Specifications of land cover datasets for SDG indicator monitoring

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A paper prepared by the Global Observation for Forest Cover and Land Dynamics (GOFC-GOLD) Land Cover Project Office at Wageningen University, an invited expert member of the working group on geospatial information of the Inter-agency and Expert Group on Sustainable Development Goals Indicators (IAEG-SDGs). This paper was reviewed by members of the working group before being made available to IAEG-SDGs at its ninth meeting in March 2019.

Contents

Context

The Inter-Agency and Expert Group on Sustainable Development Goals Indicators (IAEG-SDGs) Working Group on Geospatial Information (WGGI) addresses the use of geospatial information for measuring and monitoring the SDGs by critically analysing and providing recommendations on guidelines to better include Earth Observations in the SDG monitoring methodologies. Additionally, the group is enhancing partnerships with Space Agencies active in the Group on Earth Observations (GEO) for the Sustainable Development Goals (EO4SDG) initiative. This initiative has a number of mechanisms to support EO integration in SDG monitoring including pilot projects at the national level, capacity building on established methodologies, and identification and the development of data as well as information to advance understanding and access to EO resources. By partnering with space agencies, requirements from the users can be communicated to the data providers, and also EO derived products can be made available, and recommended for use.

This paper has been prepared by the Global Observation for Forest Cover and Land Dynamics (GOFC-GOLD) Land Cover Project Office at Wageningen University, an invited expert member of IAEG-SDGs: WGGI, for the working group. GOFC-GOLD is a coordinated international effort working to facilitate the ongoing space-based and in-situ observations of the land surface for the sustainable management of terrestrial resources and to obtain an accurate, reliable, and quantitative understanding of the terrestrial carbon budget.

This paper compliments the discussion paper: 'Global and Complementary (Non-authoritative) Spatial Data for SDG Indicators Reporting: Role and Utilisation', prepared by IAEG-SDGs WGGI Task Team (IAEG-SDG WGGI 2018), which highlights the need to develop and promote the utilization of global data, which can inform SDG indicators. This paper specifically sets out to assess the status of core datasets that are useful for SDGs, and to derive and communicate policy-driven user requirements with data providers.

This document intends to provide information on the EO contribution to the SDG Indicators, with a focus on **land cover datasets**. The aim will be to assess which and how land cover maps are proposed for use in the indicators, identify other land cover datasets which could be used as alternatives, and identify how land cover datasets might replace or complement other data types.

Other EO geospatial datasets which are not discussed in this document are also useful for monitoring SDG indicators for example, digital elevation models, or soil maps. The use of EO data in SDG monitoring is further discussed in a number of other publications including UNEP-WCMC (unpublished)[1].

SDG monitoring needs

The SDGs, which build on the 2000-2015 Millennium Development Goals development agenda consist of 17 goals with 169 targets, covering social, economic and environmental fields. One or more indicators (there are 232 in total) for each target have been established to track progress towards the goals. Although annual reporting at the national level is requested, individual indicators might be updated less frequently. Monitoring needs to be carried out for each indicator to measure progress until 2030, when the success of the initiative will be evaluated. Indicators are classified into tiers depending on their methodological development and the availability of global data. Even those with the highest level of development and data availability (Tier I) can still comprise uncertain data, so could benefit from updated data and methods. As of 31 December 2018, 101 indicators were classified as Tier I, 84 Tier II and 31 Tier III, while 6 have multiple tiers which correspond to different components of the indicator (SDG Tiers 2018).

1 http://eohandbook.com/sdg/files/CEOS_EOHB_2018_SDG.pdf and http://www.earthobservations.org/documents/publications/201703_geo_eo_for_2030_agenda.pdf are two other examples.

Beyond only tracking progress on the SDGs, good data is required to inform actions taken to increase the likelihood of reaching the goals, such as national development policies.

Use of global earth observation geospatial data

It has been estimated that approximately 20% of the SDG indicators can be interpreted and measured either through direct use of geospatial data itself or through integration with other statistical data (IAEG-SDG WGGI 2018). National data, produced by national experts should be used where available as they are likely to provide better data (e.g. higher resolution, more accurate). In the case of land cover, higher thematic detail, which suits the national context, and higher spatial and temporal resolution (if available) can be more useful to detect land cover and land cover changes, which are required to monitor the SDG indicators than coarser and less thematically detailed global products – particularly one-off products providing a snapshot of the data rather than change through multiple time frames. National data also allows a national ownership of the data, which stimulates progress towards better monitoring of the indicator. However, there are several reasons why global data may be used, and it is sometime essential to provide information quickly on the progress of the goals.

To fill data gaps

Data gaps can be quickly filled without the need to collect new data. Using open and free data sources which are already available will also be efficient and cost-effective and can provide first assessments before national data is collected and analysed.

To complement national data

Global datasets can provide a useful addition to national datasets, particularly where they have similar spatial resolutions. For examples, see IAEG-SDG WGGI (2018). Temporal resolutions can be increased where the global dataset represents a different timeframe, although ideally there should be some overlap. Legend harmonization is required but there are a number of tools available, for example EAGLE (https://land.copernicus.eu/eagle/documentation-and-tools), and multiple global maps have been successfully harmonized for use in a number of contexts (see Tsendbazar et al. 2016). It is not always the case that global data will be appropriate for integration with national data, as matching spatial, and temporal resolutions as well as definitions is often problematic – and each potential dataset should be evaluated on case-by-case basis.

To identify national priorities and support national reporting

The use of these existing data sources also allows countries to see what data sources should be updated or developed at the national level. Where global datasets show large changes (particularly negative changes), those would be the datasets to prioritize for updating. This provides useful information for national data providers and supports their capacity to create new nationally owned datasets.

To allow comparability across countries

At the global level, these datasets allow the assessment of international progress on the SDGs using consistent data across nations. This allows progress to be regularly assessed against a baseline and communicated accordingly. Open data, and access to international progress updates stimulate engagement, and can therefore underpin action at all levels. Open data also stimulates transparency at all levels. Effective communication of results based on global datasets and agreement/approval of these results at the national level is essential to ensure that appropriate action can be taken by countries and other data users.

To support reporting of cross-border issues

Although reporting at the national level is a priority for the SDGs, some dynamics typically occur across borders, for example displaced populations may be misrepresented using national datasets alone. Global datasets can assist in those situations.

Land cover data

Land cover can be defined as the observable (bio-) physical material at the earth's surface. Land cover maps describe this spatially using a number of classes, which represent different surfaces such as forests and lakes. Some maps cover a number of different thematic classes, and others focus on specific classes such as forests, water bodies and urban/built up areas. Although some countries have high-quality, regularly produced national land cover products, the accuracy and rate of updating of these products is low in a number of cases. In other countries, no national or specific LC data could be identified (Diogo and Koomen 2016). In this report, we include both land cover (which describe the cover on the ground e.g. herbaceous) and land use (which describe the use e.g. agriculture) products, and later use the term land cover to describe both, or datasets which include a combination.

An initial assessment which specifically looked at the use of land cover data for SDG indicator monitoring (Romijn et al. 2016) led by GOFC-GOLD, assessed the importance of global data, and determined that they could potentially be exclusively used for indicators from 4 of the goals (6 Clean water and sanitation, 13 Climate action, 14 Life below water, 15 Life on land), and could be used to complement other data types for four other goals (2 Zero hunger, 9 Industry, Innovation and Infrastructure, 11 Sustainable cities and communities, 12 Responsible consumption and production). In both cases, they may be essential data sources. The assessment also considered the land cover classes which were required. The land use classes which indicators required also differed, with for example 22 indicators requiring tree cover data, and 18 requiring water bodies data (Figure 1). In some cases, change data were required, for example 6 indicators could benefit from forest degradation change data. A re-assessment of some of the indicators (see Table 1) revealed that land cover data could be useful for even more indicators than was found to be the case in Romijn et al. (2016).

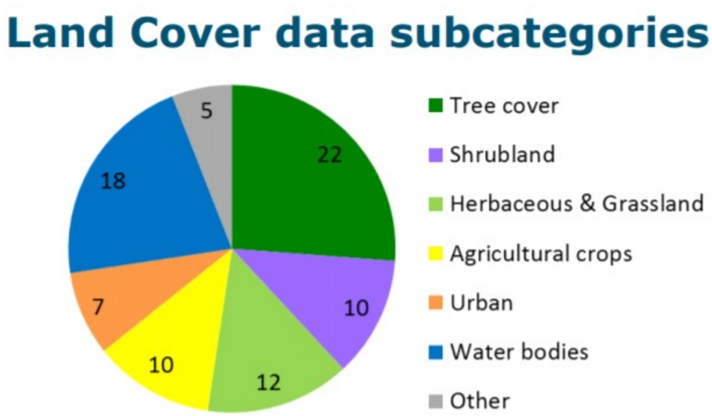

Figure 1. Number of indicators which could use land cover classes for monitoring (from Romijn et al. 2016)

Space-derived geospatial data are more available than ever, as the number of satellites providing data are increasing. These data can be used to produce new fit-for-purpose land cover and use maps for SDG monitoring. However, the production of a map is time consuming and costly which requires technical capacity due to complex image processing. Although there is now an abundance of satellite Analysis Ready Datasets (ARD), which can be analysed immediately as have been processed to a minimum standard (including geometric and radiometric calibration for example) and are organized to reduce user effort (Killough 2016), there is still a burden on the user to further process these into a product.

Available land cover datasets

Several fit-for-purpose satellite Earth observation datasets, including land cover maps, can be used directly in combination with national statistics and geospatial information, to monitor SDG indicators. We describe some of the current available (free and open data) land cover datasets which can be applied to SDG indicator monitoring (Appendix Table A.1).

Global datasets cover a number of different timeframes and spatial resolutions, and in general, both the spatial and temporal resolution of these datasets is increasing, with a number of annual or decadal 30 m products being available, which provides a promising future for the use of these products in SDG monitoring.

Selection of global land cover datasets

The use of a global dataset has to be assessed on a case-by-case basis. Firstly, the product should fit the purpose, so the thematic detail should be sufficient, or classes aggregated to what is required if there is too much detail. Each country has its own specifications and may for example have a particular land cover class which is not present globally but is significant and is required for that country. If the detail is insufficient, supporting datasets would be required for disaggregation of thematic classes, which is not easily achieved. The spatial resolution should be fit for purpose, so if small scale activities for example are required to be monitored, then high resolution imagery that can capture the needed information should be used (example: dispersed housing in rural areas or on the outskirts of cities). Datasets of multiple time periods, or datasets which show changes are often required. Reporting for SDGs should be done annually until 2030, and although this frequency of data may not be required for all datasets, one reason being that not all indicators are recommended to be monitored at this frequency. The dataset should therefore cover the recommended temporal extent and frequency of that indicator. In order to understand if a product is appropriate for use, a quality check should be done. A review of the methods is required, and for this, they should be available, transparent and open for assessment. Data should also be in a suitable format and should be easily accessible to users. Data quality in the area of interest is the key. Data products should be validated with the user in mind (focussing on the classes of interest), so one global map will have a different accuracy for each user group (Tsendbazar et al 2015). Accuracy of global products is also likely to vary across the globe, for example a forest product will vary in accuracy in different forest types (dry, tropical, temperate etc.). Temporal accuracy should be considered where global products are made up of a number of different satellite images from different time points. There is often a trade-off between for example the spatial and temporal resolution, so users should assess what is most important for each dataset in the indicator methodology.

These considerations can be summarized by the following **check list**, to assess the product's fit in terms of:

- Thematic focus and detail
- Spatial resolution
- Temporal resolution (both the length and frequency of time series – particularly for the future)
- Transparent and open methods
- Ease of access and use
- Access to and understanding of quality / accuracy information (if possible for the location of interest as assessed by national experts)

Indicators and global land cover datasets

To understand how geospatial information and Earth observations (EO), specifically land cover datasets can reliably and consistently contribute to the tracking, monitoring, and reporting on the SDG indicators, we undertake an in-depth review of several indicators for which land cover datasets are key. The IAEG-SDG, WGGI identified two shortlists of priority indicators where geospatial information has a direct and a significant/supporting contribution (Table 1)[2]. In this Table, we provide more details about the use of global land cover products – in particular which classes may be useful for monitoring the indicator.

Several indicators where geospatial datasets have a significant contribution (Table 1) were selected for an in-depth review, on the basis that they were not Tier 1 indicators (methodologies are already well established, and data are generally available). Indicator 6.6.1 was also included which was recently upgraded to a tier 1, however after a brief assessment, it was clear that the role of land cover datasets could be significant. Six indicators were therefore selected 2.4.1, 6.6.1, 9.1.1, 11.3.1, 11.7.1 and 15.3.1.

Table 1: List of indicators from IAEG-SDG, WGGI results of the analysis of the SDG Global Indicator Framework with a "geographic location" lens: priority indicators where geospatial information has a direct (although other data may be required) and a significant/supporting contribution. With additional information on the classes of interest from land use, land cover and change data. As recommended methods are updated, changes to this table may need to be made.

Goal	Target	Indicator (indicators in bold and underlined are assessed in detail later in the report)	Tier and custodian and partner agencies*	Classes of interest from (1) land use, (2) land cover, and (3) land cover change data (from Romijn et al 2016 and updated in 2019 emboldened)
A. Indicators where geospatial information has a direct contribution				
2 End hunger	2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality	**2.4.1 Proportion of agricultural area under productive and sustainable agriculture**	2 FAO and UNEP	(1) **1. Forest land 2. Wetlands** 3. Cropland, **4. Grassland 6. Other land** (2) **1. Tree cover 2. Tree cover regularly flooded 3. Shrubland 4. Grassland (pasture) 5. Herbaceous cover (natural)** 6. Herbaceous crops (natural), 7. Tree crops **10. Water bodies (Update 2019)**
6 Ensure availability and sustainable management of water and sanitation for all	6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	6.3.2 Proportion of bodies of water with good ambient water quality	2 UNEP and UN-Water	(1)2. Wetlands; (2)10. Water bodies

[2] Also available here: http://ggim.un.org/meetings/2017-4th_Mtg_IAEG-SDG-NY/documents/WG's_Initial_Shortlist-Table_A_B.pdf

Goal	Target	Indicator (<u>indicators in bold and underlined are assessed in detail later in the report</u>)	Tier and custodian and partner agencies*	Classes of interest from (1) land use, (2) land cover, and (3) land cover change data (from Romijn et al 2016 and updated in 2019 emboldened)
	6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate	6.5.2 Proportion of transboundary basin area with an operational arrangement for water cooperation	1 UNESCO-IHP, UNECE	(1)2. Wetlands; (2)10. Water bodies
	6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes	**<u>6.6.1 Change in the extent of water-related ecosystems over time</u>**	1 UNEP, Ramsar and UN-Water, IUCN	(1)2. Wetlands;(2)1. Tree cover; 2. Tree cover, regularly flooded; 10. Water bodies;(3). 5.Change in water bodies
Goal 9. Build resilient infrastructure promotes inclusive and sustainable industrialization and foster innovation	9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all	**<u>9.1.1 Proportion of the rural population who live within 2 km of an all-season road</u>**	2 World Bank and UNEP, UNECE	(1)5. Settlements; (2)9. Urban areas
	9.c Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020	9.c.1 Proportion of population covered by a mobile network, by technology	1 ITU	None identified
Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable	11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons	11.2.1 Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities	2 UN-Habitat and UNEP, UNECE	(1)5. Settlements; (2)9. Urban areas
	11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries	**<u>11.3.1 Ratio of land consumption rate to population growth rate</u>**	2 UN-Habitat and UNEP	**Update 2019: (1)5. Settlements; (2)9. Urban areas**

Goal	Target	Indicator (**indicators in bold and underlined are assessed in detail later in the report**)	Tier and custodian and partner agencies*	Classes of interest from (1) land use, (2) land cover, and (3) land cover change data (from Romijn et al 2016 and updated in 2019 emboldened)
	11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities	**11.7.1 Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities**	2 UN-Habitat	(1)5. Settlements; (2)9. Urban areas **Update 2019: 1. Forest land 4. Grassland 6. Other land (2) 1. Tree cover 3. Shrubland 4. Grassland (pasture) 5. Herbaceous cover (natural) 7. Tree crops (agriculture) 8. Bare areas**
Goal 14 Conserve and sustainably use the oceans, seas and marine resources for sustainable development	14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and act for their restoration in order to achieve healthy and productive oceans	14.2.1 Proportion of national exclusive economic zones managed using ecosystem-based approaches	3 UNEP and IOC-UNESCO, FAO	(1)2. Wetlands; (2)10. Water bodies; (3)5. Change in water bodies
	14.5 By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information	14.5.1 Coverage of protected areas in relation to marine areas	1 UNEP-WCMC, UNEP, IUCN and Ramsar	(1)2. Wetlands; (2)10. Water bodies; (3)5. Change in water bodies
Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements	15.1.1 Forest area as a proportion of total land area	1 FAO and UNEP	(1)1. Forest land; (2) 1. Tree cover; 2. Tree cover, regularly flooded; 3. Shrubland; 5. Herbaceous cover; (3)1. Forest loss; 2. Forest degradation; 3. Agricultural expansion
		15.1.2 Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type	1 UNEP-WCMC, UNEP and Ramsar	(1) 1. Forest land; 2. Wetlands; 4. Grassland (2) 1. Tree cover; 2. Tree cover, regularly flooded; 3. Shrubland; 5. Herbaceous cover; 10. Water bodies
	15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to	**15.3.1 Proportion of land that is degraded over total land area**	2 UNCCD and FAO, UNEP	(1) 1. Forest land; 2. Wetlands; 4. Grassland (2) 1. Tree cover; 2. Tree cover, regularly flooded; 3. Shrubland; 5. Herbaceous cover (3) Forest degradation; 3.

Goal	Target	Indicator (<u>indicators in bold and underlined are assessed in detail later in the report</u>)	Tier and custodian and partner agencies*	Classes of interest from (1) land use, (2) land cover, and (3) land cover change data (from Romijn et al 2016 and updated in 2019 emboldened)
	achieve a land degradation neutral world			Afforestation / Reforestation
	15.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development	15.4.1 Coverage by protected areas of important sites for mountain biodiversity	1 UNEP-WCMC, UNEP. IU	(1)1. Forest land; 4. Grassland (2) 1. Tree cover; 2. Tree cover, regularly flooded; 3. Shrubland; 5. Herbaceous cover; (3)1. Forest loss; 2. Forest degradation; 3. Afforestation / Reforestation; 4. Agricultural expansion
B. Indicators where geospatial information has a significant/supporting contribution				
Goal 1. End poverty in all its forms everywhere	1.1 By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day	1.1.1 Proportion of population below the international poverty line, by sex, age, employment status and geographical location (urban/rural)	1 World Bank and ILO	**Update 2019: (1)5. Settlements; (2)9. Urban areas**
	1.4 By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance	1.4.2 Proportion of total adult population with secure tenure rights to land, with legally recognized documentation and who perceive their rights to land as secure, by sex and by type of tenure	2 UN-Habitat and UNICEF, WHO	None identified
Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	4.5 By 2030, eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples and children in vulnerable situations	4.5.1 Parity indices (female/male, rural/urban, bottom/top wealth quintile and others such as disability status, indigenous peoples and conflict-affected, as data become available) for all education indicators on this list that can be disaggregated	Tier I/II/III depending on indices UNESCO-UIS and OECD	**Update 2019: (1)5. Settlements; (2)9. Urban areas**
Goal 5. Achieve gender equality and empower all women and girls	5.2 Eliminate all forms of violence against all women and girls in the public and private spheres, including trafficking and sexual and other types of exploitation	5.2.2 Proportion of women and girls aged 15 years and older subjected to sexual violence by persons other than an intimate partner in the previous 12 months, by age and place of occurrence	2 UNICEF, UN Women, UNFPA, WHO, UNODC and UNSD, UNDP	**Update 2019: No guidelines are given on this point, but land cover data could potentially be used to define the place of occurrence ((1) & (2) – all classes).**

Goal	Target	Indicator (<u>indicators in bold and underlined are assessed in detail later in the report</u>)	Tier and custodian and partner agencies*	Classes of interest from (1) land use, (2) land cover, and (3) land cover change data (from Romijn et al 2016 and updated in 2019 emboldened)
	5.4 Recognize and value unpaid care and domestic work through the provision of public services, infrastructure and social protection policies and the promotion of shared responsibility within the household and the family as nationally appropriate	5.4.1 Proportion of time spent on unpaid domestic and care work, by sex, age and location	2 UNSD, UN Women	None identified
	5.a Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws	5.a.1 (a) Proportion of total agricultural population with ownership or secure rights over agricultural land, by sex; and (b) share of women among owners or rights bearers of agricultural land, by type of tenure	2 FAO and UN Women, UNSD, UNEP, World Bank, UN-Habitat	**Update 2019: (1)3. Cropland (2)6. Herbaceous crops, 7. Tree crops**
		5.a.2 Proportion of countries where the legal framework (including customary law) guarantees women's equal rights to land ownership and/or control	2 FAO and World Bank, UN Women	None identified
Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable	11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities	11.7.2 Proportion of persons victim of physical or sexual harassment, by sex, age, disability status and place of occurrence, in the previous 12 months	3 UNODC and UN Women, UN-Habitat	**Update 2019: No methods are available, but land cover data could potentially be used to define the place of occurrence ((1) & (2) – all classes).**
Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	15.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development	15.4.2 Mountain Green Cover Index	1 FAO and UNEP	(1) 1. Forest land; 4. Grassland (2) 1. Tree cover; 2. Tree cover, regularly flooded; 3. Shrubland; 5. Herbaceous cover; 8. bare areas

* https://unstats.un.org/sdgs/iaeg-sdgs/tier-classification/ Tier classification sheet 31 December 2018. Where –

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.

2.4.1 Proportion of agricultural area under productive and sustainable agriculture

Overview: Tier 2, https://unstats.un.org/sdgs/metadata/files/Metadata-02-04-01.pdf
The indicator can be calculated by dividing (a) the area under productive and sustainable agriculture by (b) the agricultural land area. Agricultural land area (b) cannot be directly derived from a land cover/use dataset since state or communal land used by farm holdings is not included (http://www.fao.org/3/CA2639EN/ca2639en.pdf). Agriculture in this case includes crops and livestock production, but not forestry and fisheries. The analysis to determine whether agriculture is productive and sustainable or not (a) should be carried out at the farm level, and there are 11 sub-indicators which can be assessed by a farm survey (covering productivity, soil health, water use, fertilizer pollution risk, biodiversity and food security among others).

Reporting timeframe: Data is expected to be released through FAOSTAT annually (even if no new data are available) until 2030. Surveys are expected to take place every 3 years, although short-term changes are not expected.

Existing data: Some data is available in FAOSTAT.

Potential contribution for global land cover datasets: The agricultural land area where farm surveys will be undertaken, can be identified with a land cover/use map. The survey will enable the exclusion of state and common land which is not used exclusively by an agricultural holding or nomadic pasture lands. This map could also form a basis for stratification of farm surveys.

The use of land cover is proposed as a possible data collection instrument for the sub-indicator "Use of biodiversity-friendly practices" for the theme biodiversity in (a). Six practices are proposed, and for one of them, high resolution data could be used to determine the "Percentage of the holding area covered by natural or diverse vegetation (not cultivated), including natural pasture or grasslands; wildflower strips; stone or wood heaps; trees or hedgerows; natural ponds or wetlands". For the sub-indicator "prevalence of soil degradation" in the theme soil health, the method for 15.3.1 Proportion of land that is degraded over total land area could be used.

Criteria for global datasets: For step (b) thematic disaggregation between agriculture types is key, and where land cover data have a number of different agricultural classes, can form the basis for (or a part of) a stratification of farm surveys. For the farm surveys, at least 3 data points until 2030 are required, so the temporal resolution should be 5-10 years. High spatial resolution is not essential in this case but might be used to differentiate different parts of one farm, so should be at a resolution where this is possible. Where datasets are used for (a), high spatial resolution datasets would be required for the biodiversity sub-indicator. For the soil degradation indicator, see the analysis for 15.3.1. The minimum requirements for these datasets have been described more specifically below.

Specification for biodiversity sub-indicator of (a) of 2.4.1	**Minimum criteria**
Spatial resolution	30 m or higher
Temporal extent	Until 2030
Temporal resolution	Every 3 years
Thematic detail	In addition to agricultural classes, tree cover, shrubland, and waterbodies / wetlands

Specification for degradation sub-indicator of (a) 2.4.1	**Minimum criteria**
Spatial resolution	100 m – 1 km
Temporal extent	Until 2030
Temporal resolution	Every 4 years
Thematic detail	6 IPCC classes

Specification for (b) agricultural land area of 2.4.1	Minimum criteria
Spatial resolution	100 – 500 m,
Temporal extent	Until 2030
Temporal resolution	Every 3 years
Thematic detail	Multiple agricultural classes, such as cropland, grassland and tree crops

Selection of global datasets: CCI-LC, Copernicus Land or MODIS Land Cover to stratify agricultural land for a farm survey, and GlobeLand30 and the datasets proposed in 15.3.1 for the sub-indicators. Details of these datasets are provided in Table A1.

6.6.1 Change in the extent of water-related ecosystems over time

Overview: Tier 1, https://unstats.un.org/sdgs/metadata/files/Metadata-06-06-01a.pdf and https://unstats.un.org/sdgs/metadata/files/Metadata-06-06-01b.pdf
The indicator includes five wetland categories 1) vegetated wetlands, 2) rivers and estuaries, 3) lakes, 4) aquifers, and 5) artificial waterbodies. Two levels of monitoring are expected. Firstly, two sub-indicators identify (a) the spatial extent of water related ecosystems and (b) the water quality of lakes and artificial water bodies. Secondly, three sub-indicators measure (c) the discharge in rivers and estuaries, (d) the water quality from indicator 6.3.2 (proportion of bodies of water with good ambient water quality) and (e) the quantity of groundwater within aquifers. Earth observation data is only relevant for sub-indicator (a) and (b). For (a) the method proposes that multi-temporal SAR (Synthetic Aperture Radar) and optical satellite imagery (specifically Landsat 8 and Sentinel 1 and 2), can be combined with other geospatial datasets related to the topography of the area, the hydrography of the watershed and its drainage network, and the soil types to identify the wetland categories, as well as other supporting data (see potential contribution for global land cover products). For (b) MODIS and other sensors can be used to identify chlorophyll a (Chl) and total suspended solids (TSS) within lakes globally. The other sub-indicators are not relevant for land cover datasets so will not be discussed here.

Reporting timeframe: Reporting will be every five years: 2017, 2022, and 2027.

Existing data: Annual estimation of sub-indicators 1 and 2 is expected to be released around 2017/18.

Potential contribution for global land cover datasets: Land cover datasets are only useful for sub-indicator (a), and some might have difficulty with the identification of vegetated wetlands which include swamps, fens, peatlands, marshes, paddies, and mangroves. The Global Mangrove Watch (GMW) annual mangrove maps can be used to distinguish some vegetated wetlands. General land cover maps can be used to identify open water which is surface water unobstructed by aquatic vegetation, and can include categories such as rivers and estuaries, lakes, and artificial waterbodies. Artificial water bodies can be identified through the global reservoir and dam database.

Criteria for global datasets: The thematic classes are key, and a number of different datasets may need to be combined to identify the five different water body types. A spatial resolution of 30 m or higher is recommended, particularly to capture rivers and small changes in extent. The datasets should be able to be matched to the reporting dates.

Specification for sub-indicator (a) of 6.6.1	Minimum criteria
Spatial resolution	30 m or higher
Temporal extent	Until 2030
Temporal resolution	Every 5 years
Thematic detail	Water bodies of different types (see potential contribution of global land cover datasets)

Selection of global datasets: The Global Surface Water datasets and Copernicus land service water bodies dataset as well as the Global Mangrove Watch and can be used for the first sub-indicator.

9.1.1 Proportion of the rural population who live within 2 km of an all-season road

Overview: Tier 2, https://unstats.un.org/sdgs/files/meetings/iaeg-sdgs-meeting-05/TierIII_Work_Plans_03_03_2017.pdf
Although this is Tier 2, there is no methodology available, and only the Tier 3 work plan is available online at the time of writing. Some agencies have proposed their own methodologies (i.e. Colombia's National Administrative Department of Statistics (DANE) – pers. comm.). The use of spatial data is essential, for all three steps of this indicator. Firstly, (a) to define rural areas, a population dataset can be used. Secondly (b) a georeferenced road network (e.g. OpenStreetMap (OSM)) can be used to identify roads. Thirdly the condition of the roads should be assessed, for which the data is weakest, and may require georeferenced information by relevant ministries, and road agencies.

Reporting timeframe: Data should be collected every 3-5 years until 2030.

Existing data: None

Potential contribution for global land cover datasets: Land cover datasets could be used to identify the rural and urban areas, but overall the contribution of land cover datasets is not essential where population data can be used to identify rural and urban areas. For disaggregation of results, a land cover map could be useful.

Criteria for global datasets: The spatial resolution is not so critical, as the spatial scale of interest is 2 km (the distance to roads), and so a coarse resolution land cover map may be used to identify rural from urban.

Specification for (a) in 9.1.1	**Minimum criteria**
Spatial resolution	100 m – 1 km
Temporal extent	Until 2030
Temporal resolution	Every 3-5 years
Thematic detail	Rural areas should be identifiable – can be as non-urban

Selection of global datasets: Copernicus Land, CCI-LC, Modis Land Cover and GHSL settlement model.

11.3.1 Ratio of land consumption rate to population growth rate

Overview: Tier 2, https://unstats.un.org/sdgs/metadata/files/Metadata-11-03-01.pdf
There are two steps in this calculation. Firstly (a) population growth rate is estimated from city population estimates in two steps in time, and secondly (b) the land consumption rate is calculated as the change in extent of the city over time. Results are then aggregated at the country level (can be based on a sample of cities in the country), and can be disaggregated by for example location, income level and urban typology.

Reporting timeframe: Reporting should be every 5 years (and initial reporting was targeted for 2017 for all cities) until 2030.

Existing data: The basic methodology has been applied on 200 cities by UN-Habitat, New York University and the Lincoln Institute for Land Policy to implement the Atlas of Urban Expansion project (see Table A1).

Potential contribution for global land cover datasets: Global datasets can contribute to step (b) for example built-up area grids, or the urban settlement layer – where multiple time steps are available. A city boundary map is required, and population estimates should also match the city boundary.

Criteria for global datasets: A high spatial resolution is not critical in this case, but the time frame of the corresponding datasets for population and urban area are required.

Specification for (b) of 11.3.1	Minimum criteria
Spatial resolution	1 km
Temporal extent	Until 2030
Temporal resolution	Every 5 years
Thematic detail	Urban areas

Selection of global datasets: The GHSL population grids and GHSL settlement model could be used.

11.7.1 Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities

Overview: Tier 2, https://unstats.un.org/sdgs/metadata/files/Metadata-11-07-01.pdf
The method to estimate this indicator has three steps, which involve data download, processing and analysis, as well as gathering of supplementary non EO data, and should be carried out for the area of interest (i.e. a city):

- "a) Spatial analysis to delimit the built-up area of the city;
- b) Spatial analysis to identify potential open public spaces, field work to validate data and access the quality of spaces and calculation of the total area occupied by the verified open public spaces;
- c) Estimation of the total area allocated to streets;"

Step (a) utilizes LANDSAT, Sentinel or other similar data, and image processing software to classify the data into built-up and non-built-up for each pixel, depending on the number of pixels in a 1-km^2 circle around it. The classifications are urban >=50% of pixels are built-up, suburban >=25% and <50% and rural, the remainder. The contiguous urban and suburban pixels are considered urban area. Then (b) utilizes legal documents, fieldwork and land use plans to identify potential open spaces. Streets are also considered open spaces. Finally (c), within the urban extent, the area of each street is calculated, either by using information on the width and length of each street or using a sampling approach where streets within these samples are digitized and the average area over all samples within each city is used.

Reporting timeframe: Data should be collected every 3-5 years until 2030.

Existing data: The Atlas of Urban Expansion has data which can be used for 200 cities.

Potential contribution for global land cover datasets: Currently there is a debate about the definition of urban areas. The definition from one of the open global datasets could be adopted and used for step (a) or for higher resolution products, the built-up pixels used directly where the number of pixels within the 1 km^2 circle determines whether it is urban. For step (b) a general land cover map could be used to identify for example parks and other green open spaces, or the gaps in the urban product used in step a can represent open spaces in step b. OSM may also provide information on open spaces which can be identified from the tags, but further information may be required to know if they are public. One option where this is not known, would be to use an estimate derived from literature for the proportion of open spaces which are public, otherwise ground data would be required to establish this. For step (c), similarly, where ground data are not available, an estimated street width (where different road types are available, this could be done per road type) could be used together with a street map such as Google maps, OSM or Bing maps, meaning that geospatial data alone could be used to derive a first estimate.

Criteria for global datasets: High resolution datasets (step a and b) are essential as open spaces in cities are likely to be small. Where a Global urban map (step a) and land cover map (step b) are used, the resolution does not have to be the same, however open spaces at the edge of urban areas might be identified.

Specification for (a) urban areas in 11.7.1	Minimum criteria
Spatial resolution	100 m or higher
Temporal extent	Until 2030
Temporal resolution	Every 3-5 years
Thematic detail	Urban

Specification for (b) open areas in 11.7.1	Minimum criteria
Spatial resolution	30 m or higher
Temporal extent	Until 2030
Temporal resolution	Every 3-5 years
Thematic detail	Forest, grassland, bare and other relevant classes

Selection of global datasets: A combination of GUF and GHSL built up, or another product with an urban category used for step (a), and GlobeLand30 for step (b). Outputs can be calibrated with the Atlas of Urban Expansion.

15.3.1 Proportion of land that is degraded over total land area

Overview: Tier 2, https://unstats.un.org/sdgs/files/meetings/iaeg-sdgs-meeting-05/TierIII_Work_Plans_03_03_2017.pdf. Although this is Tier 2, there is no methodology available, and only the Tier 3 work plan is available online. Good practice guidance is available which builds on the Tier 3 work plan: https://www.unccd.int/sites/default/files/relevant-links/2017-10/Good%20Practice%20Guidance_SDG%20Indicator%2015.3.1_Version%201.0.pdf. There are three sub-indicators a) land cover, b) land productivity and c) carbon stocks, above and below ground, each of which result in either a degraded or non-degraded output. If either is degraded, then the overall classification is degraded, otherwise it is non-degraded. Land cover maps are required, and can be used exclusively for (a) and are required and combined with other data for (c) https://prais.unccd.int/sites/default/files/helper_documents/3-DD_Guidance_EN_1.pdf.

Reporting timeframe: Data should be collected every 4 years until 2030.

Existing data: Currently, the ESA CCI Land cover map (7, Table A1) is proposed for countries who are being supported to calculate this indicator as part of a UNCCD Land Degradation Neutrality target setting programme. This data is integrated into the trends.earth tool, a plugin for QGIS. This tool uses this and other default data to calculate the indicator, although these can be replaced by custom datasets.

Potential contribution for global land cover datasets: Land cover maps are essential for this indicator, and in the current methodology, their use is described (see Overview).

Criteria for global datasets: Since the land cover datasets are used in combination with other spatial datasets, the timeframes and spatial resolution should be similar (often coarse). The change, and timing of the change is important, so regular updates should be available. Thematically, only 6 classes (IPCC classes: Forest land, Grassland, Cropland, Wetlands, Settlements and Other Land) are required.

Specification for 15.3.1	Minimum criteria
Spatial resolution	100 m – 1 km
Temporal extent	Until 2030
Temporal resolution	Every 4 years
Thematic detail	6 IPCC classes

Selection of global datasets: CCI-LC, Copernicus land, Modis Land Cover and GLC-SHARE (as a baseline, as only has one-time step) could be used and are proposed in the good practice guidelines for both (a) and (c).

Recommendations

Specifically, for the five indicators analysed in this report, countries should make use of the available Global Land Cover datasets which can be used to monitor SDG indicators. In order to assess the suitability of alternative datasets (not mentioned in this report) the minimum specifications for other products are proposed in the detailed analysis of each indicator. It may be necessary to increase the awareness of countries to the availability, and potential uses for these available products, particularly for new and emerging products.

More generally, satellite data providers (NASA, USGS, ESA, EC-Copernicus) need to ensure that free and open satellite time series are available until 2030, at least, so that these can be used to continue the delivery of land use/cover products (Table A1). The products must be consistently produced, with the long-term service vision that change, and trends can be derived by comparing products (or change products are produced). The plans for future products including how regularly existing products will be updated and when new products/updates can be expected should be clearer. Often these are not known, which means that datasets cannot be considered for long-term monitoring plans required for the SDGs. In fact, there are few products which meet the requirements, when considering products which have confirmed availability until 2030. Certain sensors and products will likely not be available (such as MODIS which has already exceeded its design life), and new services which can be replacements should be planned by the space agencies.

In order to ensure that the specific needs of each indicator are met, the technical community, specifically the custodian agencies involved in methodological development can have an open dialogue with the data producers and space agencies. Complimentary data are essential and the timeframe, and sometimes spatial extent of these datasets should be matched to the land use dataset – thus the two communities need to communicate.

All actors should also be in an active and sustained dialog with countries so that their needs, according to the varying country circumstances can be met. The capacity of the country should be taken into consideration, and initiatives such as the SEPAL system for cloud computing and Trends.Earth (QGIS plugin for Indicator 15.3.1: Proportion of land that is degraded over total land area http://trends.earth/docs/en/) are valuable tools to remove some of the processing and analytical burden from the countries. In this case, default global land cover datasets are promoted, and already integrated in the tool for use. The methodologies for other indicators should include recommendations for specific global land cover products or give more explicit information about the data needs (temporal, spatial and thematic resolution etc.) so that the best option can be selected.

In order to move forward and to continue to deliver novel tools and appropriate methods, demonstrations of the use of land use and land cover datasets in SDG indicator monitoring can be carried out potentially through "centres of excellence".

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Appendix

Table A1: Selected Global Land Cover data sets

# / Theme	Product	Spatial resolution	Temporal coverage	Contents/overall reported accuracy	Notes	Source
1	Global forest change	30 m	Annual (2000-) for forest area and losses	Forest canopy cover %, gains, losses/ unknown		University of Maryland https://earthenginepartners.appspot.com/science-2013-global-forest/download_v1.5.html
2	Landsat Tree Cover Continuous Fields	30 m	2000	Percentage cover/ unknown	No updates scheduled	Global Land Cover Facility, University of Maryland http://glcf.umd.edu/data/landsatTreecover/
3	Landsat Forest Cover Change	30 m	Annual (2000-)	Forest)/ unknown	No updates scheduled	Global Land Cover Facility, University of Maryland http://glcf.umd.edu/data/landsatFCC/
4	Forest and non-forest global map	25 m	Every year 1993-1998, 2007-2010, 2015-2016	Two classes (forest/non-forest)/ 84% accuracy /L-band SAR		Earth Observation Research Center Japan Aerospace Exploration Agency http://www.eorc.jaxa.jp/ALOS/en/palsar_fnf/fnf_index.htm
5	Intact Forest Landscapes	30 m	2000, 2013, 2016	Intact forest / unknown		http://www.intactforests.org/world.map.html
6	Copernicus land service: dynamic land cover (Copernicus Land)	100 m	Annual (2015-)	10 classes / 74% (2015)	Currently only available for Africa, but global version is expected[3]	Copernicus Global Land Service https://land.copernicus.eu/global/products/lc
7	ESA Land Cover CCI (CCI-LC)	300 m -1 km	1992-2015 (annual)	22 classes/ 74% (2008-2012)		European Space Agency http://maps.elie.ucl.ac.be/CCI/viewer/download.php
8	MODIS Land Cover	500 m	2001-2012 (annual)	17 classes/75% (2005)	No updates scheduled	University of Maryland http://glcf.umd.edu/data/lc/
9	GlobeLand30	30 m	2000, 2010	10 classes/ 80.3%		National Geomatics Center of China http://www.globeLand30.com
10	Global Land Cover – SHARE (GLC-SHARE)	~1 km (30 arc-seconds)	Variable	11 classes/80.2%	Only one time – step (combines best available national, regional, subnational databases)	FAO http://www.fao.org/land-water/land/land-governance/land-resources-planning-toolbox/category/details/en/c/1036355/
11	Global Urban Footprint (GUF)	12 m	2010-2013	3 classes: urban fabric, non-built up land surface, water / unknown		German Aerospace Center (DLR) https://www.dlr.de/eoc/en/desktopdefault.aspx/tabid-9628/16557_read-40454/

3 http://www.iiasa.ac.at/web/home/research/researchPrograms/EcosystemsServicesandManagement/C-Glops.html

# / Theme	Product	Spatial resolution	Temporal coverage	Contents/overall reported accuracy	Notes	Source
12	Global Human Settlement Layer (GHSL) – built up	38 m	1975, 1990, 2000, 2014	Scale from 0-98 / Confidence map about built up presence, and supporting data mask are available		Joint Research Center (JRC) of the EC https://ghsl.jrc.ec.europa.eu/ghs_bu.php and https://ghsl.jrc.ec.europa.eu/ghs_bu_qual.php
13	Global Human Settlement Layer (GHSL) – population grids*	250 m	1975, 1990, 2000, 2014	Number of people per cell / unknown		Joint Research Center (JRC) of the EC https://ghsl.jrc.ec.europa.eu/ghs_p
14	Global Human Settlement Layer (GHSL) – settlement model	1 km	1975, 1990, 2000, 2014	Rural, Urban Cluster, Urban Centre/ unknown		Joint Research Center (JRC) of the EC https://ghsl.jrc.ec.europa.eu/ghs_smod.php
15	Atlas of Urban Expansion	Not wall to wall (200 cities). 30 m	3 time steps: C.1990, C. 2000 C. 2014	Urban extent: Urban built up, Suburban Built-up, Rural Built-up, Urbanized Open Space; Exurban Area: Exurban Built-Up Area, Exurban Open Space; Rural Open Space / For urban areas, user's accuracy 91%, producer's accuracy 89.3%		NYU Urban Expansion Program http://www.atlasofurbanexpansion.org/
16	Global Surface Water: Water Occurrence	30 m	Covers time frame 1984-2015	0-100% / unknown		Joint Research Center (JRC) of the EC https://global-surface-water.appspot.com/
17	Global Surface Water: Water Occurrence Change Intensity	30 m	Covers time frame 1984-2015	High – low / unknown		Joint Research Center (JRC) of the EC https://global-surface-water.appspot.com/
18	Global Surface Water: Water Seasonality	30 m	2014-15	1-12 / unknown		Joint Research Center (JRC) of the EC https://global-surface-water.appspot.com/
19	Global Surface Water: Annual Water Recurrence	30 m	Covers time frame 1984-2015	0-100% / unknown		Joint Research Center (JRC) of the EC https://global-surface-water.appspot.com/
20	Global Surface Water: Water Transition (First Year to Last Year)	30 m	Covers time frame 1984-2015	Permanent, New Permanent, Lost Permanent, Seasonal, New Seasonal, Lost Seasonal, Seasonal to Permanent, Permanent to Seasonal, Ephemeral Permanent, Ephemeral Seasonal / unknown		Joint Research Center (JRC) of the EC https://global-surface-water.appspot.com/
21	Global Surface Water: Maximum Water Extent	30 m	Covers time frame 1984-2015	One class / unknown		Joint Research Center (JRC) of the EC https://global-surface-water.appspot.com/
22	Copernicus land service: water bodies	300 m / 1 km	Every 10 days	Sea / water / no water Variable / unknown quality		Copernicus Global Land Service https://land.copernicus.eu/global/products/wb
23	Global Inundation Extent from Multi-Satellites (GIEMS) Average yearly minimum inundation	15 arc-seconds (approximately 500 meters at the equator)	Covers time frame 1993-2004	1 class / unknown	Data available on request	McGill University http://www.estellus.fr/index.php?static13/giems-d15

# / Theme	Product	Spatial resolution	Temporal coverage	Contents/overall reported accuracy	Notes	Source
24	Global Inundation Extent from Multi-Satellites (GIEMS) Average yearly maximum inundation	15 arc-seconds (approximately 500 meters at the equator)	Covers time frame 1993-2004	1 class / unknown	Data available on request	McGill University http://www.estellus.fr/index.php?static13/giems-d15
25	Global Inundation Extent from Multi-Satellites (GIEMS) Long term maximum inundation	15 arc-seconds (approximately 500 meters at the equator)	Covers time frame 1993-2004	1 class / unknown	Data available on request	McGill University http://www.estellus.fr/index.php?static13/giems-d15
26	Global Mangrove Watch	Approx. 30 m	2010 (1996, 2007, 2008, 2009, 2010, 2015 and 2016 are expected shortly	1 class / 94%	New time frames expected early 2019	Aberystwyth University and solo Earth Observation https://www.globalmangrovewatch.org/
27	Global Reservoir and Dam (GRanD) Database	Unknown	Unknown	Unknown	Website currently not working	Center for development Research (ZEF), University of Bonn http://www.gwsp.org/products/grand-database.html

*This is not strictly a land use/cover product but is part of a set of others which are.