# Soil Organic Carbon

**Indicator name** **Soil organic carbon indicator (SOCI)**

**Indicator unit** Amount of carbon stored in the soil (0 to 30 cm depth), expressed in Mg (megagrams or tonnes) per $km^2$.

**Area of interest** The SOCI has been calculated in DOPA for each terrestrial and coastal protected area of size ≥ 25 $km^2$.

**Related targets**

Sustainable Development Goal 2 on zero hunger

Sustainable Development Goal 13 on climate action

Sustainable Development Goal 15 on life on land

Aichi Biodiversity Target 11 on protected areas

Aichi Biodiversity Target 15 on contribution to carbon stocks

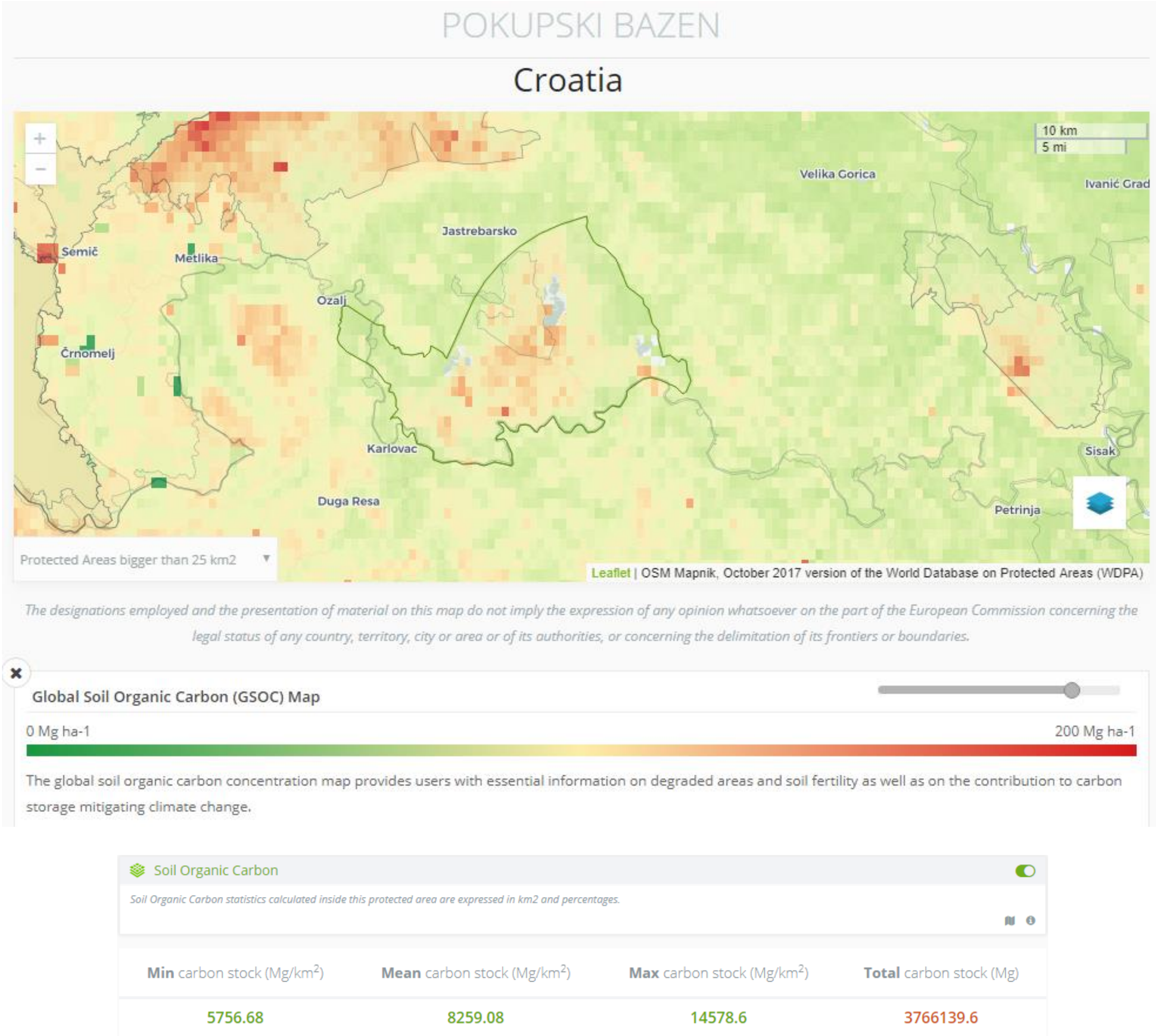
**Policy question** There are two main policy questions to which the SOCI indicator is relevant:

- How do protected areas contribute, through the conservation of soil resources, to the fertility, health and productivity of the ecosystems and to the livelihoods of the local communities that depend on these resources? Soil organic carbon (SOC) is the main component of soil organic matter, which is critical for the stabilization of soil structure, retention and release of plant nutrients, and water infiltration and storage in soil. SOC is therefore essential to ensuring soil health, fertility and food production. The loss of SOC indicates a certain degree of soil degradation, and can happen through unsustainable management practices such as excessive irrigation or leaving the soil bare, without significant vegetation cover.
- How do protected areas contribute to soil carbon storage and hence to offset the impacts of fossil fuel emissions and to climate change mitigation? Soils represent the largest terrestrial organic carbon reservoir. Carbon stored in soils worldwide exceeds the amount of carbon stored in phytomass and in the atmosphere, and is the second largest global carbon store (sink) after the oceans. Changes in land use and land cover can cause SOC decreases and carbon emissions, which are one of the largest sources of human-caused carbon emissions to the atmosphere. Protected areas

may contribute to soil carbon retention and hence to the reduction of net emissions of greenhouse gasses responsible for climate change.

**Use and interpretation**

Soil organic carbon (SOC) is the carbon that remains in the soil after partial decomposition of any material produced by living organisms. Depending on local geology, climatic conditions and land use and management (amongst other factors), soils hold different SOC amounts. DOPA Explorer provides maps of SOC and summary statistics of the SOC distribution at country, ecoregion and for all protected areas not smaller than 25 km$^2$ as illustrated in Figure 1.




| Min carbon stock (Mg/km²) | Mean carbon stock (Mg/km²) | Max carbon stock (Mg/km²) | Total carbon stock (Mg) |
|---|---|---|---|
| 5756.68 | 8259.08 | 14578.6 | 3766139.6 |

**Figure 1.** Map and summary statistics of soil organic carbon content overlaid by a protected area as displayed in DOPA Explorer.

The largest amounts of SOC are stored in the northern permafrost region, mostly in peat soils, where carbon accumulates in soils in huge quantities due to the low temperatures leading to low biological activity and slow decomposition of soil organic matter. In contrast, in dry and hot regions, plant growth is naturally scarce and only very little carbon enters the soil, leading to low SOC content. Climate change can also alter SOC levels, in contrasting magnitudes and directions depending on the considered regions.

Land cover and land use also have an important influence on SOC. Conversion of natural vegetation to cropland can cause large decreases in SOC levels. Unsustainable agricultural management practices such as excessive irrigation or leaving the soil bare are also drivers of important SOC losses, while the opposite is true for practices associated to sustainable soil management, such as mulching, planting cover crops, reduced or no tillage, moderate irrigation and judicious fertilization (Scharlemann *et al.*, 2014; FAO and ITPS, 2018a, 2018b) .

The SOCI provides useful information about the soil condition in protected areas, particularly when compared with other unprotected areas with similar environmental conditions, such as the unprotected buffers around protected areas. This information can contribute to identify potentially degraded areas, evaluate the conservation performance of protected areas, set restoration targets, and assess the contribution of protected areas to reduce net global carbon emissions.

**Key caveats**

The Global Soil Organic Carbon (GSOC) map (FAO and ITPS, 2018a, 2018b), which has been used to obtain SOCI, only provides data on carbon stocks up to a depth of 30 cm. In parts of the world, however, organic soils can be up to 11 m deep, and they therefore contain more organic carbon than what is indicated by the GSOC map. For this reason, it is highly probable that SOCI underestimates the total amount of SOC, although the estimates it provides have been obtained using, for all locations, a common soil depth (0-30 cm), which therefore allows for comparisons across locations on that basis.

The global soil carbon map (GSOC) is based on national SOC maps and national soil sampling schemes, which may differ in their sampling period, intensity and spatial distribution. In addition, even when all countries have followed a common methodological approach to derive the national SOC maps, there might be national specifies and differences in the details of the approaches used to produce the 1 km resolution maps from the soil sampling data. All these reasons suggest the need for caution in the comparison of the SOCI values for protected areas located in different countries.

SOC mapping involves making predictions or extrapolations at locations where no soil measurements were taken. This inevitably leads to some prediction errors because soil spatial variation is the result of a complex set of factors and processes that cannot be modeled perfectly at a national or global level. Given that the soil sampling schemes are commonly focused preferentially on areas for agricultural production, the number of soil samples taken within protected areas may be low in different countries. This would imply that the SOCI values are more largely based on predictions, rather than on actual measurements, in these protected areas compared to agricultural-dominated areas.

Because the SOCI is computed within the boundaries for each protected area with a size of at least 25 $km^2$, results will be affected by the accuracy of the available protected area boundaries.

**Indicator status**

The GSOC map, developed by FAO, is publicly available for visualization and download at http://54.229.242.119/GSOCmap, and is described in detail in FAO and ITPS (2018b) and in the information available at http://www.fao.org/global-soil-partnership/pillars-action/4-information-and-data-new/global-soil-organic-carbon-gsoc-map. The assessment of SOCI in protected areas has not been published but a similar approach can be found in Campbell et al. (2008).

## Available data and resources

**Data available** SOCI values are available for each protected area of size ≥ 25 km$^2$ and can be compared at country and ecoregion levels, on the DOPA Explorer website: http://dopa-explorer.jrc.ec.europa.eu/dopa_explorer/.

**Data updates** Planned with each update of DOPA.

**Codes** Standard GIS operations applied to vector and raster data.

## Methodology

**Methodology** The SOCI is based on the information provided by the global soil organic carbon (GSOC) map (version 1.2.0), which quantifies, with a spatial resolution of 1 km, the amount of organic carbon (Mg/km$^2$) stored in the soil worldwide, considering a soil depth of up to 30 cm. The GSOC map was produced through a participatory approach in which countries developed their capacities and stepped up efforts to compile all the available soil information at the national level. It is the result of the combination of national SOC maps, with one SOC map developed independently in each country but following a common methodological approach for all countries. The GSOC map, and hence the SOCI values, build on the information from soil samples were carbon measurements were made in each country. The information from these samples was used to build, in each country, a full continuous SOC map through predictions or extrapolations, involving covariates that were shown to be related to SOC levels in the sampled locations and hence useful to provide SOC estimates in the unsampled locations.

The GSOC map data, with a spatial resolution of 1 km, were overlaid with the boundaries of each terrestrial or coastal protected area of size ≥ 25 km$^2$ to calculate the minimum, maximum and mean (Mg km$^{-2}$) SOC within each protected area or their surrounding buffers, as well as the total SOC stored (Mg) in each protected area. UNESCO Biosphere Reserves were discarded as well as protected areas with known areas but undefined boundaries. Only the part of the buffer around each protected area that does not overlap with other protected areas is considered; therefore, there might be cases of protected areas with no SOCI information in their buffer area, when such buffer area fully overlaps with other surrounding protected areas.

**Input datasets** The indicator uses the following input datasets:

Protected Areas

- WDPA of July 2018 (UNEP-WCMC & IUCN, 2018).
    - Latest version available from: www.protectedplanet.net

Soil Organic Carbon

- Global Soil Organic Carbon (GSOC) map (FAO and ITPS, 2018a, 2018b)
    - Available at: http://www.fao.org/global-soil-partnership/pillars-action/4-information-and-data-new/global-soil-organic-carbon-gsoc-map

**References**

Campbell, A., *et al.* (2008). *Carbon storage in protected areas*. Technical report. UNEP World Conservation Monitoring Centre. https://archive.org/details/carbonstorageinp08camp/page/3

FAO and ITPS. (2018a). *Global Soil Organic Carbon Map (GSOC map)* Version 1.2.0 - Leaflet. Rome, Italy. 5 pp.

FAO and ITPS. (2018b). *Global Soil Organic Carbon Map (GSOC map)* - Technical Report. Rome. 162 pp.

Scharlemann, J.P.W., Tanner, E.V.J., Hiederer, R., & Kapos, V. (2014). Global soil carbon: understanding and managing the largest terrestrial carbon pool. *Carbon Management*, 5: 81-91, https://doi.org/10.4155/cmt.13.77

**Contact**

Please contact us at: JRC-DOPA@ec.europa.eu

**Factsheet last updated**

March 25, 2019

@EU_DOPA