WORKING GROUP ON DATA INTEGRATION

The integration of geospatial data and statistics to compute SDG indicators: requirements and practices

UN-GGIM: EUROPE

UNITED NATIONS COMMITTEE OF EXPERTS ON GLOBAL GEOSPATIAL INFORMATION MANAGEMENT

Guidelines for SDG Indicator Calculation

15.1.1 Forest area as a proportion of total land area

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A. INDICATOR CALCULATION AND DISCUSSION

1. DEFINITION

This indicator is used to monitor the progress towards SDG 15 on protecting, restoring, and promoting sustainable use of land. This includes targeting the conservation, restoration and sustainable use and management of forests, combat desertification, and halt and reverse land degradation and biodiversity loss.

At global level, the indicator is defined as the proportion of forest area of the total land area of a country. It follows FAO's definition regarding the following two components:

i) Forest area: includes "land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use."

ii) Land area: corresponds to the country area excluding area under inland waters (natural or artificial water courses) and coastal waters (comprising internal water, territorial sea, and archipelagic waters).

The indicator corresponds to a tier I level indicator, meaning that it is conceptually clear, it has an internationally established methodology and standards are available.
The indicator is provided at national level, with no further disaggregation being required at global level.
Monitoring of the indicator is dependent in the data release calendar, which is set to be at five-year intervals.
FAO is the UN custodian agency for this indicator and collects national level data from member countries, proceeding to its standardization and dissemination.

2. METHODOLOGY

This indicator is the result of the percentage relation between forest area and total land area. It therefore requires the existence of information for the two components of this proportion according to a common definition. For international comparability it requires data sources based on harmonised classifications and reliable methodologies.

This indicator is calculated based on the following formula and is expressed as a percent (%):

Forest area (reference year) / Land area (reference year) x 100

At the global level, the methodology relies on country reporting following a questionnaire-standardized format, as described below:

Forest area:
FAO has been collecting and analysing data on forest area, as part of the Global Forest Resources Assessment (FRA) since the late 40's and the collection frequency has been every five years since 2000.
The FRA is based on two primary sources of data: country reports prepared by national correspondents and remote sensing analysis that is conducted by FAO together with national focal points and regional partners.
FRA collects country data following a standard format. It includes the original data and reference sources and descriptions of how these have been used to estimate the forest area for different points in time.
Detailed methodology and guidance on how to prepare the country reports and to convert national data according to national categories and definitions to FAO's global categories and definitions can be found in FRA 2020 Guidelines and Specifications.

For countries with missing data, FAO estimates forest area based on existing information from previous assessments, literature search, remote sensing, or a combination of these data sources.

Land area:
Data on land area are collected from FAO members through the annual FAO Questionnaire on Land Use, Irrigation and Agricultural Practices. Missing data may be sourced from national statistical yearbooks and other official government data portals. Supplemental information for further gap filling may be derived from national and international sectoral studies and reports, as well as from land cover statistical information compiled by FAO and disseminated in FAOSTAT.
For countries with missing data, land area data is collected from other sources or when land area for a specific reference year is not available in FAOSTAT, land area is imputed by using data for closest available reference year.

Although, the global methodology allows for achieving international comparability of data, the data collection strategy, valid at country level, does not allow for a proper territorial sub-national disaggregation of the indicator over smaller spatial units. Geospatial layers, based on remote sensing techniques, could be used, allowing for a more territorial detailed result and an improvement in the computation frequency.
Geospatial layers that can be used for this purpose are different at global and at European level and, in general, European geospatial data layers are more detailed (thematic detail and spatial resolution) and reliable.
At national level, even more detailed data sources may be available, ranging from Land Use and Land Cover Maps and/or National Forest Inventories. These data sources can provide a greater territorial detail of the results for this indicator and, according to their thematic detail may allow to segment results according to different types of forests (e.g., indigenous forests; deciduous forest).

3. DATA SOURCES

The sources of information available for the calculation of this indicator may differ in terms of their geographical or statistical basis and their scope (pan-European, EU-wide, and national). The following tables present a systematisation of the data sources available, taking into account this segmentation. Nevertheless, it is important, however, to have in mind that when adopting different geospatial layers, land cover maps or Forest Inventories, definitions in terms of forest area may not exactly fit with underlying FAO definition for this SDG indicator.

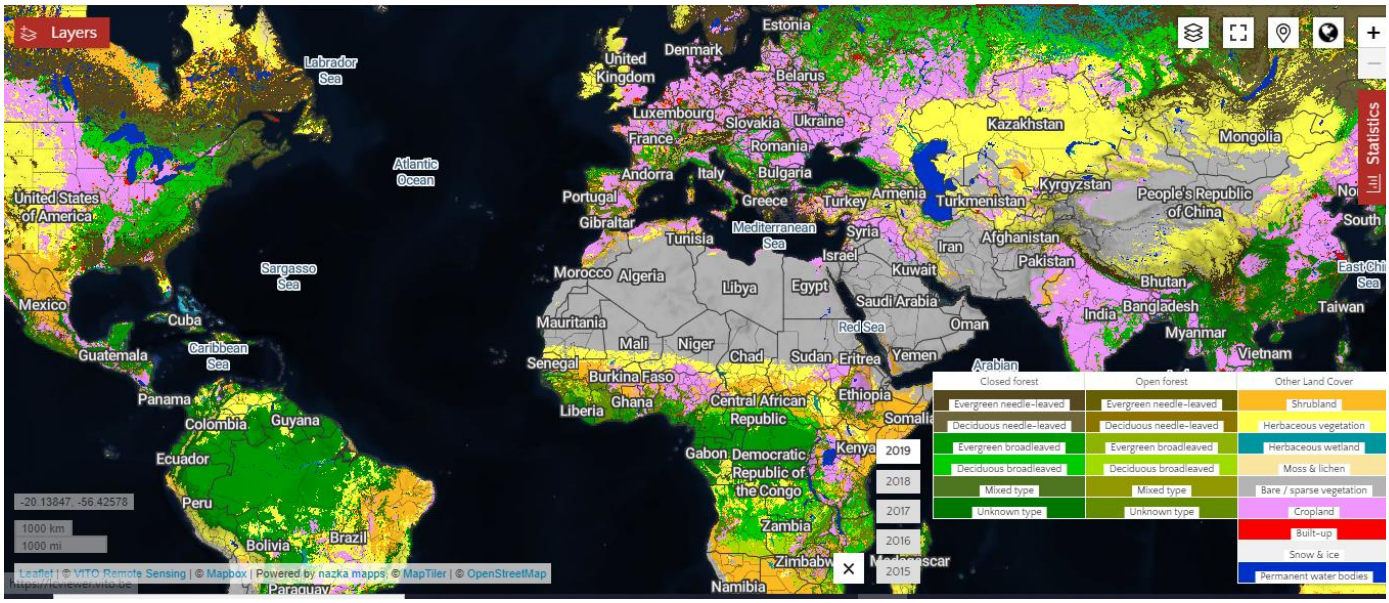
Table 1 Global Geospatial Data Sources

Name	Source	Periods of reference available	Frequency	Spatial Resolution	MMU	INSPIRE Data Theme	Core Data Theme
ESA-CCI Land Cover	MR Satellite	1992 - 2015	1 year	300 m	9 ha	Land cover	Land cover
Copernicus Global Land Cover	MR Satellite	2015 - Today	1 year	100 m	1 ha	Land cover	Land cover

The Land Cover generated by European Space Agency (ESA) in support to the Climate Change Initiative is based on automatic workflows for the generation of land cover with a resolution of down to 30 meters and a land cover map on a worldwide basis is generated annually from which geospatial layers related to forestry areas can be extracted.

The Copernicus Global Land Cover Map are global annual maps, since 2015, and include a discrete classification with 23 classes, following UN-FAO's Land Cover Classification System (LCCS) and related surface area statistics (km^2) per level 0 and 1 administrative area as defined in UN-FAO Global Administrative Unit Layer.

Figure 1 Copernicus Global Land Cover Map



Source: Copernicus Global Land Service – Land Cover – © Copernicus Service Information 2021.

Table 2 Pan-European Geospatial Data Sources

Name	Source	Periods of reference available	Frequency	Spatial Resolution	MMU	INSPIRE Data Theme	Core Data Theme
FTY - Forest Type Product	Copernicus HRL	2012, 2015 and 2018	3-years	10 m (2018); 20 m (2012, 2015) and 100 m	0.5 ha	Land Cover	Land Cover
Water and Wetness	Copernicus HRL	2015 and 2018	Annual (7-year period)	10 m (2018; 20m (2015), and 100 m	0.5 ha	Hydrography	Hydrography
Corine Land Cover	HR Satellite	1990, 2000, 2006, 2012 and 2018	6-years	100 m	25 ha	Land Cover	Land Cover

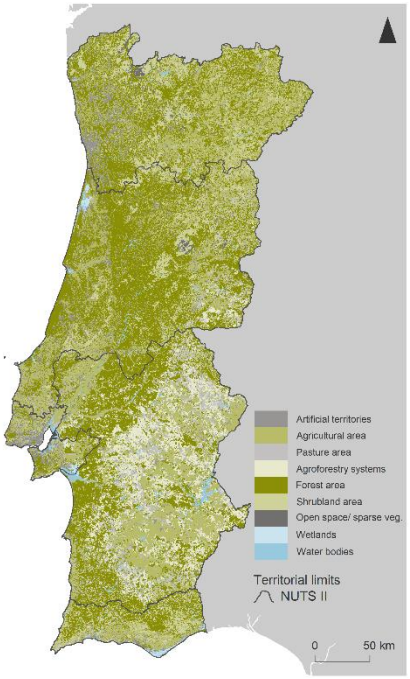
In the framework of Copernicus Pan-European High-Resolution Layers, geospatial data layers are available at the EU level, allowing the whole computation of the indicator. The Forest Type geospatial layer allows to get as close as possible to the FAO forest definition, with a Minimum Mapping Unit (MMU) of 0.5 ha, as well as a 10% tree cover density threshold applied. For the final 100 m product trees under agricultural use and urban context from the support layer are removed, in line with the FAO forest definition. The Water and Wetness geospatial layer provides a detailed measure of inland waters (to be subtracted to total land area for indicator computation).

The CORINE Land Cover (CLC) consists of an inventory of land cover in 44 classes at EU level. It is a ready-to-use product, and it provides a strategy for the identification of inland waters. It uses a Minimum Mapping Unit (MMU) of 25 hectares (ha), which can be considered as relatively coarse for the purpose of this indicator.

Table 3 Geospatial National Data Sources

Name	Source	Periods of reference available	Frequency	Spatial Resolution	MMU	INSPIRE Data Theme	Core Data Theme
PT- Land Use/Cover Map (COS)	Directorate-General for Territory	1995, 2007, 2010, 2015 and 2018	Irregular, expected to be every 3 years	20 m	1 ha	Land Cover Land Use	Land Cover
ES- Information System om Land Cover /Use SIOSE	National Geographic Institute of Spain	2005; 2009; 2011 and 2014		15 m	0.5 ha	Land Cover Land Use	Land Cover

Figure 2 Land Use and Land Cover Map



In Portugal, the official source for indicator 15.1.1 relies on data from the National Forest Inventory with a territorial detail up to NUTS 3 level. Alternatively, the Land Use and Land Cover Map (COS) can also be used to compute this indicator with a greater territorial disaggregation. COS corresponds to a national product under the responsibility of the Directorate-General for Territory (Portuguese NMCA). Data series are available for Mainland Portugal and correspond to polygonal maps that represent homogenous land use/cover units. COS is based on a vector data model with a MMU of 1 ha. The nomenclature of COS 2018 consists of four levels of detail that can be grouped into 9 classes of first level of detail (1 - Artificial land; 2 - Cropland area; 3 - Grassland area; 4 – Agroforestry areas; 5 - Forest area; 6 - Shrubland area; 7 - Open spaces or sparce vegetated areas; 8 - Wetlands; 9 - Surface water bodies) and there is a common and comparable subset of 83 LCLU classes. Based on COS, it is also possible to analyse the data based on the type of forest and monitor their change and evolution at regional and local level.

Source: Directorate-General for Territory, Land Use and Land Cover Map.

The SIOSE is part of the National Monitoring Plan (PNOT), managed and coordinated by the NMCA (National Geographic Institute of Spain), and integrates different data of regional and national administrations. It includes 85 classes and a resolution of 2 ha for forest and natural areas. SIOSE is produced in conformity with INSPIRE implementing rules on interoperability of spatial datasets and services.

Table 4 Statistical European Data Sources

Name	Source	Periods of reference available	Frequency	Max territorial granularity	Other relevant disaggregation	ESS regulation reference
Land Use /Cover Area frame Survey	ESTAT-LUCAS	2012, 2015 and 2018 (EU 27 MS)	3-years	NUTS 2		Part of the Community Statistical Programme

LUCAS survey is based on *in situ* data, meaning that observations are registered on the ground by field surveyors. It is based on a standardised survey methodology in terms of a sampling plan, classifications, data collection processes and statistical estimators that are used to obtain harmonised and unbiased estimates of land use and land cover.

A mixed panel approach is used, so some points are visited in subsequent years. In the field, the surveyor classifies the land cover and the visible land use according to the harmonized LUCAS land cover and land use classifications. LUCAS data is used to calculate the EU-SDG indicator on the *Share of forest area*, which has a direct correspondence to the one defined at the global level.

Table 5 Statistical National Data Sources

Name	Source	Periods of reference available	Frequency	Max territorial granularity	Other relevant disaggregation	ESS regulation reference
PT-National Forest Inventory	Portuguese Institute for Nature Conservation and Forests	1995, 2005, 2010 and 2015	Every 5-years	NUTS 3	Forest type	
DE-Area Survey	Federal Statistical Office	2010-2019	Annual			

The Portuguese National Forest Inventory (NFI) is the process of producing statistics on the existence, state and condition of national forest resources. It is based on data collection from aerial images and measurements of vegetation on the ground throughout the territory. These data collections are repeated, which makes it possible to monitor the evolution of the forest areas. The NFI is the official data source for the country report to FAO supporting the calculation of the 15.1.1 SDG indicator. It provides data up to NUTS 3 level and the possibility of depicting the forest area according to forest types and monitor its change and progress over time at regional level.

The German Area survey of the Federal Statistical Office categorizes the surface by land cover or land use. The main categories are settlement, transportation, vegetation, and water surfaces, which are further subdivided into different subtypes. The area survey as a total calculation is based on administrative data of the Official Real Estate Cadastre of the Länder (federal states).

4. COMPUTATION

Workflow based on global geospatial data source – ESA Land Cover

The indicator computation using ESA Land Cover can be carried out based on the following workflow:

- ESA Land Cover data and administrative boundaries geospatial layer
- Extraction of the Regional / National area subset of the ESA Land Cover
- Computation of the forest area by selecting the following classes:
  ESA Land Cover classes: 40 (Mosaic natural vegetation (tree, shrub, herbaceous cover)/cropland), 50 (Tree cover, broadleaved, evergreen, closed to open), 60 (Tree cover, broadleaved, deciduous, closed to open), 70 (Tree cover, needle-leaved, evergreen, closed to open), 80 (Tree cover, needle-leaved, deciduous, closed to open), 90 (Tree cover, mixed leaf type), 100 (Mosaic tree and shrub/herbaceous cover), 110 (Mosaic herbaceous cover/tree and shrub)
- Computation of the internal water area to be subtracted by considering class 210
- Computation of the total reference unit area from administrative borders
- Calculation of the indicator by applying the formula: (forest area) / (administrative unit area - internal water area) x 100

Workflow based on Pan-European geospatial data source – Copernicus HRL

The indicator computation using Copernicus HRL can be carried out based on the following workflow:

- Copernicus HRL Forest Type geospatial layer and Copernicus HRL Water and Wetness geospatial layer and administrative borders geospatial layer
- Computation of the total country area by administrative borders geospatial layer
- Computation of the total land area by subtracting water bodies geospatial layer from the total country area
- Computation of indicator based on the ratio HRL Forest Type / Total land area x 100

Workflow based on National geospatial data source – Land Use and Land Cover Map (COS)

The indicator computation using the Portuguese Land Use and Land Cover Map (COS) can be carried out based on the following workflow:

- Land Use and Land Cover Map and Official Administrative Map for Portugal (total area)
- Selection and extraction of areas and forest is set to correspond to the first level class 5 – 'Forest area'
- Total land area is captured as the sum of all classes subtracted of class 9 – 'Surface water bodies'
- Extract 'Forest area' and 'Surface water bodies' according to the boundaries of the Administrative Map
- Computation of indicator based on the Forest area / Total land area x 100

5. RESULTS

Results based on ESA Land Cover

The results of the indicator calculated for Italy for 2012 is 33.4%, a value that should be compared with the one reported in FRA 2010 (36.7%) and FRA 2015 (37.7%). The following figures show the results obtained for the case of Italy considering a disaggregation at NUTS 3 and commune level.

Figure 3 Forest area as a proportion of total land area by NUTS 3 level, 2012

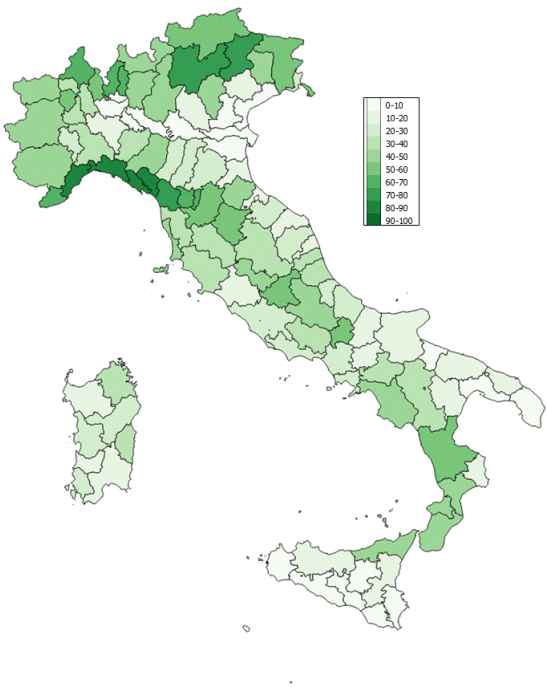
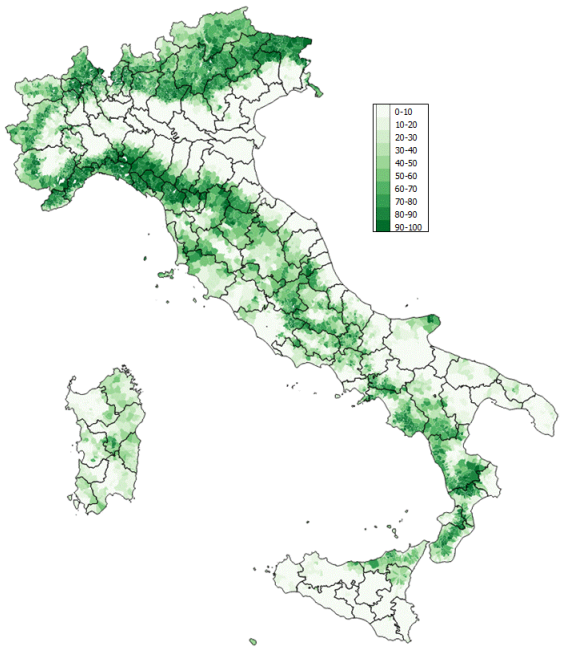


Figure 4 Forest area as a proportion of total land area by commune level, 2012



Source: ESA Land Cover.

Results based on Pan-European data sources

The results of the indicator calculated for Italy for 2012 was 36.9%, also a close value to those reported in FRA 2010 (36.7%) and FRA 2015 (37.7%). The following figures show the results obtained by using only Copernicus geospatial layers for the case of Italy considering a disaggregation at NUTS 3 and commune level.

Figure 5 Forest area as a proportion of total land area by NUTS 3 level, 2012

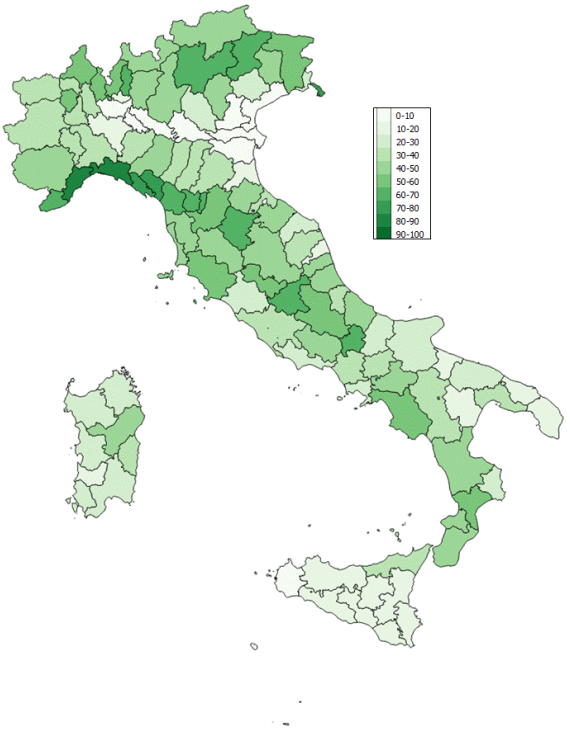
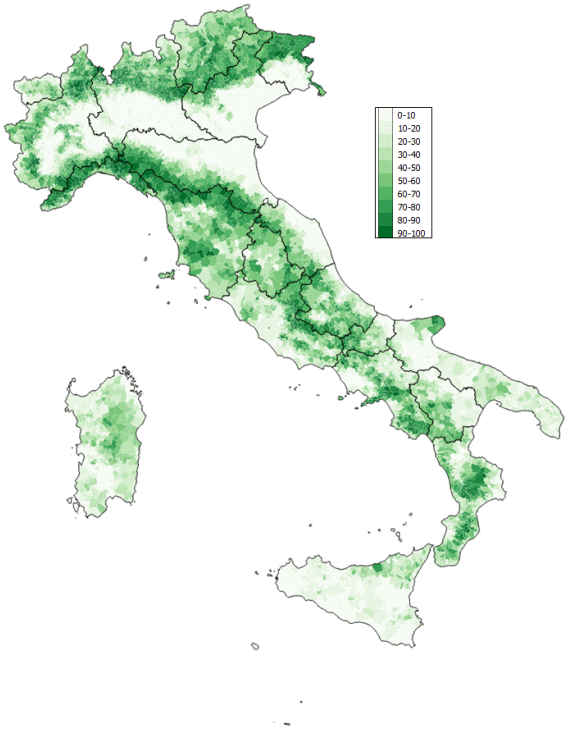


Figure 6 Forest area as a proportion of total land area based by commune level, 2012



Source: Copernicus High Resolution Layers.

Results based on Geospatial National data sources

The results based on the Portuguese Land Use and Land Cover Map can be breakdown at a very detailed level such as grid level and for local administrative units, namely at municipality level, as shown in the following figures. This type of results provides a more territorially detailed picture and monitoring of the evolution of forest, a relevant input for regional and local measures regarding forest and policies on land planning.

Figure 7 Distribution of forest area at 1km² grid level (Portugal mainland), 2018

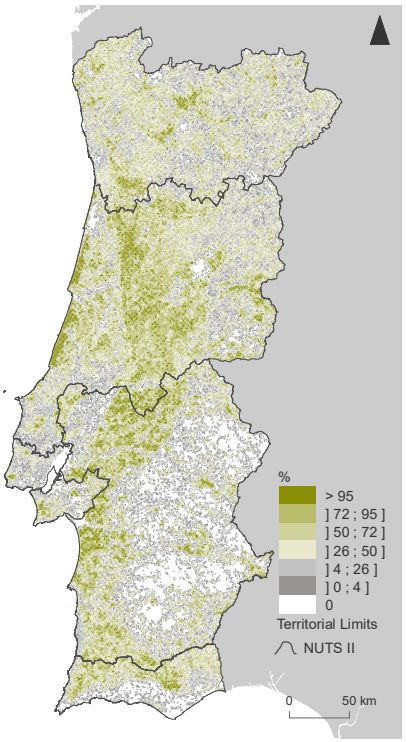
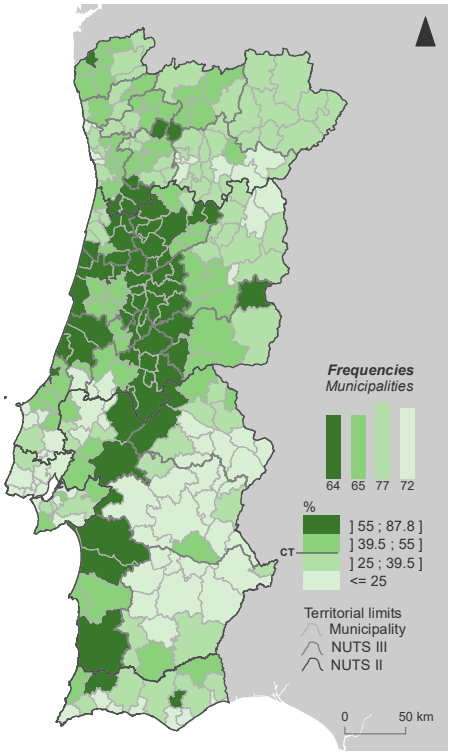


Figure 8 Forest area as a proportion of total land area by municipality (Portugal mainland), 2018



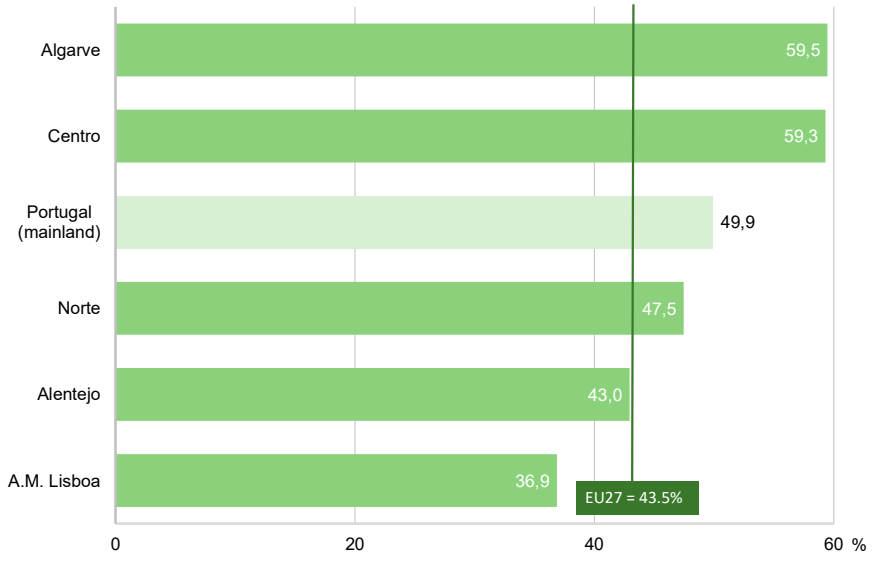
Source: Land Use and Land Cover Map - Directorate-General for Territory (DGT).

At national level, the indicator computed for 2015 and 2018 accounted for 39.5%, a value that can be compared to the one reported by FAO (FRA 2015 – 36.2%). The results at municipality level obtained for 2018 indicate that in 64 out of the 308 Portuguese municipalities, forest area occupied more than 55% of the total land area.

Results based on Statistical data sources

The EU-SDG indicator on the *share of forest area* based on the LUCAS survey provides comparable results up to NUTS 2 level for all EU Member States. The following figure presents the results for 2018 for Portugal at NUTS 2 level having the EU-27 average as a reference. In 2018, the share of forest area for Portugal (mainland) was 49.9%, a value that stood above the EU27 average, and this share was higher in the and Algarve and Centro regions.

Figure 9 Share of forest area (EU-SDG) by NUTS 2 level – Portugal (mainland) and EU27, 2018

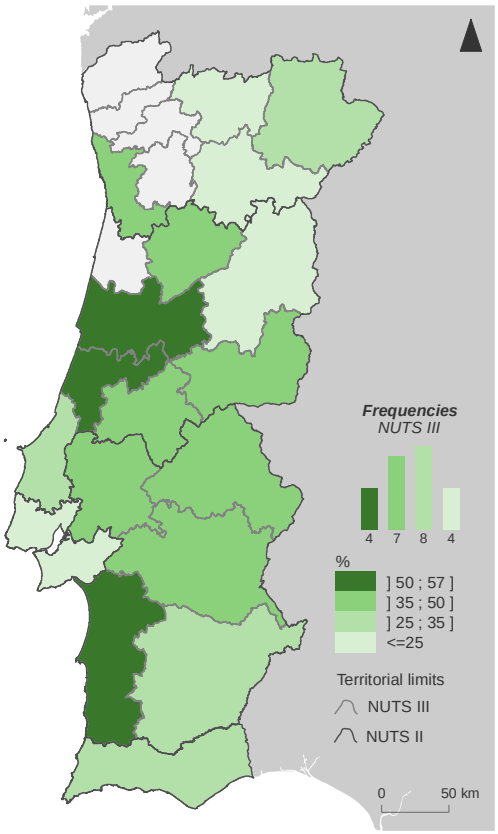


Source: Eurostat - LUCAS Survey.

The calculation of the indicator based on the Portuguese National Forest Inventory makes it possible to analyse the status and the evolution of forest up to NUTS 3 level. The results for 2015, as shown in the figure, show that the proportion of forest area occupies more than 50% of the total land area in three NUTS 3 regions (Região de Aveiro, Região de Coimbra and Região de Leiria) located in the Centro region and in the NUTS 3 region of Alentejo Litoral in the Alentejo region.

The operationalization of an indicator with a relatively straightforward computation may produce different results depending on the type of data source, and it can be expected that differences between data sources will tend to increase as the territorial breakdown of information also increases.

Figure 10 Forest area as a proportion of total land area by NUTS 3 level (Portugal mainland), 2015



Source: National Forest Inventory - Institute for Nature Conservation and Forests.

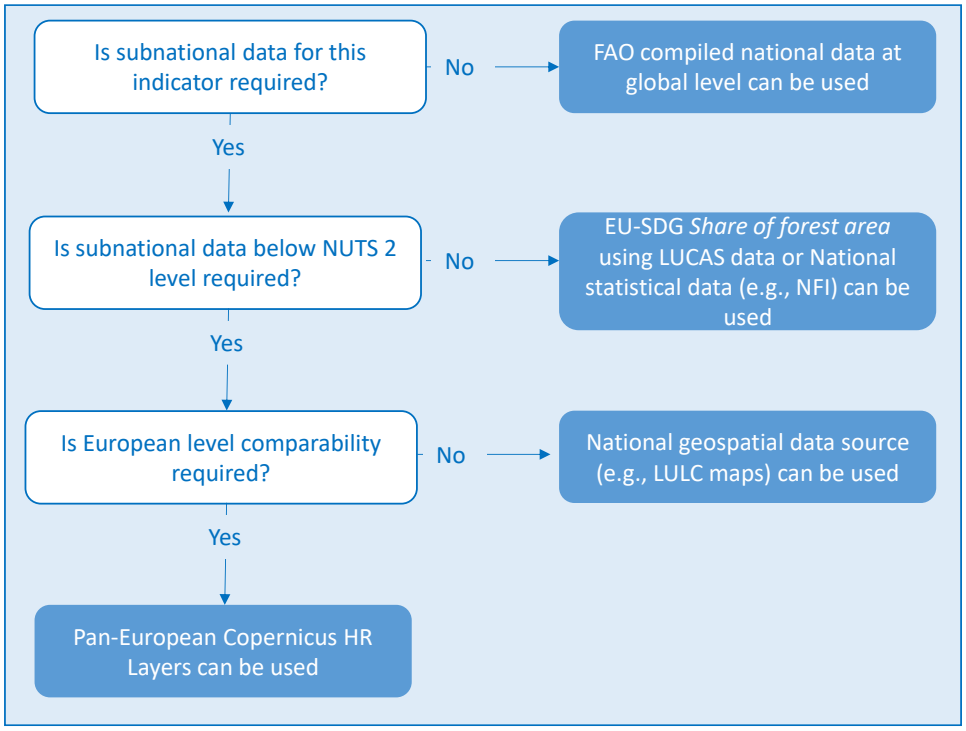
B. NORMATIVE GUIDELINES

1. ALGORITHM WORKFLOW

The computation steps for the calculation of this indicator are relatively straightforward and the algorithm workflow can be divided into three main phases:

- Data inventory, which involves selecting the data source to capture both components of the indicator. Different data sources based on geospatial and statistical data can be used and opting from one can be dependent on the need for international and/or European comparability and the need and relevance to have subnational data at different territorial levels, as shown in the following diagram:

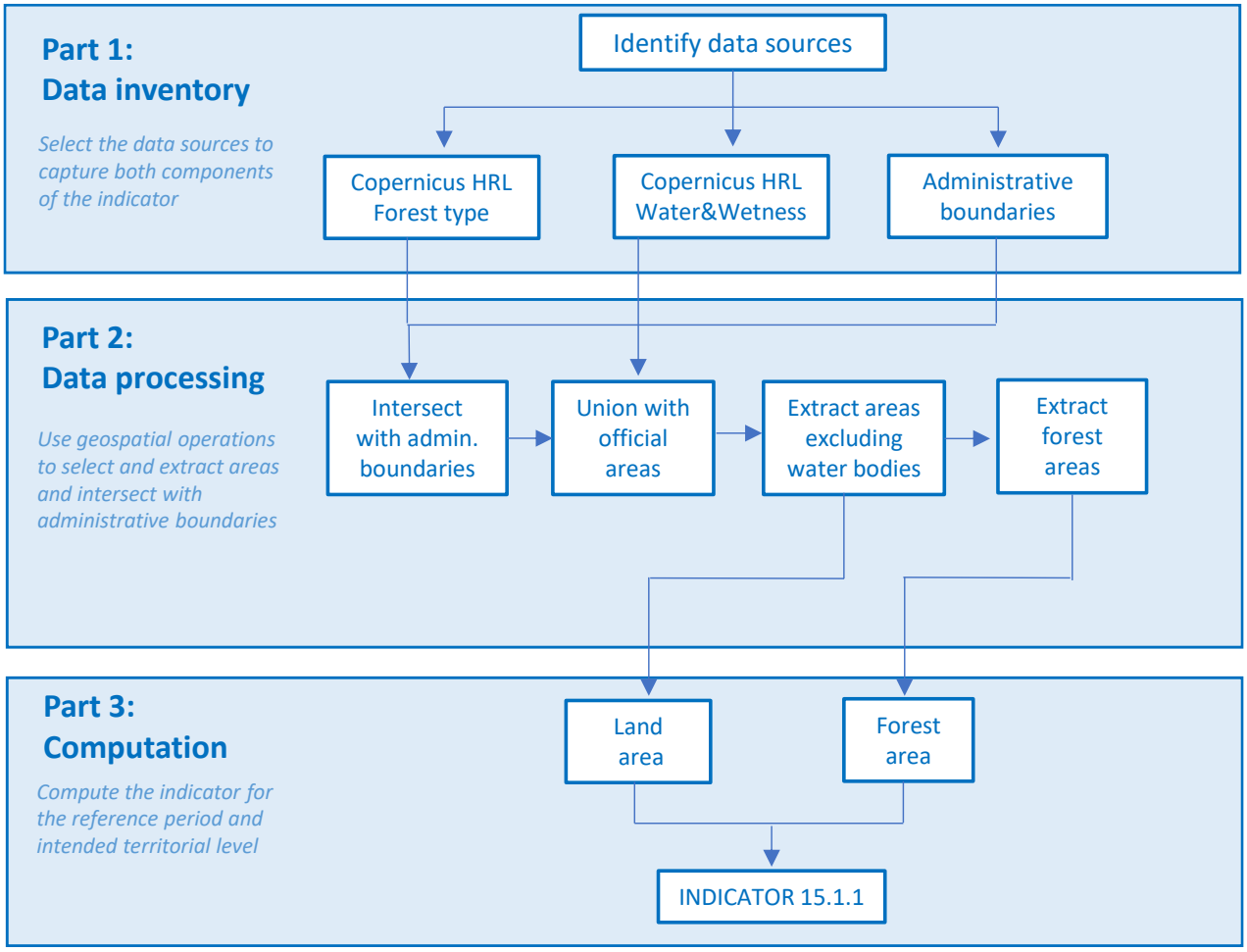
Figure 11 Guideline chart for data source selection



- Data processing, in which all data needed for indicator computation are processed to allow capturing both components of the indicator
- Computation, in which the final value of the indicator is computed by making use of the indicator's formula

The following diagram summarises processing steps divided into the three main phases for indicator calculation having as a reference the Pan-European Copernicus HRL. The same workflow can be applied on national geospatial land cover data sources.

Figure 12 Chart summarising the steps for indicator computation



2. RECOMMENDATIONS

- When using geospatial layers for SDG 15.1.1 indicator it is important to deal with the underlying forest definitions and any deviations from the one proposed by the FAO.
    - If possible, approximate the definition to that defined at the global level by adjusting selection criteria in the data source. At EU level, the indicator being calculated based on LUCAS data has a direct correspondence to the global one as data has been mapped to match FAO definitions.
    - If not possible, deviations from the FAO definition should be identified and reported, to clarify the scope being addressed by the computed indicator in relation to the one defined at the global level.

- At European level, the Copernicus HR Layers (Forest Type and Water & Wetness) should be used for indicator computation as they allow to get as close as possible to the FAO forest definition and provide comparable, reliable, and territorial detailed results.
    - The Copernicus HR Layers (Forest Type and Water & Wetness) Copernicus HRL for 2018 present a more detailed spatial resolution (10 m) than for previous years. In principle, the production and availability of more detailed geospatial products is a positive development area to be encouraged.
    - However, and to enhance the use of this type of sources within the scope of statistical production and within the framework of SDG monitoring, it is important to ensure continuity in terms of data series, so that it is possible to guarantee consistent and comparable data series.

- At the European level, use administrative boundaries from EuroGeographics which are based on national authoritative data. For consistency and comparability of results at the European level, it is important to consider the availability of official data regarding administrative delimitation for the definition of regional and national territorial boundaries. EuroGeographics is working towards providing easy access to pan-European open data created using official map, geospatial and land information.

- At national level, depict the data by types of forest to increase insight on forest monitoring. Although definitions based on national sources may diverge further from those defined at global level by FAO, national data sources can provide greater segmentation of results according to different types of forests (e.g., indigenous forests; deciduous forest), which can be an important input for SDG national monitoring and for forest policy management and planning at local level.