the Global Mangrove Watch (GMW) project, based on 25-meter resolution global satellite mosaic data from the Japanese radar satellites (JERS-1, ALOS and ALOS-2), and combined with optical (Landsat) satellite data (Figure 5). As of November 2018, maps for seven annual epochs have been produced: 1996, 2007, 2008, 2009, 2010, 2015 and 2016 (and with 2017 foreseen to be completed in 2019). By comparing maps from different years in the time-series, the corresponding change maps can be derived. Indicator 6.6.1 measures change in the extent of water-related ecosystems over time and it focuses on 3 categories of water-related ecosystems: lakes, rivers and estuaries, artificial water bodies and vegetated wetlands. The Global Mangrove Watch data can make a major contribution to the vegetated wetlands category as mangroves represent some of the most significant wetland areas in the Tropics. In addition to reporting on change in wetland extent, mangrove extent maps can be used for reporting on the Nationally Determined Contributions under the Paris Agreement and the UN Reducing Emissions from Deforestation and forest Degradation scheme (REDD+) under the UN Framework Convention on Climate Change.

Figure 4: An example of GSWE data for the Kahan River Delta, North Kalimantan, Indonesia. [Left] Surface Water Occurrence shows where surface water occurred between 1984 and 2015 and provides information concerning overall water dynamics; [Right] Transitions map provides information on the change in surface water seasonality between 1984 and 2015 and captures changes between the three classes of not water, seasonal water and permanent water. Source: EC JRC/Google.

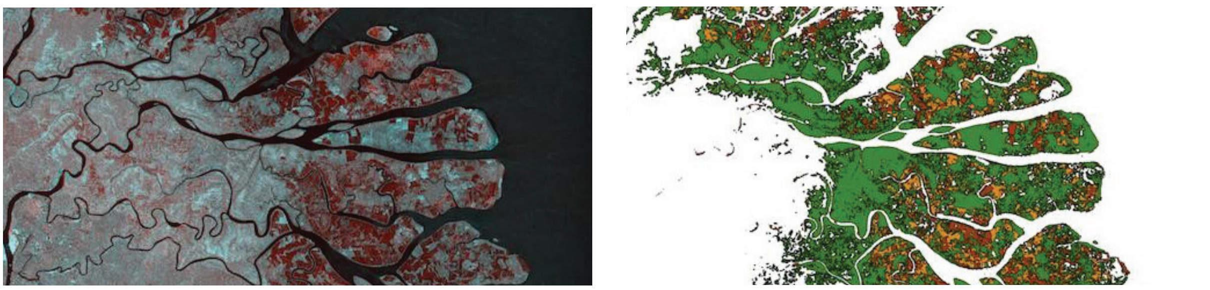


Figure 5: An example of GMW data for the Kahan River Delta, North Kalimantan, Indonesia. [Left] Multi-temporal radar image composite (1996 JERS-1 SAR and 2016 ALOS-2 PALSAR-2); [Right] Global Mangrove Watch extent and change map; Red – mangrove loss 1996-2007; Orange – loss 2007-2016; Green – mangrove cover in 2016 (Satellite image copyright JAXA/METI).

EARTH OBSERVATION FOR LAND-RELATED SDGs

TARGET 15.3

INDICATOR 15.3.1: PROPORTION OF LAND THAT IS DEGRADED OVER TOTAL LAND AREA

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

Trends.Earth – Monitoring land change using earth observations

Trends.Earth, developed by Conservation International in corporation with NASA and Lund University, under funding of the Global Environment Facility, is a tool to integrate national level data with globally available EO datasets to calculate SDG indicator 15.3.1 (proportion of degraded land). It is based on standardised methods, while also providing the flexibility for customisation to local conditions. The tool uses data from three sub-indicators –land cover, vegetation productivity and soil organic carbon - to estimate the degraded land area

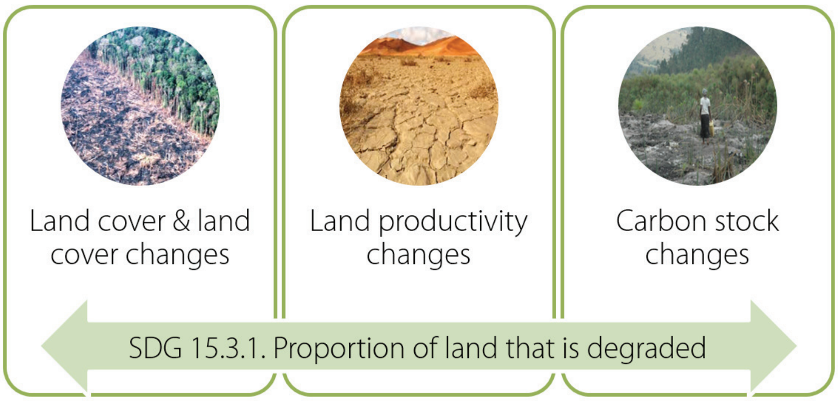


Figure 6: Overview of the SDG 15.3.1 Sub-Indicators

and is able to produce spatial explicit information (Figure 6).

For each Sub-indicator, changes have to be assessed and depicted as (i) positive or improving, (ii) negative or declining, or (iii) stable or unchanging. Based on the evaluation of the changes in these three sub-indicators, the proportion of land that is degraded over total land area (%) is calculated and reported as a binary (i.e. degraded/not degraded) quantification as required by SDG target indicator 15.3.1.

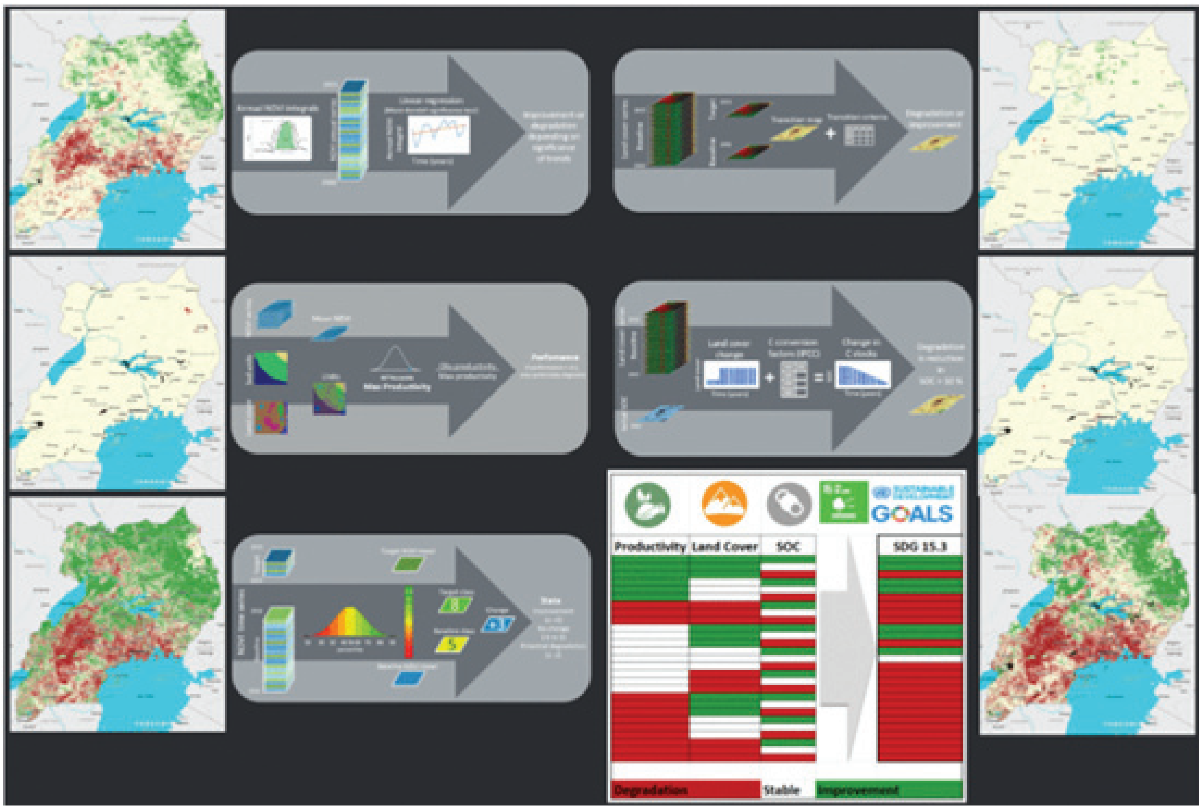


Figure 7: Schematic illustration of Trends.Earth processing and results for a case study in Uganda

The quantification follows the so called "One out all out" (1OAO) principle. That is, if one of the sub-indicators is negative (or stable when degraded in the baseline or previous monitoring year) for a particular land unit, then the particular area would be considered as degraded. The baseline is established over the period 2000 to 2015, with the base year being 2015. All changes are assessed relative to the baseline value with a reporting interval of 4 years, starting in the year 2018. The land degradation assessment is illustrated in Figure 7.

Earth team, as of November 2018, has trained over 400 people – from representatives of national statistics offices and ministries of environment, to academic and non-profit users – on how to use the tool for reporting purposes.

The method for calculating SDG indicator 15.3.1 is extensively described in the Good Practice Guidance (GPG) developed by the custodian agency, the United Nations Convention to Combat Desertification (UNCCD). In collaboration with UNCCD, the Trends. Earth team, as of November 2018, has trained over 400 people – from representatives of national statistics offices and ministries of environment, to academic and non-profit users – on how to use the tool for reporting purposes.

Earth observation for urban-related SDGs

TARGET 11.1

INDICATOR 11.1.1: PROPORTION OF URBAN POPULATION LIVING IN SLUMS, INFORMAL SETTLEMENTS OR INADEQUATE HOUSING

By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums

Predicting slum dwellers' deprivations from space: a pilot study in Dhaka (11.1.1)

One of the most pressing development challenges is how to respond to the unmet demand for basic infrastructure services, like adequate housing, clean water, and sanitation, for the 1 billion people living in informal settlements. One of the main difficulties to improve their housing standards is the lack of adequate spatial data for planning.

In response to this challenge, in 2017 the World Bank Group Water Global Practice launched the "Improving Access and Sustainability of Water Supply and Sanitation Service Provision in the Context of Rapid Urbanization" umbrella, a pilot study in Dhaka (Bangladesh), a city particularly challenged due to congestions, poor infrastructures and regular flooding. The main objective was to create an analytical tool to support decision-making leading to improved pro-poor policy interventions. The project was conducted through a collaboration between GP Water Supply and Sanitation Global Solutions Group, the WASH Poverty Diagnostic team in Bangladesh, the remote sensing service company GISAT, a member of an EO4SD Urban consortium working for the European Space Agency (ESA), and researchers from the University of Massachusetts (UMASS).

As part of this project, a novel, predictive model combining spatial characterization analysis, with statistical modelling to identify and delineate informal settlements and characterize informal settlement deprivation, was devised and tested. Two sources of data were combined: very high resolution EO data and analytics of informal settlements for the whole Dhaka Metropolitan area, and an in-depth household survey conducted in 2016 (Figure 8). Multiple variables derived from EO data were found to be statistically significantly associated with measures of deprivation based on the UMASS' Slum Severity Index model. For example, distance to Central Business Districts, arterial roads, average dwelling size, percentage of informal, local primary, secondary and tertiary streets in informal settlements, were found to increase the relative risk of overall deprivation. The results from this analysis, because of their potential ability to predict future scenarios, will be able to support the development of inclusive policies and targeted planning interventions to help populations living in informal settlements. Despite promising results the approach is still experimental and the model transferability is being tested on other cities.

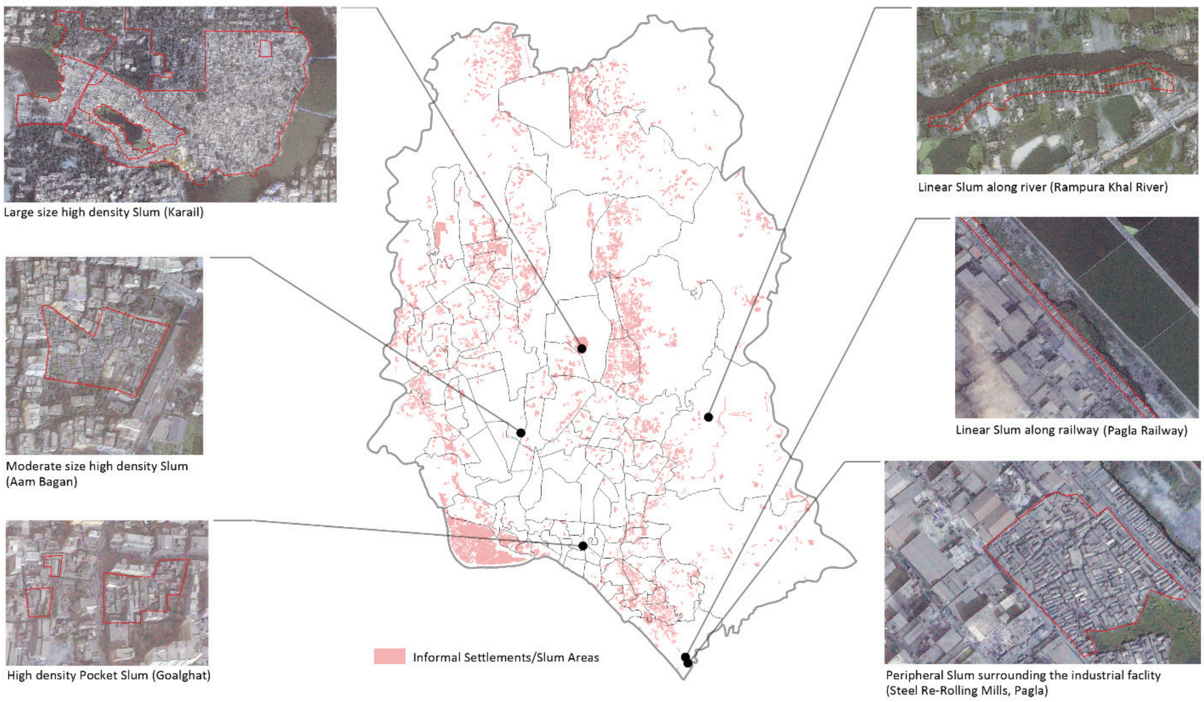


Figure 8: World Bank Group Water Global Practice launched a novel, predictive model based on satellite EO, combining spatial characterization analysis, with statistical modelling to identify and delineate informal settlements

Barriers to the use of EO in indicator methodologies and for target setting

The 2030 Agenda for Sustainable Development is a country-led process. The Global Indicator Framework throws up new challenges and creates an impetus for countries to put data at the forefront of national planning and sustainable development policies. It has been encouraging to see the speed and enthusiasm shown especially by low income countries to grasp the opportunities that EO provides to support policy making and target setting. For example, EO have been used in planning afforestation programmes, the use of marine resources and developments along the coastal zone; others have encouraged citizens to participate in data collection using geolocations from EO.

In many countries EO is not systematically used for target setting or monitoring progress; its full potential has yet to be realised in the development of sustainable development indicators. However, there are genuine barriers to the use of EO and geospatial data more broadly in the generation of national statistics, and for progress reporting. The first concerns the fundamental nature and accuracies of EO data itself, when compared with data collected through household surveys. Improvements in accuracy are expected however with the advent of higher resolution satellite sensors and more advanced. The second concerns the data access difficulties faced due to lack of resources to process and store data. However, there are efforts to offer cloud computing solutions. Cloud services offer countries access to vastly more powerful computing infrastructure, being available on demand without direct active management by the user.

There are also barriers related to the lack of a statistical infrastructure in the majority of countries which allow the seamless integration of multi-sectoral statistics for SDG reporting. While EO would not necessarily be a direct solution to the problem, spatial data infrastructures to process national EO data could also be the foundation for statistical infrastructures. Helping countries to build such infrastructures could help address poor information flows across sectors. Even with the appropriate infrastructure, middle to low income countries should still be financially supported in accessing very high spatial resolution EO data from commercial providers. In comparison, NSO outputs appear outdated and lack spatial accuracy. These barriers need to be carefully considered and addressed, in order to facilitate the uptake of EO for SDG monitoring among countries.

EO can make a significant contribution but it is not the panacea for all environmental SDGs

There has been a tendency to assume that EO has all the necessary solutions to deliver the data for the main environmental SDGs (6, 9, 11, 13, 14,

and 15) particularly as the number of publicly-funded satellites in operation with free and open data policies, continues to increase alongside an overall increase in the wealth and diversity of EO data. However, current indicator definitions and their computational methodologies do not generally allow for a seamless integration of Earth Observations hence their potential contribution to SDG indicators has not been fully exploited.

There are technical limitations that persist due to the physical nature of how satellite-based sensors perform their measurements (e.g. optical sensors such as Landsat or Sentinel-2 cannot see through clouds). However, the high revisiting time of new satellite optical sensors (such as the 5 days of Sentinel-2), combined with the development of multi-sensor approaches, is now helping to solve this problem. There are also limitations to sensor performance in some ecological settings, e.g. coastal and shallow waters present many challenges for accurate measurement of water parameters such as chlorophyll concentration. The lack of comprehensive and historical EO data also means that significant efforts need to be made to align EO data with historical baselines of some indicators, particularly those with pre-2000 baselines. Nevertheless satellite Earth Observation is still the only means to provide a comprehensive and contemporary picture of Earth surface change. New and creative ways are being found to link contemporary EO with historical baselines, e.g. though national airborne imaging surveys and citizen science observations.

While gaps in EO coverage, e.g. due to sensors not recording, or where and when coverage is sparse, were previously a barrier, they are becoming a thing of the past as the European Commission's Copernicus Program has data continuity as its core objective. This means that its Sentinel satellite missions are designed to minimise any data gaps and to provide continuity with other missions, e.g. Landsat 8.

Finally, assessing the accuracy of EO–derived datasets – important to comply with the statistical rigour required for

SDG reporting – is improving, e.g. as seen by efforts to use citizen science to assess accuracy of global land cover maps through the Geo-Wiki initiative. The EO community is therefore becoming more actively involved in accuracy assessment and validation efforts. Furthermore, efforts to support the NSOs, and the custodian agencies, to develop the tools to integrate EO with other sources of data will assist in accuracy assessment and gap-filling efforts.

Information flows need to be improved to inform SDG related decision making

The flow of environmental information from EO into geospatial datasets, indicators and ultimately into the hands of policy makers in decision-making fora, can be further streamlined. This will support NSOs and agencies within countries to use EO more widely. Although custodians have issued methodological guidelines, the information needs to flow seamlessly at the country level if EO as well as other forms of geospatial data, are to be integrated into country processes and systems. Without a logical architecture and consensus on information flows, there will be potential bottlenecks, e.g. where information is exchanged between government ministries or from private to public sectors within countries. Policy-makers continue to need institutional and technological support from Intergovernmental

Organisations such as the UN, through capacity building amongst the NSOs and agencies in using EO. Up-skilling is needed on the demand-side by improving EO literacy, and outlining how policies can benefit from EO. In countries where this has happened, investment has successfully taken place on both the technology and the human development side.

Partnerships between NSOs and EO experts need to be strengthened

There should be stronger collaboration between NSOs and EO experts, to enable the potential of satellite data to be fully realised within the statistical system. New and old ways of thinking need to be combined for a more complete integration of EO with statistics, as part of the end-to-end information flow to decision makers. In many countries the statistical agencies, mapping and remote sensing experts sit within different parts of government. The establishment of national remote sensing centres could be a first step in linking EO data with national data requirements. Creating partnerships amongst the different agencies and departments is a second step to building an effective collaboration. The involvement of many SDG stakeholders in the process of data and information gathering for the SDGs is also key. New partnerships, focused on Agenda 2030, need to combine both the public policy and private agenda, to ensure greater streamlining. This is important as EO is becoming increasingly relevant for private and public sector decision-making in environmental matters.

Very high resolution EO is in the commercial domain

Although countries are beginning to invest in commercially sourced datasets for national and sub-national uses, there is still a barrier to using EO where it is really needed on demand, e.g. in informal; settlement mapping for indicator 11.1.1. Brokering data access agreements between the commercial sector and private companies in countries with the ministries responsible for SDG reporting, could be a potential solution to greater access to such data. Further efforts should be taken to facilitate access to commercial data in low to middle income countries where costs for commercial data can be prohibitive.

The way forward

There are several immediate, clear and practical steps that can be taken to join the efforts of the EO community, NSOs and the custodian agencies in realising the potential of EO for Agenda 2030 and particularly in supporting the indicator framework.

Elevating tier II and tier III indicators with EO

As of December 2018, there were still 73 tier II indicators, which means indicators where access to data is still an issue. Of these, EO could support 17 of the suggested methodologies. This analysis demonstrates that 8 of these could be directly supported by EO, while a further 9 could be partly supported. With concentrated efforts to support these indicator custodians to integrate EO for improved methodologies, any of these indicators could potentially be upgraded to tier I. The same holds true for the one remaining tier III indicator methodology (14.1.1) which could be upgraded with further EO support and technical development.

EO Enabling Infrastructures

Discussions on new and innovative geospatial data infrastructures are key to realising the potential of EO, especially given the volume and complexity of EO data now being produced. Some of the main enabling infrastructures are described below.

The European Copernicus Programme has deployed five cloud-based platforms known as Data and Information Access Services (DIAS). The DIAS are funded by the European Commission to facilitate access to Copernicus data and services, including the Sentinel data, as well as to on-line EO data processing and analytic tools.

The ESA Thematic Exploitation Platforms provide collaborative virtual work environments with access to EO data and tools, processors, and Information and Communication technology (ICT) resources required to process and analyse vast amounts of environmental data in a seamless and cost effective way. There are TEPs for coastal, forestry, geohazards, polar, urban, hydrology, and food security thematic areas.

Google Earth Engine, a cloud-computing platform for global-scale Earth Observation data and analysis, which has been used for the generation of a number of global datasets that are used to complement national data.

Data cubes are multi-dimensional arrays of stacked, image data, aggregated from a variety of sources but standardised and harmonised to be analysis ready, i.e. to be used in further analysis with minimal effort. Data cubes are deployed on the cloud for efficient, on-demand data processing. The production of Analysis Ready Data (ARD) will significantly reduce the burden on countries by minimizing the time and scientific knowledge required to access and prepare the EO inputs. The principle of provision of ARD is a key asset of the data cube, and is being used to support multiple users working on the Paris and Sendai Agreement in addition to the SDGs.

These Big Earth Data Infrastructures have some key advantages for SDG indicators, not least that they enable the processing and analysis of large EO data sets in combination with non-satellite data. However they still require technical capacity and expertise to use.

The strength of partnership

Having the technical infrastructure for EO data provision and analysis in place and improving national capacities to use it, can benefit from the appropriate data and information and supporting governance structures.

For example, in Mexico there is a national council for Agenda 2030, which involves all actors, supported by a Committee specialising in SDG indicators. Without such mechanisms in place, EO data, as well as other types of data used in SDG monitoring will remain fragmented, risking duplication of effort. These coordination mechanisms must also recognise the right of citizens to interact with statistical information, and be a part of the big data drive. Non-traditional data sources such as citizen science, are important in some countries for the collection of in situ data for validation, in addition to the dissemination of EO data for SDG indicators.

Conclusion

The number and diversity of satellite EO missions can provide unprecedented insights into national scale environmental change. The EO revolution will change how we assess trends, track progress at the local and national scale on sustainable development. This is despite some barriers, especially those related to raising the level of technical knowledge within user partnerships, as well as open access and equitable data sharing.

If we are to fulfil the commitment at the heart of the SDGs – to leave no one behind – the process needs to be carefully guided, data access democratised and expertise shared.

On a practical level, this policy brief illustrates the scale of work that remains to elevate the tier status of almost 10% of the SDG indicators – those that are in need of an accepted methodology and where EO can help custodian agencies in that effort. However even where there are indicators with agreed methodologies, there are also data issues where EO can help. Countries will continue to require support from experts in the implementation of EO-based methods. Although this may become easier with advent of big data analytics platforms, the human element will remain crucial for the foreseeable future.

Further information

- GEO/CEOS (2017) Earth Observations in support of the 2030 Agenda for Sustainable Development. Available at: eohandbook.com/sdg
- GEO (2019) GEO Earth Observations for the Sustainable Development Goals (EO4SDG). Available at: eo4sdg.org

DISCLAIMER

TITLE

View from the sky – the contribution of Earth observation to the Sustainable Development Goals and selected indicators

PUBLISHED

March 2019

AUTHORS

Brian O'Connor (UNEP-WCMC)

Hilary Allison (UNEP-WCMC)

REVIEWERS

Franziska Albrecht (GeoVille)

Marc Paganini (ESA)

Jacqueline McGlade

Henrik Larsen (UNEP-DHI)

LAYOUT

Maria Lemper (GeoVille)

esa

This project has received funding from the European Space Agency under Contract No 4000123494/18/I-NB.

PROJECT PARTNERS

UNEP DHI

UN environment WCMC 40 years

GeoVille

DHI GRAS

VIEW FROM THE SKY

THE CONTRIBUTION OF EARTH OBSERVATION TO THE SUSTAINABLE DEVELOPMENT GOALS AND INDICATORS

POLICY BRIEF