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Land cover statistics

Global, regional and country trends

2000–2019

HIGHLIGHTS

- In 2019, herbaceous crops covered on average 1.5 billion hectares in total, or 11 percent of the global land surface. Tree-covered areas were 4.7 billion hectares, or roughly one-third of the total land surface, while grassland and shrub-covered areas combined covered 4.3 billion hectares.
- Regional and country results for herbaceous crops were consistent with existing land use information on arable land. Country data showed that India, China, the United States of America, the Russian Federation and Brazil have, in descending order, the largest areas, above 150–200 million hectares each.
- Wetlands covered on average 260 million hectares globally in 2019. Europe (including the Russian Federation) has the largest wetland area worldwide.
- Comparisons of land cover statistics with land use information showed good agreement across major classes, indicating the possibility to use land cover data to gap fill land use information on arable land, permanent meadows and pastures, forest land and inland waters.

FAOSTAT LAND COVER STATISTICS

INTRODUCTION

Land cover statistics provide information on the bio-physical aspects of the land surface. They codify the observable features of its living and non-living components, including natural and managed ecosystems such as croplands, forests, and urban areas, into simplified classes such as herbaceous crops, tree-covered areas and built-up areas.

Land cover and land use statistics are closely interrelated, supporting improved understanding of key local, regional and planetary trends that help quantify human-driven land dynamics, such as conversion of land to or from agriculture, deforestation and land degradation. In this perspective, land cover information and statistics are used in FAOSTAT as geospatial input to estimate greenhouse gas (GHG) emissions from [drained organic soils](#) (FAO, 2020) and from [burning biomass](#) (Prosperi *et al.*, 2020). Land cover statistics can furthermore be used to support data quality assessment and quality control (QA/QC) and gap filling of FAO [land use](#) statistics (FAO, 2021a, 2021b, 2021c).

The FAOSTAT [land cover statistics](#) (FAO, 2021d) are based on the Food and Agriculture Organization of the United Nations (FAO) Land Cover Classification System (FAO-LCCS) (Di Gregorio, 2005). Information is derived by aggregating three independent geospatial products, generated from remote sensing by specialized agencies, specifically: *a*) the European Space Agency Climate Change Initiative (CCI); *b*) the National Aeronautics and Space Administration (MODIS); and *c*) the Copernicus Global Land Service (CGLS). These products are available for different periods, based on the type and duration of the satellites and sensors from which they are derived: 1992–2019 for CCI; 2001–2019 for MODIS;

and 2015–2019 for CGLS. All three datasets have comparable global accuracies; they are generated independently by means of different raw data processing chains and algorithms adapted to the different satellite products from which they are sourced (see more details in Explanatory Notes). They are widely used in a number of FAO applications (e.g. [WaPOR](#) on remote sensing for water productivity) as well as within the United Nations (UN) system, including in support of Sustainable Development Goals (SDG) indicators (e.g. SDG 15.4.2 on the [Mountain Green Cover Index](#) and SDG indicator 15.3.1 on the [proportion of land that is degraded](#)). The three land cover data products have different applications depending on specific technical requirements. For instance, the higher thematic detail of the agricultural land cover classes of CCI makes it suitable for applications that distinguish between rainfed and irrigated crops, or between herbaceous and woody crops. Conversely, the higher spatial resolution of CGLS allows it to detect surface features in more detail, but within analyses limited to shorter periods compared to CCI and MODIS. The latter land cover product can in turn be paired to the MODIS burnt area, produced using the same satellite sensor, to derive indicators in a consistent manner, for instance GHG estimates (FAO, 2021e).

FAOSTAT statistics harmonize the land cover legends of the three underlying land cover products by mapping them, using the FAO-LCCS approach, into the common UN land cover legend of the UN System of Environmental Economic Accounting (United Nations, European Commission, Food and Agricultural Organization of the United Nations, International Monetary Fund, Organisation for Economic Co-operation and Development and World Bank, 2014). This results in statistics for 14 classes of land cover (see Table 1 below) that are disseminated separately for CCI, MODIS and CGLS to provide users with the full range of variability in the information provided across specific land cover classes and different regions.

This analytical brief presents global, regional, and country results of land cover statistics, with a focus on classes relevant for food and agriculture, in particular herbaceous crops. For each land cover class analysed, results are presented for the three individual land cover products and summarized in terms of the resulting means and associated errors.

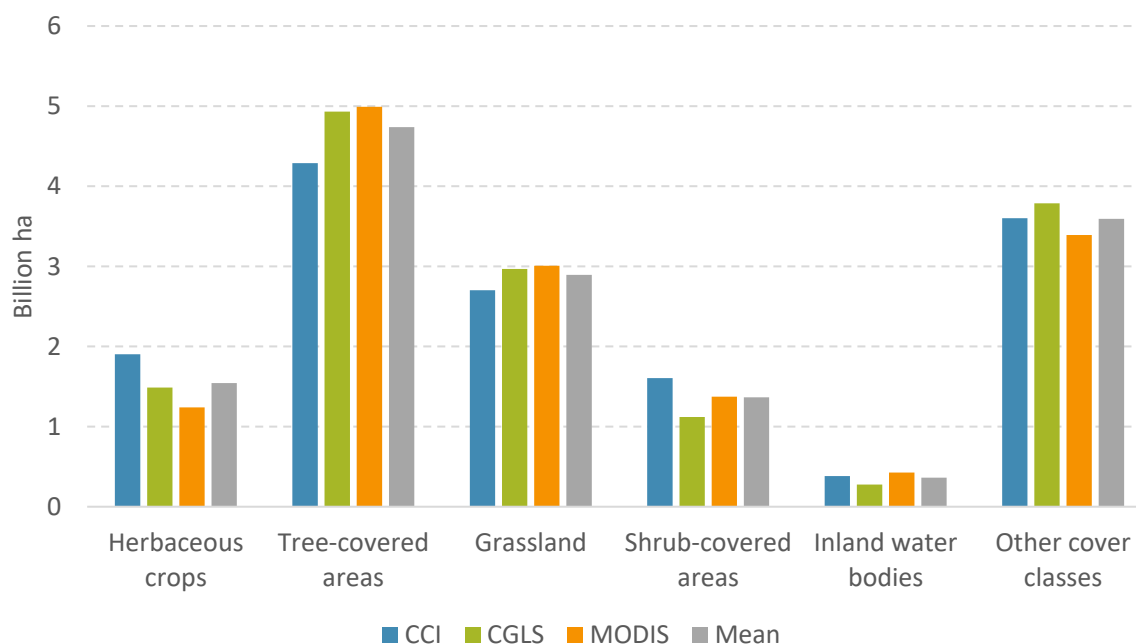
GLOBAL OVERVIEW

The global mean land surface was estimated to 14.7 billion hectares (ha) in 2019. Tree-covered areas accounted for 4.7 billion ha. An additional 4.3 billion ha consisted of either grassland or shrub-covered areas. Herbaceous crops covered about 1.5 billion ha and inland water bodies 360 million ha. Land cover types not typically associated with agriculture, such as built-up areas, bare land (deserts) and permanent snow and ice covered a significant portion of the remaining land surface, totalling 3.5 billion ha (Figure 1). Artificial surfaces covered about 100 million ha.

In general, the statistics generated with CCI data were quite different from the MODIS- and CGLS-derived data, while the latter two products agreed more closely with each other.



Figure 1: Global land cover statistics by source, 2019



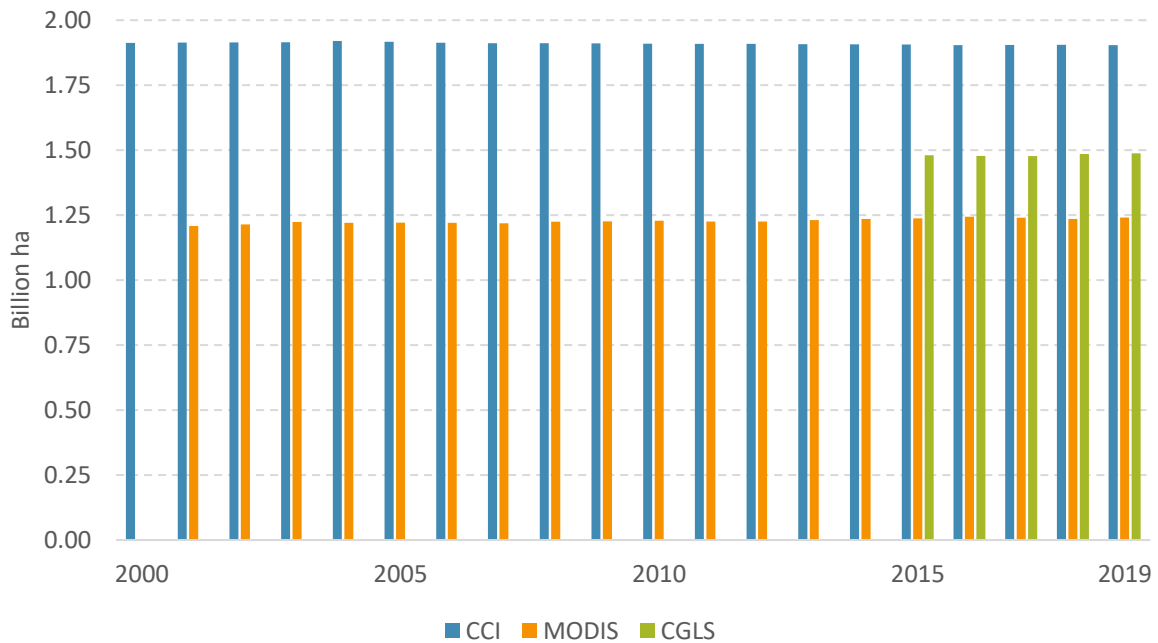
Source: FAO, 2021d.

HERBACEOUS CROPS

In 2019, the global area of herbaceous crops from the three products was 1.5 ± 0.4 billion ha. Values ranged from 1.2 (MODIS) to 1.5 (CGLS) and 1.9 (CCI) billion ha (Figure 2), corresponding to an error of 27 percent (computed as the half range divided by the mean; it represents an uncertainty in land cover extent generated using three different products; hereafter referred to as error). MODIS and CGLS were in closer agreement with each other compared to CCI.

We furthermore performed an analysis of land cover change dynamics derived from the CCI, MODIS and CGLS land cover products. Large variability and significant differences were observed in land cover change data across the three land cover products, at annual to decadal temporal scales, and including at global spatial aggregations. This suggests that the national aggregates of land cover products disseminated in FAOSTAT should not be used to compute land cover change statistics. Figure 3 provides an example for the class of herbaceous crops.

Figure 2: Global land cover of herbaceous crops by source



Source: FAO, 2021d.

Figure 3: Estimated global annual land cover change for class herbaceous crops by source

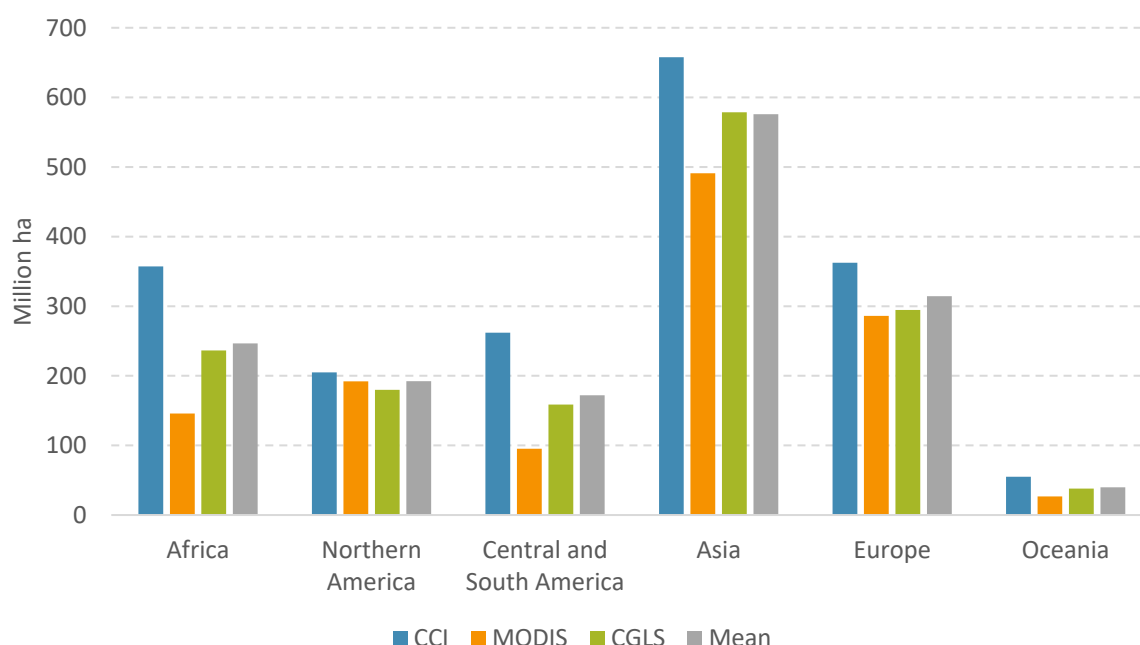


Source: FAO, 2021d.

Looking at the different regions, in 2019 in Central and South America, the regional mean of herbaceous crops was 173 ± 83 million ha. Values varied widely across products, from 100 million ha (MODIS) to 160 million ha (CGLS) and 260 million ha (CCI), resulting in a 48 percent error around the

mean. In Africa, the regional mean was 255 ± 105 million ha. Values varied ranged from 150 million ha (MODIS) to 240 million ha (CGLS) and 360 million ha (CCI) (41 percent error). In Oceania, the regional mean was 41 ± 15 million ha. Values varied ranged from 27 million ha (MODIS) to 40 million ha (GCLS) and 55 million ha (CCI), with a 38 percent error. There was better agreement across land cover products in Asia, resulting in a regional mean of 547 ± 77 million ha. Values varied from 400 million ha (MODIS) to 580 million ha (CGLS) and 660 million ha (CCI), corresponding to a 23 percent relative error. Good agreement was also present for Europe, with an estimated regional mean herbaceous crop cover of 313 ± 38 million ha. Values varied ranging from 290 million ha (MODIS and CGLS) to 360 million ha (CCI) (12 percent error). Northern America was the region with the best agreement between the three land cover datasets, with a regional mean of 190 ± 10 million ha. Here, CCI mapped about 200 million ha of herbaceous crops, MODIS close to 190 million ha and CGLS 180 million ha, with a 5 percent error. The high agreement was likely also due to more precise and consistent validation data available to develop the three land cover products for this region (Figure 4).

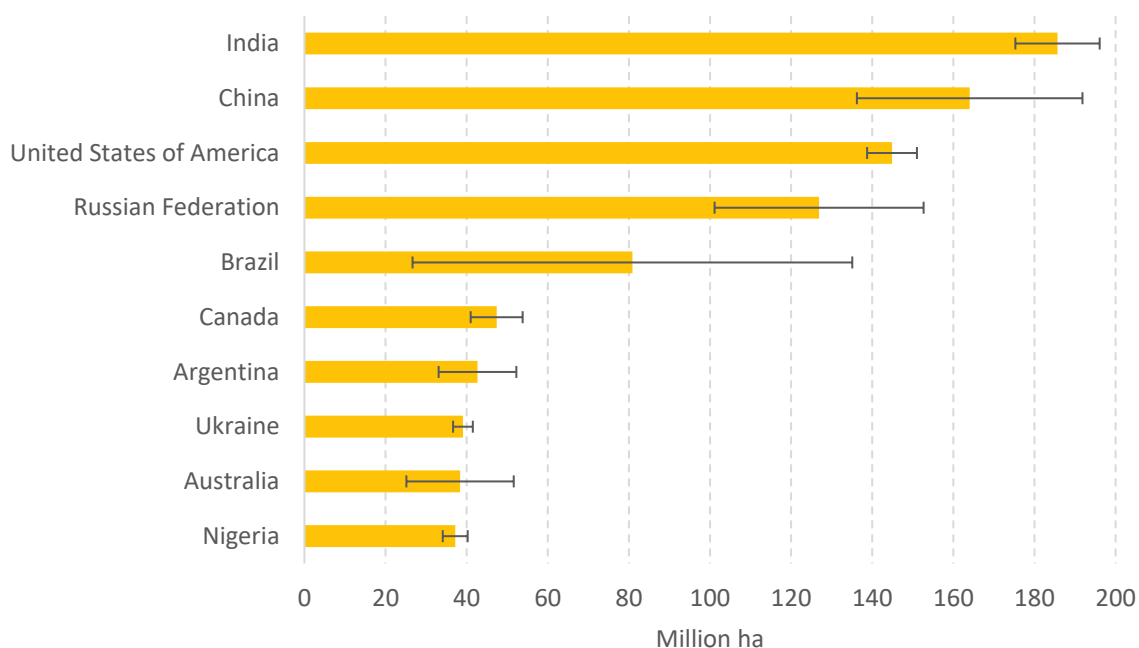
Figure 4: Regional land cover of herbaceous crops by source, 2019



Source: FAO, 2021d.

In 2019, India had the largest mean area of herbaceous crops (190 million ha) (Figure 5). China and the United States of America followed, with respectively 165 and 145 million ha, ahead of the Russian Federation with nearly 130 million ha and Brazil with about 80 million ha. The remaining countries in this ranking (Canada, Argentina, Australia, Ukraine, Australia and Nigeria) ranged between 40–50 million ha each. The countries where the three datasets agreed more closely were the United States of America (4 percent relative error), India and Ukraine (6 percent each). Large variations were found for Brazil (67 percent) and Australia (34 percent), possibly due to the significant heterogeneity of cropping systems in these two countries, spanning a large range of agri-climatic zones and management types. Country case studies are needed to further investigate the reasons for such large discrepancies and thus improve the precision of land cover information.

Figure 5: Top ten countries by mean herbaceous crops area, in 2019



Source: FAO, 2021d.

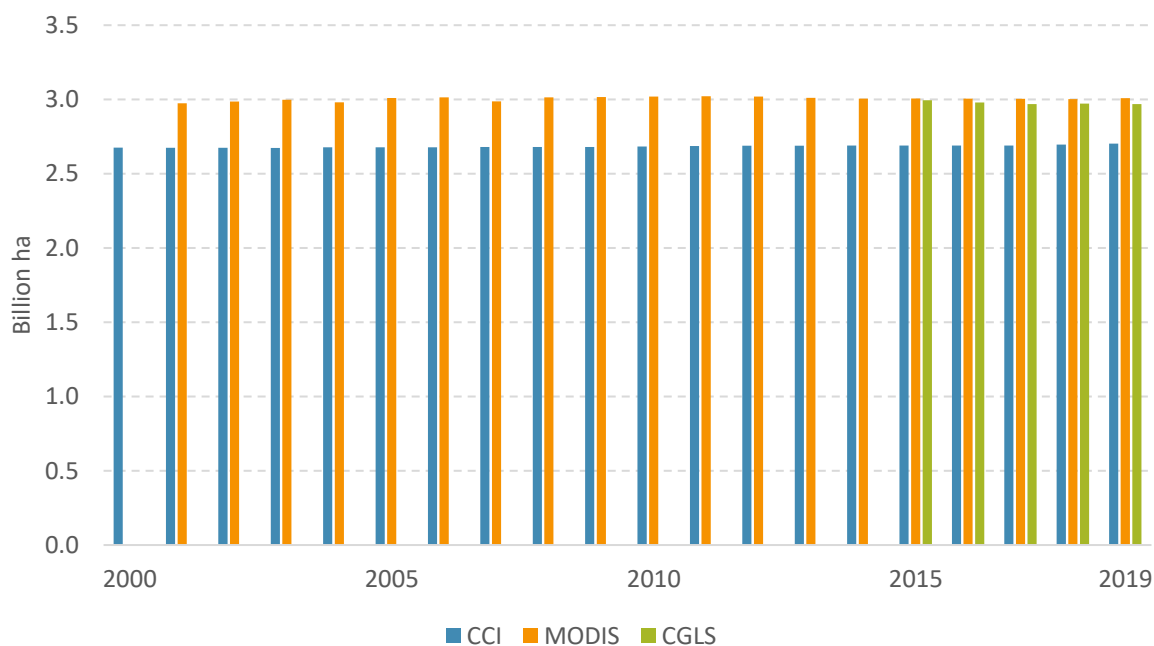
OTHER LAND COVER CLASSES

Grassland and shrub-covered area

In 2019, the global mean grassland land cover area was 2.9 ± 0.15 billion ha. Values ranged between 2.7 billion ha (CCI) and 3 billion ha (MODIS and CGLS) (Figure 6), resulting in a 5 percent error. The overall temporal trends were not significant across the three products.

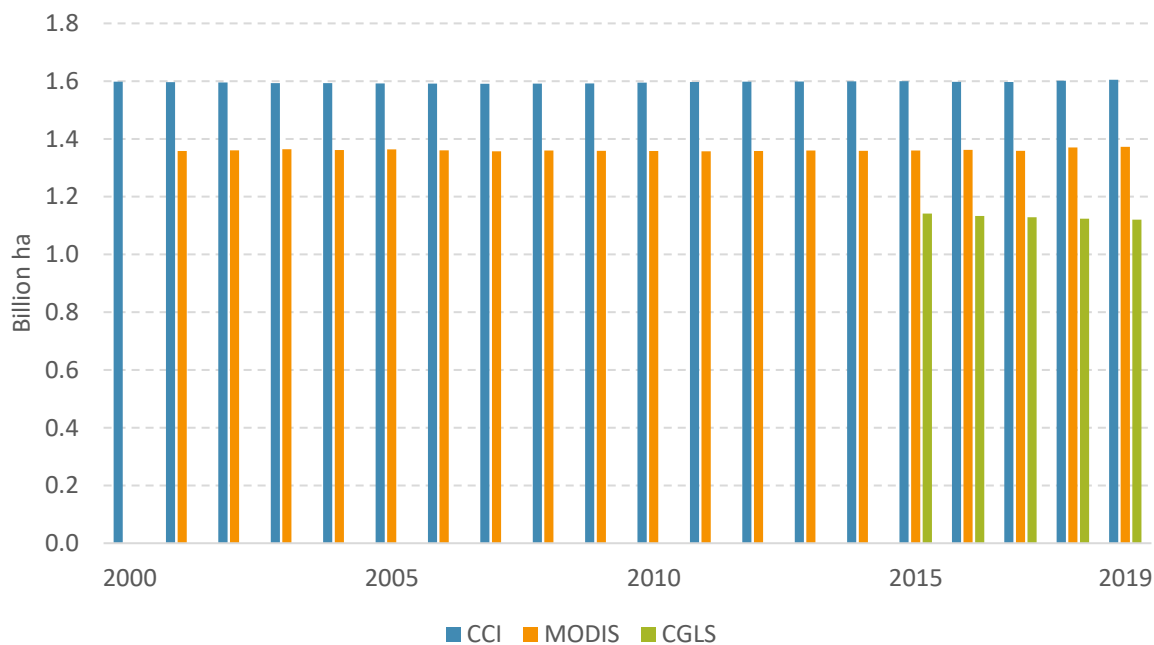
In 2019, the global mean shrub-land area was 1.4 ± 0.25 billion ha. Values varied ranged from 1.1 (CGLS) to 1.4 (MODIS) and 1.6 (CCI) billion ha (Figure 7), with an error of 18 percent. CCI and MODIS data did not record significant trends for the period 2001–2019, whereas CGLS showed a reduction of about 2 percent during 2015–2019.

Figure 6: Global land cover of grassland by source



Source: FAO, 2021d.

Figure 7: Global land cover of shrub-land by source

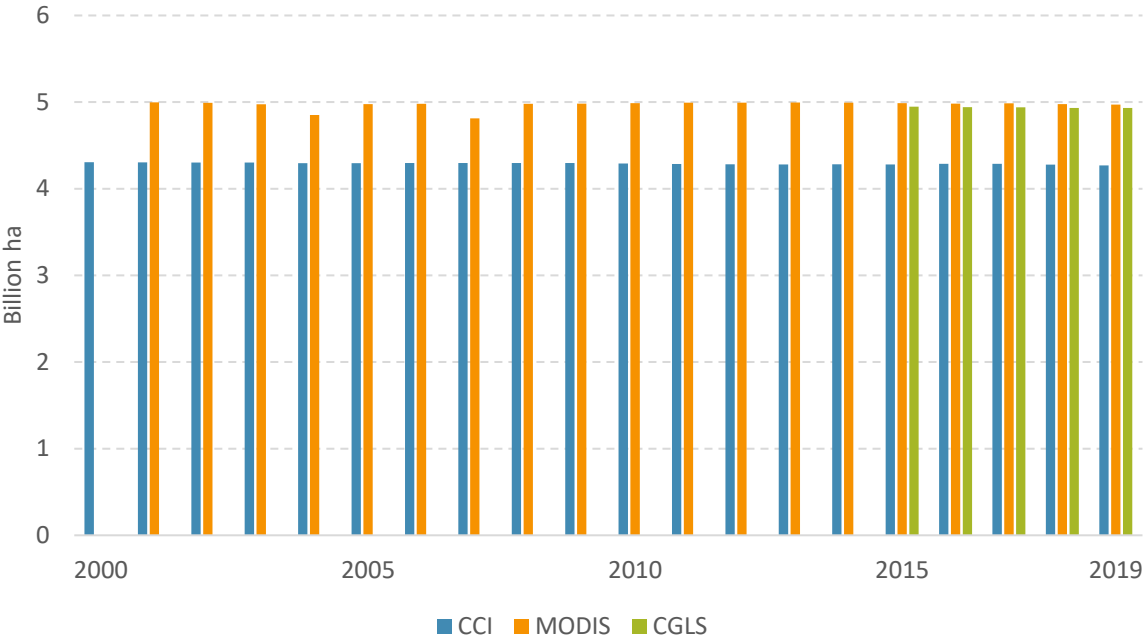


Source: FAO, 2021d.

Tree-covered areas

In 2019, global mean tree-covered area was 4.8 ± 0.33 billion ha. Values varied ranged from 4.3 (CCI) to 5.0 (MODIS and CGLS) billion ha (Figure 8), with a 7 percent error. Trends indicate a decline in global tree coverage.

Figure 8: Global tree-covered area by source



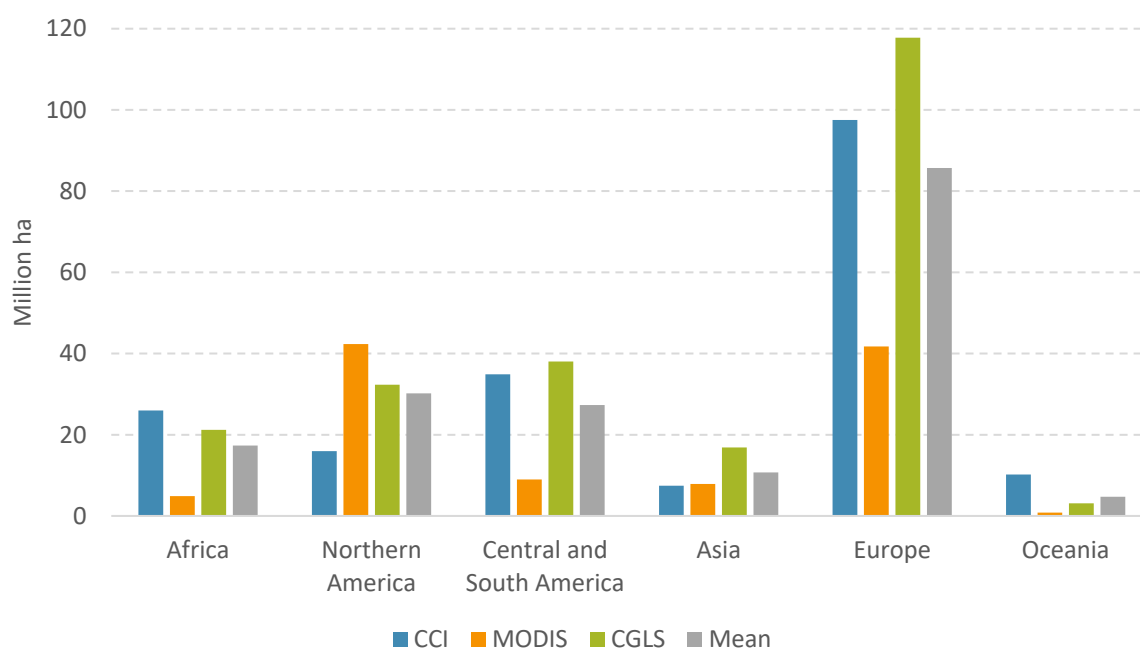
Source: FAO, 2021d.

Mangrove forests as a land cover class were mapped separately by both CCI and MODIS, but not CGLS. Data show good agreement between the two products in 2019, with a narrow range between 18.5 (CCI) and 20 (MODIS) million ha.

Wetlands

In 2019, the global mean wetlands area was 177 ± 62 million ha. According to all datasets (Figure 9), Europe (including the Russian Federation) had the largest area of wetlands, at 86 ± 38 million ha (44 percent error). Northern America was the second largest region by extent of wetlands, at 30 ± 13 million ha (also 44 percent error), similarly to Central and South America, with an area of 27 ± 15 million ha (53 percent error). Smaller total areas were estimated, with larger relative errors, in Africa, with 17 ± 11 million ha (61 percent), Asia had a wetland area of 11 ± 5 million ha (44 percent error) and Oceania had 4.7 ± 4.7 million ha (99 percent).

Figure 9: Regional land cover of wetlands by source, 2019

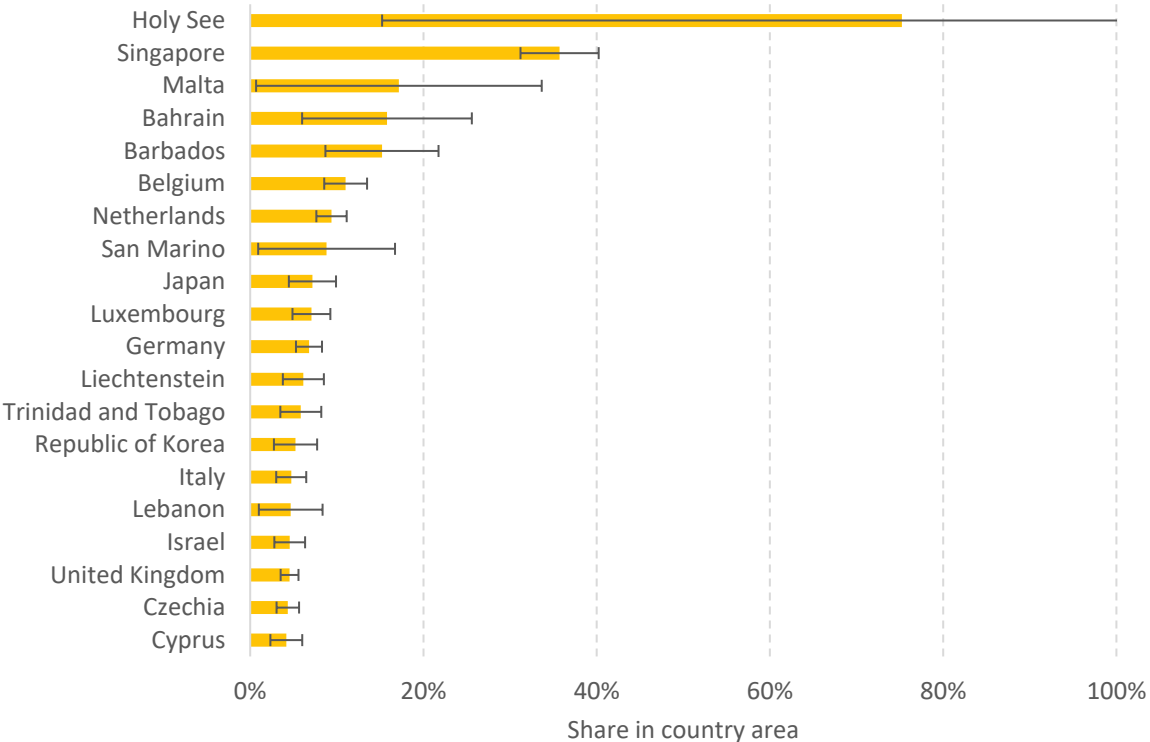


Source: FAO, 2021d.

Built-up areas

In 2019, the top 20 countries by share of artificial surfaces to total country area included very small countries, for instance the Holy See and Singapore (Figure 10) as well as larger countries in significantly urbanized regions (e.g. Belgium, the Netherlands, Germany and Italy). Large relative errors were associated to the difficulty of mapping this relatively less represented class of land cover, which covers on average less than 1 percent of the global land. CCI typically mapped less built-up areas than MODIS except for Bahrain, the Holy See, Malta and San Marino. CGLS typically recorded larger areas than the other two products, possibly due to higher spatial resolution than CCI and MODIS.

Figure 10: Top 20 countries by average share of built-up in total country area and errors, 2019



Source: FAO, 2021d.

COMPARING LAND COVER TO LAND USE INFORMATION

Land cover statistics can be used to gap fill missing country information on land use, including for quality control/quality assurance of land use country data reported to FAO (FAO, 2021a, 2021b, 2021c). This analysis found good agreement at the global level between land cover and land use information for the major land use classes in FAOSTAT (FAO, 2021a) (Figure 11). For arable land, which represents land use for annual crops including fallow, and thus corresponds roughly to herbaceous crops as land cover, FAOSTAT land use statistics were 1.4 billion ha in 2019, compared to 1.5 ± 0.3 billion ha of herbaceous crops area. Forest land was 4.1 billion ha in 2019, compared to 4.7 ± 0.3 billion ha of tree-covered area. The overestimate of the land cover information was in this case expected because tree-covered areas may include areas outside of forest land (intended as land use), for instance trees within land used for agriculture, such as woodlands and rangelands used by livestock. Land use for permanent meadows and pastures was 3.2 billion ha in 2019, compared to 4.0 ± 0.5 billion ha of the total covered by grassland and shrub-covered areas. Land cover information also tends to overestimate land use in such a case, since the latter likely also includes land not grazed by livestock. Finally, there was good agreement for inland waters between land cover and land use information. The land use data indicated in 2019 was 430 million ha, compared to 360 ± 75 million ha from land cover products.

Figure 11: Comparison of land cover and land use statistics, 2019

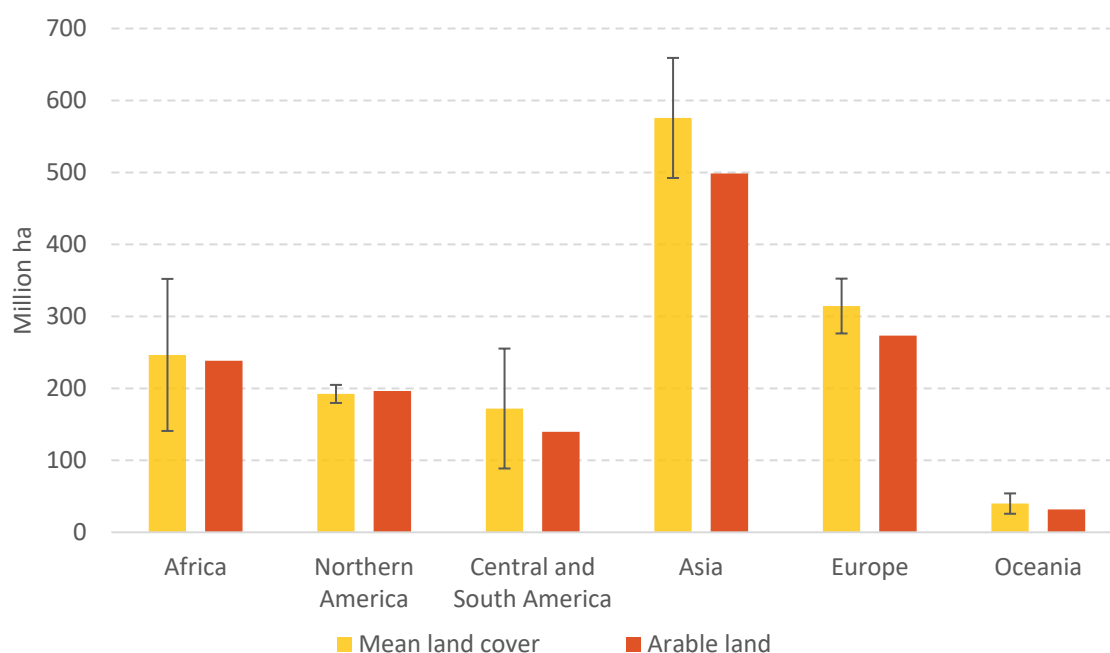


Note: For land cover, the mean and absolute error of three land cover products are shown.

Source: FAO, 2021a, 2021d.

A good correspondence between the herbaceous crops cover and arable land use can be observed in almost all regions, thus confirming the good agreement between land cover and land use information (Figure 12). In Northern America, the arable land was 196 million ha, well within the range of the herbaceous crops cover (192 ± 12 million ha). Likewise, the comparison gathered similar results in Oceania where the arable land was 32 million ha and within the range of the herbaceous crops (40 ± 14 million ha). In Africa, the herbaceous crops were 246 ± 106 million ha, thus with a large variability between the three sources of land cover. At the same time, the average crop cover was very similar to the area of arable land (239 million ha).

Figure 12. Regional comparison of herbaceous crop cover and arable land use statistics, 2019



Note: For land cover, the mean and absolute error of three land cover products are shown.

Source: FAO, 2021a, 2021d.

EXPLANATORY NOTES

The FAOSTAT [Land Cover](#) statistics are available for 198 countries and 41 territories over 1992–2019. The domain provides statistics of land cover area, aggregated at the national level by country for the 14 land cover classes adopted by the UN System for Environmental-Economic Accounting (United Nations, European Commission, Food and Agricultural Organization of the United Nations, International Monetary Fund, Organisation for Economic Co-operation and Development and World Bank, 2014; FAO and UNSD, 2020), based on FAO Land Cover Classification System (LCCS) classifiers (Di Gregorio, 2005). Land cover statistics are computed by FAO from annual maps of three medium-resolution global land cover products. All three datasets have been validated by their data producers and statistics of overall accuracy, measured globally for all classes and including commission and omission errors, were produced. The three source of land cover are:

1) CCI Land Cover. Catholic University of Louvain (UCLouvain) Geomatics land cover, produced as part of the Climate Change Initiative of the European Spatial Agency and currently under the framework of the European Copernicus Climate Change Service (C3S) (Defourny *et al.*, 2017) available for 1992–2018. These maps have a spatial resolution of 300m. Data validation indicates an overall accuracy of 73 percent;

2) MODIS-LCCS. NASA MODIS Land Cover Collection 6 (MCD12Q1), available for 2001–2018 (Sulla-Menashe and Friedl, 2018; Sulla-Menashe *et al.*, 2019). MODIS Land Cover Classification System (LCCS) types at 500m resolution are used to compute the FAOSTAT data. The overall accuracy for the MODIS LCCS layers is 80 percent;

3) Copernicus Global land cover produced under the Copernicus Global Land Service (CGLS), available for 2015–2019 (Buchhorn *et al.*, 2020) with a spatial resolution of 100m. FAOSTAT statistics utilize CGLS discrete land cover maps but this dataset also contains fractional land cover information. The overall accuracy of this product is 81 percent.

Based on corresponding LCCS classifiers and following a mutually exclusive approach, the land cover classes of the MODIS, CCI and CGLS images were mapped to SEEA land cover classes (Table 1), when the original land cover legends made possible this translation. The harmonized dataset aligns well with FAO efforts towards a standard system of land cover classification (O’ Brien *et al.*, 2021).

Table 1. SEEA land cover classes and correspondence to the three land cover products used in FAOSTAT

SEEA Class value and label	CCI	MODIS	CGLS
1. Artificial surfaces (including urban and associated areas)	✓	✓	✓
2. Herbaceous crops	✓	✓	✓
3. Woody crops	✓	n.a.	n.a.
4. Multiple or layered crops	n.a.	n.a.	n.a.
5. Grassland	✓	✓	✓
6. Tree-covered areas	✓	✓	✓
7. Mangroves	✓	✓	n.a.
8. Shrub-covered areas	✓	✓	✓
9. Shrubs and/or herbaceous vegetation, aquatic or regularly flooded	✓	✓	✓
10. Sparsely natural vegetated areas	✓	n.a.	n.a.
11. Terrestrial barren land	✓	✓	✓
12. Permanent snow and glaciers	✓	✓	✓
13. Inland water bodies	✓	✓	✓
14. Coastal water bodies and intertidal areas	n.a.	n.a.	✓

Source: Authors’ own elaboration based on the SEEA classification.

A complete description of the methodology is available under the “Related documents” section of each domain as well as in FAO (2021c). For this analysis, we note the following:

Herbaceous crops and woody crops. The SEEA land cover legend includes three classes of crop cover: 1) ‘**Herbaceous crops**’, 2) ‘**Woody crops**’ and 3) ‘**Multiple or layered crops**’. The SEEA defines the first category as *herbaceous cultivated plants such as graminoids or forbs (including those used for hay) which do not last for more than two growing seasons*. In the SEEA, the ‘woody crops’ are defined as *being composed of permanent tree or shrub crops. Fruit trees, coffee and tea plantations, oil palm and rubber plantations, Christmas trees fall in this category*. Thirdly, the SEEA describes the ‘multiple or layered crops’ as *situations in which there may be two layers of herbaceous and woody crops (e.g. wheat fields under olive trees as in the Mediterranean area) or cropping systems in which one layer of natural tree vegetation covers another layer of cultivated crops (e.g. coffee plantations shadowed by natural trees in the equatorial area of Africa)*. CCI is the only land cover that provides, albeit with limited geographical coverage, specific information on the distribution of woody crops. Conversely, both MODIS and CGLS map the perennial woody crops as natural vegetation under the appropriate tree or shrub-land cover types. Information on the third agricultural class is currently

unavailable. Due to these limitations, the analysis compares the three land cover products for the class of herbaceous crops, which is common to all three datasets.

Tree-covered areas. In the SEEA definitions, the **tree-covered** class includes *trees with a cover of 10 percent or more within the pixel, even if other land cover types, including grassland and shrub-covered areas, may represent the majority within that pixel. Areas planted with trees for afforestation purposes and forest plantations are included in this class. This class includes areas seasonally or permanently flooded with freshwater but excludes coastal mangroves, which are classified separately.*

Grassland and shrub-land. The SEEA land cover defines **grassland** as *natural herbaceous plants (grasslands, prairies, steppes, and savannahs) where grasses cover 10 percent or more of the land. Woody plants (trees and/or shrubs) can be present, assuming their land cover is less than 10 percent.* For CCI only, the SEEA class sparsely natural vegetated areas is also included under grassland.

According to the SEEA, **shrub-covered areas** (shrub-land hereafter) include *natural shrubs having with cover of 10 percent or more. Trees can be present in scattered form as long as their cover is less than 10 percent; grasses can be present at any density. The class also includes shrub-covered areas permanently or regularly flooded by fresh water, but not those flooded by salt or brackish water in coastal areas.*

Wetlands. The SEEA defines **shrubs and/or herbaceous vegetation, aquatic or regularly flooded** (hereafter described as wetlands) as the land cover class that includes *any geographical area dominated by natural herbaceous vegetation (cover of 10 percent or more) that is permanently or regularly flooded by fresh or brackish water (swamps, marsh areas, etc.). Flooding must persist for at least two months per year to be considered regular.*

Built-up areas. The SEEA defines the class **artificial surfaces (including urban and associated areas)** as the land cover *composed of any type of areas with a predominant artificial surface. Any urban or related feature is included in this class, for example, urban parks (parks, parkland and laws).* The class (hereafter named built-up areas) also includes *industrial areas, and waste dump deposit and extraction sites.*

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