# CSF.Ind - Climate Smart Forestry (CSF) Indicators Generator

## Background

The Climate Smart Forestry (CSF) Indicators Generator (CSF.Ind) is a user-friendly Shiny web app designed to calculate CSF indicators using forest inventory data (e.g., field surveys or remote/proximal sensing forest inventory data) at tree, plot or stand levels. The app allows users to select an indicator from the two CSF pillars and configure the analysis for one or more plots. When provided with the required data, the app generates outputs organized by forest management intensity, forest types, and other options. It is particularly useful for forestry technicians, stakeholders, researchers, and the public who are not familiar with climate-smart forestry assessment. CSF.Ind calculates indicators aligned with the mitigation and adaptation pillars of CSF. The generated output is specific to a given time, and when computed across multiple periods, it can be used to create composite maps of the CSF indicators.

Link GIT Framework: [https://github.com/Cesarito2021/CSF.Ind.git](https://github.com/Cesarito2021/CSF-Ind.git)

## Requested data

Specific input data in an Excel file (table format) is required to generate CSF indicators using the CSF.Ind web-app. A detailed list of input data includes (Table 1):

Table : List of variables required for running the web app.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *ID* | *Mandatory input data* | *ID* | *Recommendend input data* | *ID* | *Optional input data* |
| *1* | *IDPlot (order number),* | *10* | *ForManInt (Forest management intensity)* | *15* | *Area of Interest (AOI) boundary (.shp)* |
| *2* | *CoordsPlot (Lat., Long.)* | *11* | *TimeLastSilv (Time from last silvicultural intervention)* | *16* | *Single Plots boundary (.shp)* |
| *3* | *PlotArea (m²)* | *12* | *Standing Deadwood components (2 vars)* |  |  |
| *4* | *IDTree (order number)* | *13* | *Lying Deadwood components (2 vars)* |  |  |
| *5* | *TreeDiameter (cm)* | *14* | *CoordsTree (x, y, of IDTree* |  |  |
| *6* | *TreeHeight (m)* |  |  |  |  |
| *7* | *EUForestTypes (see Section 3)* |  |  |  |  |
| *8* | *TreeSpecies (see Section 3)* |  |  |  |  |
| *9* | *BasalArea (m2/Tree).* |  |  |  |  |

***Variables explanation***

Mandatory data:

1. ***PlotArea*** (m²): size of plot area. (A unique value is required for all plots, as it will be presented as a slider button)
2. ***IDPlot*** (order number): Identify number for each field plot;
3. ***CoordsPlot*** (Lat., Long. of IDPlot): provide the coordinates (WGS84 or ETRS89-extended / LAEA Europe) of the centroid of plot.
4. ***IDTree*** (order number), Identify number for each tree;
5. ***TreeDiameter*** (cm);
6. ***TreeHeight*** (m);
7. ***EUForestTypes*** (see Section 3);
8. ***TreeSpecies*** (see Section 3);

Recommended data:

1. ***ForManInt*** (Forest management intensity based on Dunker et al., 2012 - <http://dx.doi.org/10.5751/ES-05262-170451>):

* P - Passive - Unmanaged forest nature reserve (no harvesting, 0%)
* L - Low - Close-to-nature forestry (single or group selection, <20%)
* M - Medium - Combined objective forestry (shelterwood - coppice with standards 40-70%)
* H - High - Intensive even-aged forestry (clearcut, 70-100%)
* I - Intensive - Short rotation forestry (short-rotation forestry, 100%).
* NA

1. ***TimeLastSilv*** (Time from last silvicultural intervention; Gasparini et al. 2022):

* A - <10 years,
* B - 11-20 years
* C - 21-30 years
* D - 31-40 years
* E - 41-80 years
* F - 81-120years.
* G - >120 years,
* NA

1. ***CoordsTree***: xCoords, yCoords for IDTree (WGS84 or ETRS89-extended / LAEA Europe);
2. **Deadwood components** (see Section 3):

Standing Deadwood:

**4.1 *TreeHeightDW*** (m): this is a request for stump or snag (cm)

**4.2 *TreeDiameterDW*** (cm): this is a request for stump or snag (cm);

Lying Deadwood: When the half-diameter is supplied, “mindialog” and “maxdialog” are not required.

***4.3 LengthLog*** (m): Length of log (m)

* 1. ***MinDiaLog***: Minimum diameter of lying trees (cm; ≥10cm);
  2. ***MaxDiaLog***: Maximum diameter of lying trees (cm; ≥10cm);
  3. ***Half***-DiaLog: Half-diameter of log.

Optional:

1. ***AOI\_stand***: Area of Interest (AOI) boundary (.shp): shapefile of the forest stands;
2. ***AOI\_plots*:** Single Plots boundary (.shp): shapefile of the sampling plots

## Consideration for Input data

Before compiling the input dataset in a table format i.e., an Excel (.xlsx) document, providers must verify specific details (Table 2):

* European Forest types (Abb EUForestTypes): Please select the relevant forest type from the European forest types nomenclature. Most precisely we used the categories extracted by table 4.1., pg 28 of the European forest types categories and types for sustainable forest management reporting and policy (technical report EEA 2006 here: https://www.eea.europa.eu/publications/technical\_report\_2006\_9). The list of EU Forest Types is provided in the Excel supplementary document.
* Tree species (Abb. TreeSpecies): Please use the English name of the dominant tree species or add “mixed” if no dominant tree species are present. Examples: 1) “Scots Pine”, 2) “Norway Spruce”, and other single tree species, and 3) the option “mixed” is represented by “Broadleaf Mixed” (mixed of broadleaf trees) or “Conifer Mixed” (mixed of conifer trees) or “BC Mixed” (mixed of broadleaf and conifer trees)(Federici et al., 2008). The list of tree species is provided in the Excel supplementary document.
* Five-decay classes for deadwood: the state of decomposition should be classified in the field into one of five-decay classes based on simple characteristics of the deadwood (Hunter et al 1990; Gasparini et al., 2022):
  + RD - recently dead - Bark still attached.
  + WD - weakly decayed - Bark is loose but not fragmented.
  + MD - medium decayed - Bark is fragmented. Wood

consistency reduced but the log still has a hard core.

* + VD - very decayed - Bark absent. Rotten throughout the log.
  + D - decomposed - Bark absent. Wood consistency is lost (dust).

Overall, the input variables allow to assess some CSF indicators namely: ***growing stock***, ***carbon stock***, ***lying and standing deadwood***, ***age structure and/or diameter distribution*** (Table 2), obtaining several output data very helpful for additional elaboration concerning the forest structure, as well as mitigation and adaptation.

Table 2: Climate Smart Forestry (CSF) indicators generated by the “CSF.Ind” web-based app. Filling the “TreeSpecies” task requires a reading consideration section. All input data containing \*\* are slider buttom and not column data.

|  |  |  |  |
| --- | --- | --- | --- |
| Climate Smart Forestry (CSF) dataset | | | |
| Pillars | Indicator | Input Data | Output data |
| Mitigation | Growing Stock (single and multi-plots) | 1. IDPlot (order number), 2. IDTree (order number), 3. PlotArea (m2)\*\* 4. TreeHeight (m), 5. TreeDiameter (cm), 6. TreeSpecies. 7. ForManInt. | 1. Vol\_m3\_ha: forest volume regarding the volume of stem and large branches (diam.>=5cm, m3/ha), 2. DomTreeSpecies: Dominant Tree Specie. |
| Carbon Stock (single and multi-plots) | 1. IDPlot (order number), 2. IDTree (order number), 3. PlotArea (m2)\*\*, 4. StandVolume (corresponding to Vol\_m3\_ha), 5. DomTreeSpecies. 6. ForManInt. | 1. AGB\_tn\_ha: aboveground biomass (tons/ha), 2. CS\_tn\_ha: Carbon Stock (tons/ha). |
| Lying  Deadwood (multi-plots) | 1. IDPlot (order number), 2. IDTree (order number), 3. PlotArea (m2)\*\*, 4. LengthLog (Length of logs; m), 5. MinDiaLog (Min Ø of log ; cm), 6. MaxDiaLog (Max Ø of log; cm), 7. or (Half-Dia (cm)) 8. ForManInt. | 1. LDT: Lying Deadwood Tree (m3/ha), 2. CWD: Coarse woody debris (CWD) (m3/ha), 3. SDT: Standing Deadwood Tree (m3/ha), 4. SNAG: Snag deadwood (m3/ha), All deadwood (m3/ha). |
| Standing Deadwood (multi-plots) | 1. IDPlot (order number), 2. IDTree (order number), 3. TreeHeightDW (m), 4. TreeDiameterDW (cm). 5. ForManInt. |
| Adaptation | Age structure and/or diameter distribution (multi-plots) | 1.IDPlot (order number),  2.IDTree (order number),  3.PlotArea (m2)\*\*,  4.TreeHeight (m),  6.TreeSpecies,  7.ForManInt. | 19 Diversity Indices:   1. Mean\_dbh: mean of diameters at tree height (cm), 2. Mean\_th = mean of tree heights (m), 3. Sum\_ba: sum of basal area ( m2), 4. N\_sp: number of tree species, 5. SI\_dbh: Simpson of diameters at tree height, 6. SH\_dbh: Shannon-Weiner of diameters at tree height , 7. SD\_dbh: standard deviation of diameters at tree height , 8. GI\_ba: Gini of basal area, 9. CV\_ba: coeficient of variation of basal area, 10. SD\_th: standard deviation of tree heights, 11. CI\_1000: complex index at 1000m2, 12. SHsp: Shannon-Weiner of tree species, 13. SH\_th: Shannon-Weiner of tree heights, 14. SI\_sp: Simpson of tree species, 15. SDI. Stand Density Index, 16. TDD: Tree Diameter Diversity, 17. THD: Tree Height Diversity, 18. VEm: Vertical Evenness Index, 19. VarDH: difference of diameter and height. |

## CSF output organization

The app allows users to generate outputs grouped by Forest Management Intensity (ForManInt) types or individual plots (Figure 1). Grouping results by ForManInt types provides the average values across the plots included within each ForManInt type. Grouping by plots, on the other hand, displays the actual values for each individual plot. Additional grouping levels can be included upon request.

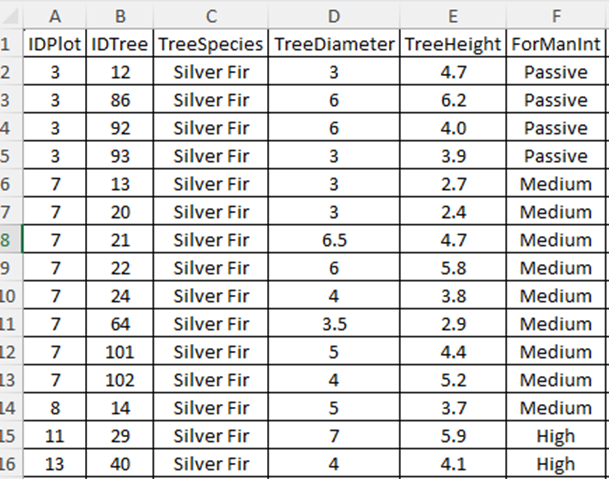
Immagine che contiene testo, Carattere, schermata, diagramma

Descrizione generata automaticamente

Figure : Scheme of the CSF indicator generation.

## Examples of input data organization

Example 1: the adequate organization of input column data in an Excel file (.xlsx) for estimating the “Growing stock” for multiple plots (similar to a single plot) is shown in the screenshot.



## Reference

Duncker, P. S., Barreiro, S. M., Hengeveld, G. M., Lind, T., Mason, W. L., Ambrozy, S., & Spiecker, H. (2012). Classification of forest management approaches: a new conceptual framework and its applicability to European forestry. Ecology and Society, 17(4).

Gasparini, P., Di Cosmo, L., Floris, A., & De Laurentis, D. (2022). Italian National Forest Inventory—Methods and Results of the Third Survey: Inventario Nazionale delle Foreste e dei Serbatoi Forestali di Carbonio—Metodi e Risultati della Terza Indagine (p. 576). Springer Nature.

Hunter, M. L. Wildlife, Forests and Forestry: Principles of Managing Forests for Biological Diversity; Englewood Cliffs, NJ, 1990; 370 pp.