EUROPEAN COMMISSION

EUROSTAT

Directorate E: Sectoral and regional statistics

Unit E-2: Environmental statistics and accounts; sustainable development

INCA TOOL
User's guide
1.1.0

Eurostat – Unit E2

Ecosystem accounting toolbox for Europe

Version : 1.1.0
Release date : November 2023

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1 Introduction

To facilitate the development and production of ecosystem accounts in Europe, a tool is provided that supports Member States towards the regular production of service accounts according to the Amendment on ecosystem accounting to the EU Legislation 691/2011 (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2022:329:FIN). The tool is based on the free QGIS package and provided as a plug-in to this tool. "INCA stands for 'Integrated Natural Capital Accounting' and it was a Knowledge and Innovation Project founded by the European Commission to develop experimental ecosystem accounts.

The INCA tool supports the development of ecosystem services accounts in a systematic way and can be applied at (regional,) country or continental level in Europe. The models are based on the INCA models originally developed by the JRC (https://ecosystem-accounts.jrc.ec.europa.eu/), and further refined by VITO (as contractor for Eurostat) on compliancy to the European ecosystem service guidelines. The tool is based on the availability of official European statistical inputs. These inputs may be changes by the user but requires compliancy with the official statistics for both syntax and semantics. **The tool does not include support to report ecosystem extent accounts, neither ecosystem condition accounts.**

This version of the tool, named 1.1, is an update of the first public version (1.0 in May 2023) to test on a voluntary basis the first four models as presented below by EU member states, led by Eurostat. This version of the tool includes 7 models in total to generate biophysical accounts. The first five models are based on and made compliant to the European guidelines, while the latter two models are exploratory based on the KIP-INCA models:

1. Crop provision service
2. Wood provision service
3. Global climate regulation service, including both carbon retention and carbon sequestration
4. Nature-based tourism recreation service
5. Air filtration service
6. Soil retention service
7. Flood control service

The INCA tool is made, wherever possible, compliant to the Guidance notes for ecosystem accounting, as part of the European Task force on ecosystem accounting. These guidelines are not yet finalized and hence include some open discussion topics that could result in revision of the models in the near future.

The INCA models do include some additional exploratory features (e.g. monetary valuation) which can only be activated through the command line console. The user is referred to the Developers manual to get more information on these features.

A second version of the tool is planned to further improve the available models and include additional models for:

- Crop pollination service

- Local climate regulation service

2 Getting started

The purpose of the INCA plugin is to configure the input files and parameters needed to calculate accounts for the different ecosystem services and start a computation or "run". A run produces accounts for a single service and a single year. You can load and save the INCA plugin settings as part of a QGIS project or save settings for a single service to a text file.

The reader is referred to the "INCA QGIS tool installation manual" to install the plugin. This manual supports INCA versions 0.3 or higher.

After a successful installation, you can start the INCA tool via the Plugins Menu, selecting INCA and Calculate NCA, as shown in Figure 1 below, or the INCA icon in the toolbar.

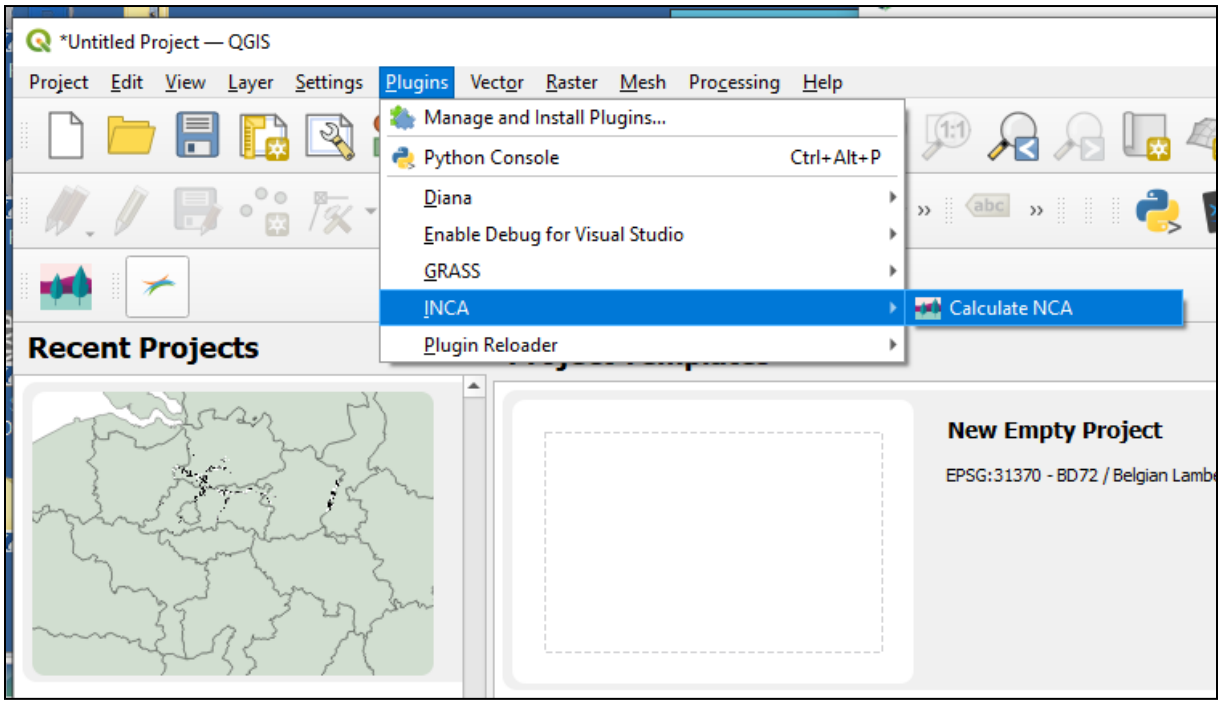


Figure 1: Starting the INCA plugin

Chapter 3 provides an overview of the INCA tool interface.

Chapter 4 explains how to deal with custom input data.

Chapter 5 explains for each ecosystem service the methodology references, the configuration parameters, the account output, the metadata form, the limitations, changes compared to previous version and a set of references to methodological papers.

Chapter 6 explains how errors are handled.

Chapter 7 (Annex) provides more detailed information on the format of database (csv) input files.

Note, the INCA tool keeps a log file `inca_<YYYYMMDD>.log` with errors and diagnostic messages for all runs started on the same day. A user is allowed to remove (clean start) or rename (store) this log file.

- On Windows, the log file is written to the %**AppData**% directory, typically `C:\Users\<username>\AppData\Roaming`.
- On Linux, the log file is written do the directory specified in the desktop environment variable **$XDG_STATE_HOME**, or the default location **$HOME**`/.local/state`.

Support can be requested by sending an email to ESTAT-ECOSYSTEMS@ec.europa.eu.

3 Interface overview

After activation, the INCA plugin interface is shown and is divided into two parts. The top ofthe plugin window (see Figure 2) contains the generic settings which apply to all accounts:

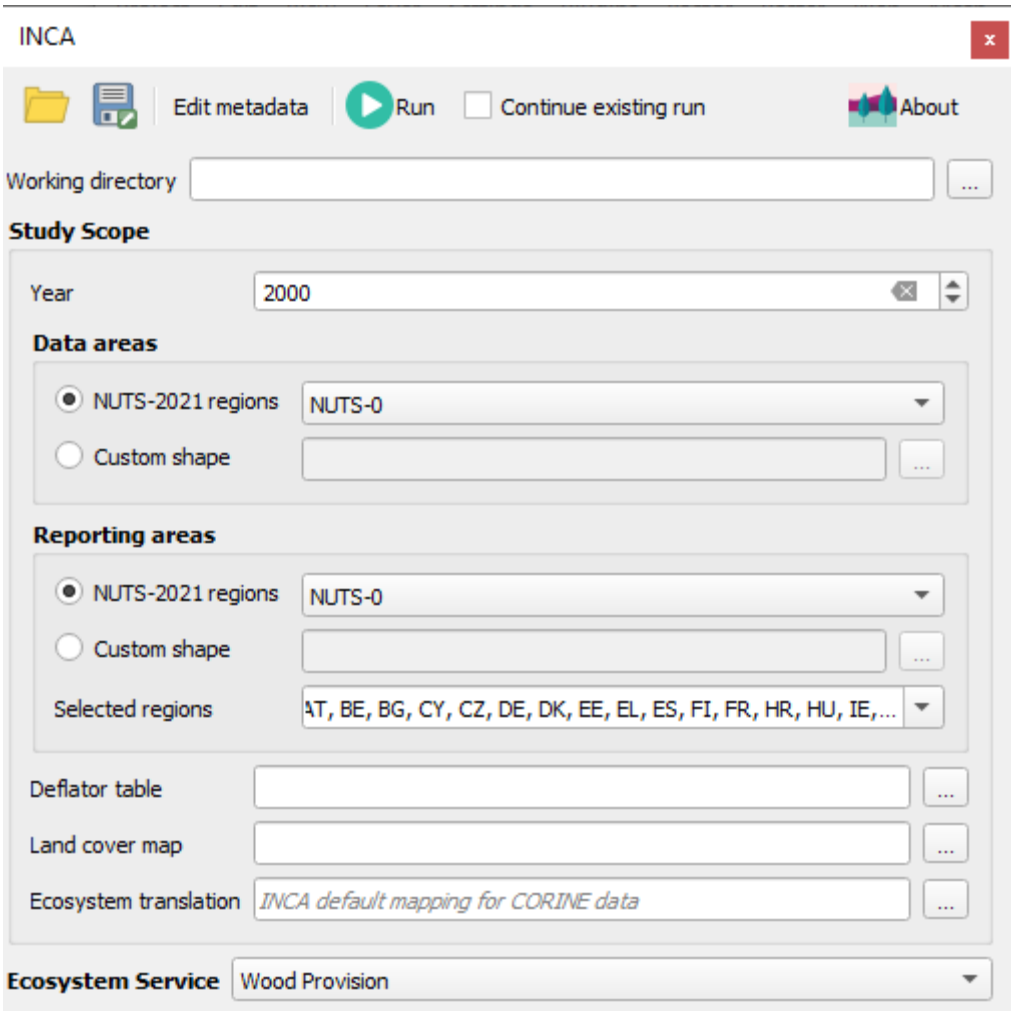
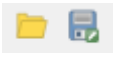


Figure 2: INCA Plugin generic settings.

1. **Load/Save**  : Using these buttons, you may import or export the configuration settings (yaml file) for a single service.

2. **Edit metadata**: Opens a dialog where the user can provide information about the input data, settings and validation for this run. Currently only available when the wood provision service is selected.

3. **Run:** starts the calculation.

4. **Continue existing run:** To avoid accidentally overwriting results of a previous run (run name) or mixing output from different configurations or services in a single directory, the INCA tool will not start with the calculations if the run output directory (working directory & run name combination) already exists. Check the box to allow the INCA tool to work in an existing directory.

IMPORTANT: Since the INCA tool reuses existing output and/or temporary files, this option should be only used when Configuration Errors due to missing entries in the service configuration arise. Usage of this option to test parameter changes is not recommended since it can lead to unexpected results when outdated intermediate files are reused. E.g. adaptations of the land cover map entry or the ecosystem translation table entry after a finished successful run would not lead to the generation and usage of this adapted ecosystem map in the processing. For sensitivity analysis or parameter tests please always use a new "run name".

5. **About**: provides basic information about the tool and the current version installed

6. **Working directory:** INCA tool will save the results of a run in a subdirectory of the chosen working directory. **Note**: the working directory is used in combination with the run name (see further) to write output files.

7. **Study scope:**
   - **Year:** The year for which the service account is calculated. **Note:** make sure the selected input files contain the correct data for the chosen year, as the tool cannot verify this automatically.
   - **Data areas:** This selection specifies the geographic (statistical) regions for which the input data is provided (e.g., table data) and for which the service model is run. The user can select either
     - Regions from the 2021 standard NUTS level 0-2 vector files (https://ec.europa.eu/eurostat/web/nuts/background), restricted to EU-27 member states, or
     - a custom vector file (e.g., ESRI shapefile, gpkg-files). The custom shape file must contain the boundary shapes and identify these by an attribute called 'NUTS_ID'.

     Note: The 'NUTS_ID' attribute is used to link the region shapes to tabular input data such as price tables, area specific parameters, Eurostat statistics, etc. When using custom input data, make sure the NUTS_ID labels from tabular input data and selected data areas match.

   - **Reporting areas:** This selection specify the geographic (reporting) regions for which the model results will be reported (as maps, SUTs and statistic files). If the reporting areas are different from the data areas, the statistical uncertainty for these reported results will be depending on the quality of the chosen spatial disaggregation proxies and/or the chosen aggregation level. The user can select either
     - Regions from the 2021 standard NUTS level 0-2 vector files (https://ec.europa.eu/eurostat/web/nuts/background), restricted to EU-27 member states, or
     - a custom vector file (e.g., ESRI shapefile, gpkg-files). The custom shape file must contain the boundary shapes and identify these by an attribute called 'NUTS_ID'. **Note:** you can use custom 'NUTS_ID' labels. The tool will read the labels from the input file and display them in the interface.

- **Selected regions:** Select the id's of the reporting regions from the selected vector file to include in the report. Right-click the list of id's to access the options **Select All** / **Deselect All**.

- **Deflator table:** A table containing an inflation index per region, which can be used to correct monetary values for inflation, to obtain a real monetary evaluation with respect to the reference year 2000. The table should be provided as a CSV file, where the first column contains the id for each region (column must be named 'NUTS_ID'), and subsequent columns contain yearly index values per region. (see appendix 7.7 for an example). Note: the id's must match the selected data regions identifier level.

- **Land cover map:** A categorical raster file describing the land cover for the area of interest. The dataset should be provided as GeoTiff. **IMPORTANT**: the resolution of the given land cover map specify the spatial resolution of the model run. All other input raster files will be resampled to this resolution automatically. The INCA tool projection system is fixed to LAEA Europe (EPSG:3035), but the land cover map can be provided in all projected coordinate systems with a valid EPSG number – automatic reprojection is applied. Note: the INCA tool will inform when the provided land cover map is smaller than the needed 'data area' extent – please provide then the land cover map with the minimum stated extent.
- **Ecosystem translation:** A csv file which describes the mapping between the land cover categories used in the land cover map, and the standard ecosystem types used by INCA (see Table 2 and Table 3). If this input is left unspecified, the INCA tool assumes the land cover map is a CORINE map and uses a default mapping from CORINE land cover classes to ecosystem types at level 1 and level 2.

Next, we can configure the specific settings for the requested ecosystem service:

- Use the **Ecosystem Service** drop-down menu to select the service for which you want to calculate accounts. In the current release you can choose between Wood Provision, Soil Retention, Nature-based tourism, Global Climate Regulation, Flood Control, Crop Provision, and Air Filtration. In future versions more service accounts will be added.
- **Run name** will be used to name the directory where output is written: results are written to <*working directory*> / <*run name*>. E.g., if your working directory is 'C:\INCA' and the run name is 'run01_timber', results are written to 'C:\INCA\run01_timber. Using the same run name for multiple services would mix the results in a single directory, so it is advised to use different run names for different services.

- The remaining settings are specific to the selected ecosystem service and are explained for each service in a separate section below.

TIPS:

- the ‘Run name’ is free format and can be used in combination with the ‘Working directory’ to organize your results. As an example, you could create a directory ‘C:\INCA\EA_20211110’ and set to the Working directory. The run names could then be set to ‘timber2000-18’ and ‘soil2000-18’ which will create separate subdirectories for each account under the C:\INCA\EA_20211110.
- the selected “year” in the Study Scope does not necessarily correspond to the input files given, i.e. if a raster input file contains data for the year 2018, but the “year” in the Study Scope is set to 2016, it may be that output data (biophysical and or monetary) is generated, because it’s not possible (and perhaps not desired to) to detect such mismatches automatically. Hence the user is required to carefully check that all input data reflects the ‘Study Area’ configuration.
- When a run has started, a progress bar is shown at the bottom of the QGIS window, as shown in Figure 3. Click the progress bar displays an overview of all currently running QGIS tasks. The progress bar provides a rough estimate of the remaining calculation time.
- You may also cancel a running task from the task overview window: hover the mouse over the “play” icon ▶ shown in the task overview to turn it into a red cross ✖. Click the red cross to cancel the task, as shown in Figure 4.
- creating a specific QGIS template with some default country data could be helpful, e.g., adding administrative boundaries or other ancillary information. To keep your QGIS project in a good shape, you can create a group with name of service (i.e., wood_provision) and select this group-layer before the run to ensure that maps are organized in the group.
- the accounting tables are written to .csv and .xlsx files per service. The user can combine these files into single Supply-Use tables. In the current version of the tool, there is no support to perform this combination automatically.

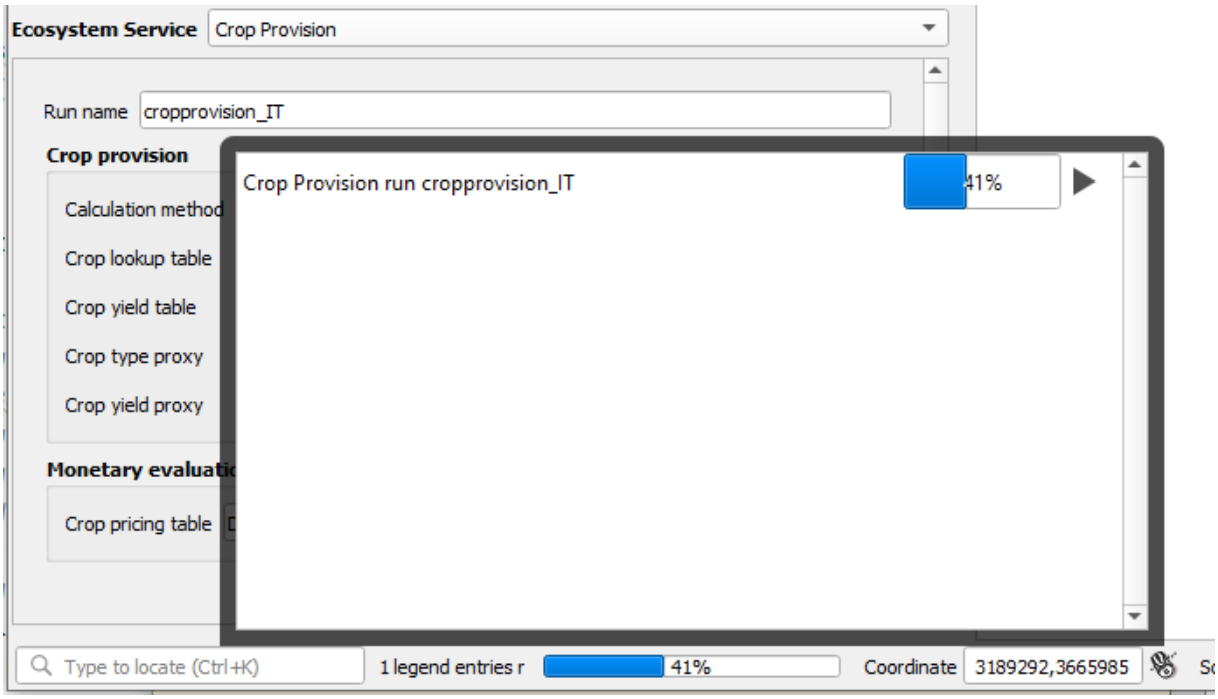


Figure 3: Progress bar.

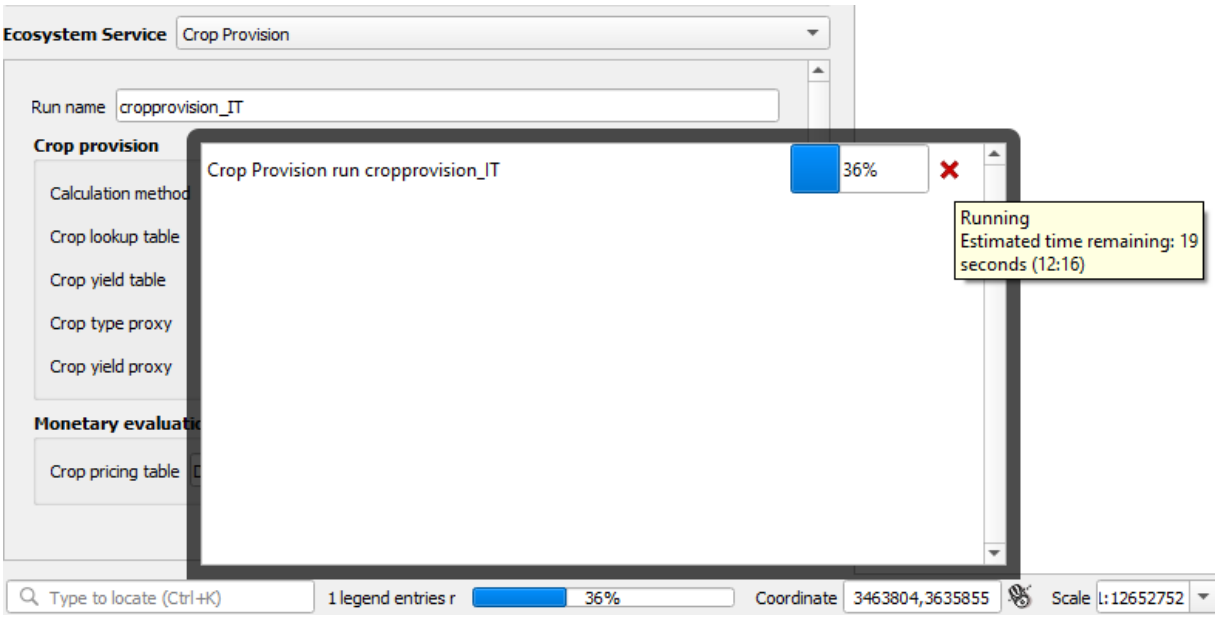


Figure 4: Cancel button: Clicking the red cross will cancel the run.

4 Handling custom input data

4.1 Ecosystem typology

As a default, the INCA tool uses the Corine Land Cover Accounting Layers (CLCACC) and a crosswalk table to map ecosystems to the European Ecosystem Extent Typology. Reporting is required at Level-1 typology, as shown in Figure 5. The mapping table can be found in Annex §7.6.

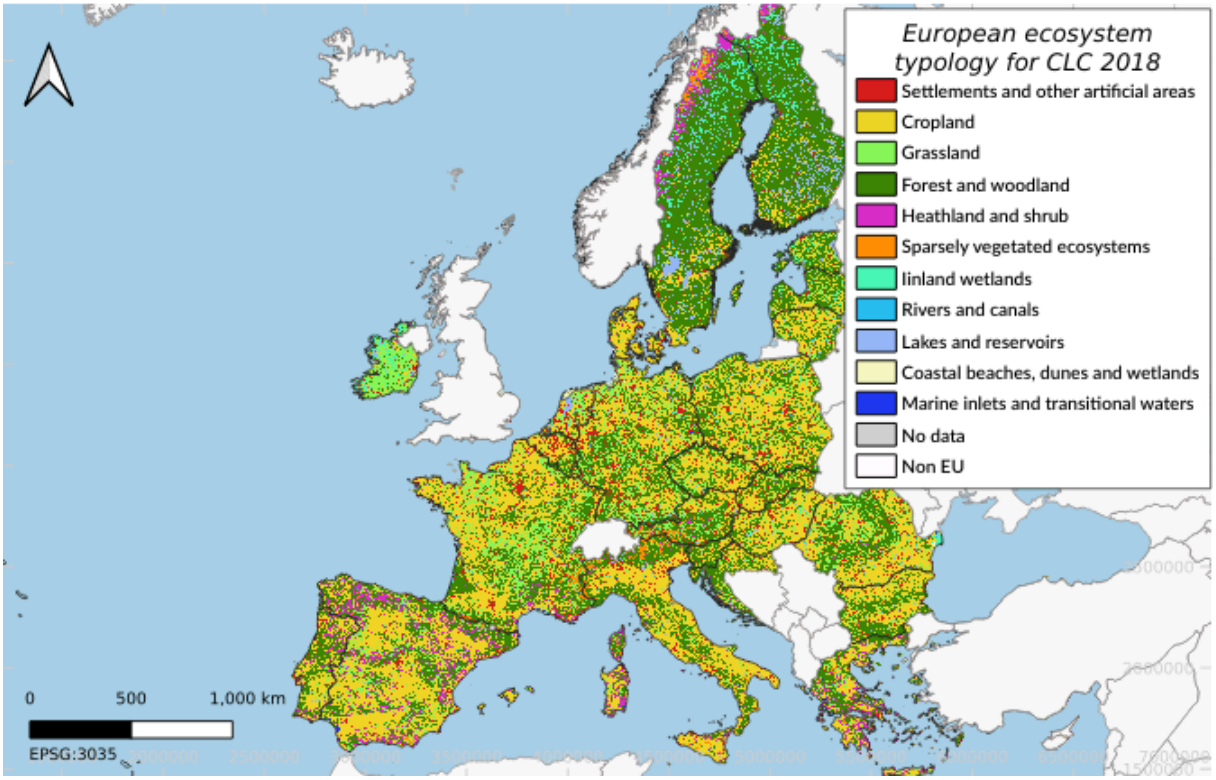


Figure 5 Ecosystem typology as implemented in INCA Tool from CLC accounting layers for 2018 (EU).

According to the typology, the classes "bare rocks" and "marshes" have to be partly assigned to 'Coastal beaches, dunes and wetlands'. The definition of partly is still under discussion (e.g. a buffer from coastline or …) and hence the tool does not assign these classes to this ecosystem type (11). Another observation is that the land cover class "beaches, dunes and sands (CLC 331)" is sometimes misclassified which leads to the assignment of inland pixels to the "Coastal beaches, dunes and wetlands' ecosystem type.

DISCLAIMER: Therefore the CLC 332 (bare rocks) is always classified as 'Sparsely vegetated ecosystems (6)' and CLC 411 (marshes) as 'inland wetlands (7)'. Furthermore sometimes the CLC 331 to "Beaches, dunes and sands" ecosystem types is assigned in-land, hence outside a buffer from the coastline. These issues are expected to be resolved in a new version of the tool.

4.2 Input raster pre-processing

For user convenience, the INCA tool automatically reprojects, resamples and/or cuts input raster files to the data area extent, projection and resolution as needed. The automatic transformation can influence the accuracy of the given data and therefore introduce higher uncertainties in the results. Users may check the adapted files which are saved in the TEMP-

folder of the run. Table 1 provides an overview of the standard geoprocessing methods and filters implemented in the INCA-tool (methods are based on the GDAL library).

Uses who want to use their own input data sets, but do not wish to rely on these automatic transformations, should provide all input raster files in the projection system EPSG:3035, on a grid which matches the grid of the chosen input land cover map.

Table 1: standard geoprocessing and resampling methods for input raster pre-processing in INCA

data type	**crop**	**translate**	**warp**
discrete data	gdal_translate (nearest neighbour)	gdal_translate (down-sampling: mode, up-sampling: nearest neighbor)	gdalwarp (down-sampling: mode, up-sampling: nearest neighbor)
continuous data			
a) relative unit (e.g. tonne / ha)	gdal_translate (bilinear)	gdal_translate (down-sampling: average, up-sampling: bilinear)	gdalwarp (down-sampling: average, up-sampling: bilinear)
b) absolute data			
i. point data (e.g. DEM)	gdal_translate (nearest neighbor)	gdal_translate (down-sampling: average, up-sampling: bilinear)	gdalwarp (down-sampling: average, up-sampling: bilinear)
ii. pixel content data (e.g. population per pixel)	gdal_translate (nearest neighbor)	own approach (3-step oversampling method)	own approach (3-step oversampling method)

4.3 Units

The INCA tool can not verify the units of provided input data. Therefore, users should make sure that any custom input data is provided in the correct unit, as described in the configuration section for every service.

Note: input raster datasets with quantities per unit of area should also be provided in the exact unit described in the manual (normally "x" *per hectare*), regardless of input raster resolution. For example, an input raster with a unit of tonne per hectare should always be provided in that unit, even if the raster resolution (pixel size) is 1km².

Updates

Beta 2:

- Not available

Beta-3:

- No automatic pre-processing. Checks on data input format were done, and an error was thrown if not compliant.

Beta3-rev_e2a0ca3:

- Automatic pre-processing available.

5 Service account module interfaces

5.1 Wood provision

For the wood provision ecosystem service, INCA calculate the actual flow per reporting region. The flow in physical units is based on the net annual increment of timber in forests available for wood supply, and removals from forests not available for wood supply. The standard source of this input data is the Eurostat dataset 'Volume of timber over bark (source: EFA questionnaire)'.

The INCA tool calculates a supply-and-use table in monetary (millions of EUR) and physical (thousands of tonnes) terms, as well as maps (rasters) where these supply values are distributed on the map according to the chosen proxy.

Methodology

The wood provision service is defined as the ecological contribution to the production of timber that can be harvested and used as a raw material. In terms of the ecological process, we need to refer to natural growth of a biotic resource; this in turn implies that the service flow for accounting purposes is the net annual increment (NAI) of standing timber in forests that is available for wood supply.

The method for wood provision accounting follows the EU INCA account model, as shown in Figure 6. More details can be found in [2019, Vallecillo et al.] and [2021, LaNotte et al.].

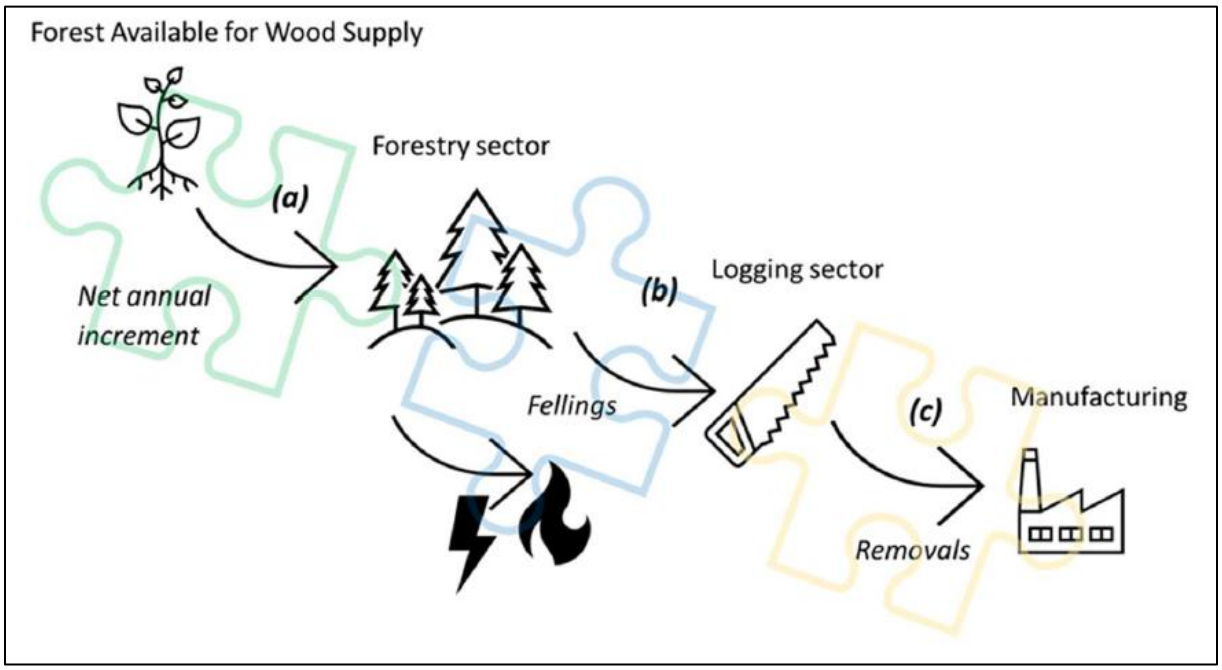


Figure 6: Service flows along the chain of timber management, extraction and transformation (from 2021, LaNotte et al.)

The INCA tool calculates the actual flow per member state based on the tabular inputs. To generate maps, the total flow per member state is then spatially distributed based on the ecosystem type map, a spatial proxy and the proxy weight as follows:

- Multiply spatial proxy and prox y weight maps to obtain the relative contribution from each pixel.
- Using the ecosystem type map, set contributions from pixels outside of 'Forest and woodland' ecosystems to 0.
- Per reporting area, transform the relative contributions into weights, by dividing the contribution from each pixel by the sum of the relative contributions from all pixels in the same member state.
- Multiply the weight for each pixel by the total actual flow of the region.

Configuration

The specific settings (see Figure 7) for wood provision are:

- **Timber volume over bark** Provide a file containing Eurostat dataset 'Volume of timber over bark (source: EFA questionnaire)' (https://ec.europa.eu/eurostat/web/products-datasets/-/for_vol_efa) in the tab-separated format (tsv), or an equivalent dataset with the same structure.
- **Spatial Proxy**: This raster (geotiff) is used to draw a spatial representation of the ecosystem service use. The pixel values should be a suitable proxy for the amount of wood produced in each location (for example: annual dry matter productivity). Raster projection, resolution and extent must be identical to that of the land cover map.
- **Proxy weights**: This raster (geotiff, optional input) can be used to further correct the spatial proxy, for example by ruling out areas where no forestry can take place (set weight to zero), and/or by otherwise increasing or decreasing the contribution from specific areas. Raster projection, resolution and extent must be identical to that of the land cover map. **Note**: The raster file will be automatically reprojected, resampled and cut to the data area extent if needed.

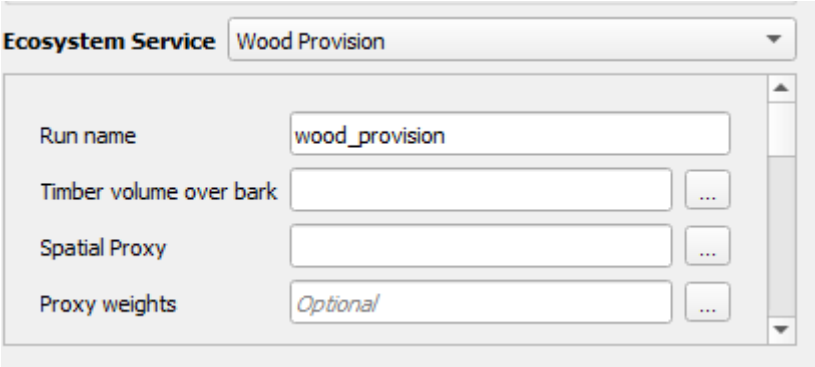


Figure 7: INCA Plugin 'Wood Provision' interface.

Metadata

When the user clicks 'Edit metadata', a dialog appears where the user can provide information about the chosen input data and settings for this run, and describe the validation approach (if

any). The dialog consists of two tabs, for information about the data used for ‘forests available for wood supply’ and ‘forests not available for wood supply’. This metadata will be saved together with the run’s output data.

When the user clicks ‘Run’, the metadata window is shown to allow the user to make final adjustments. Click OK to start the run with the provided metadata, Cancel to go back to the run settings.

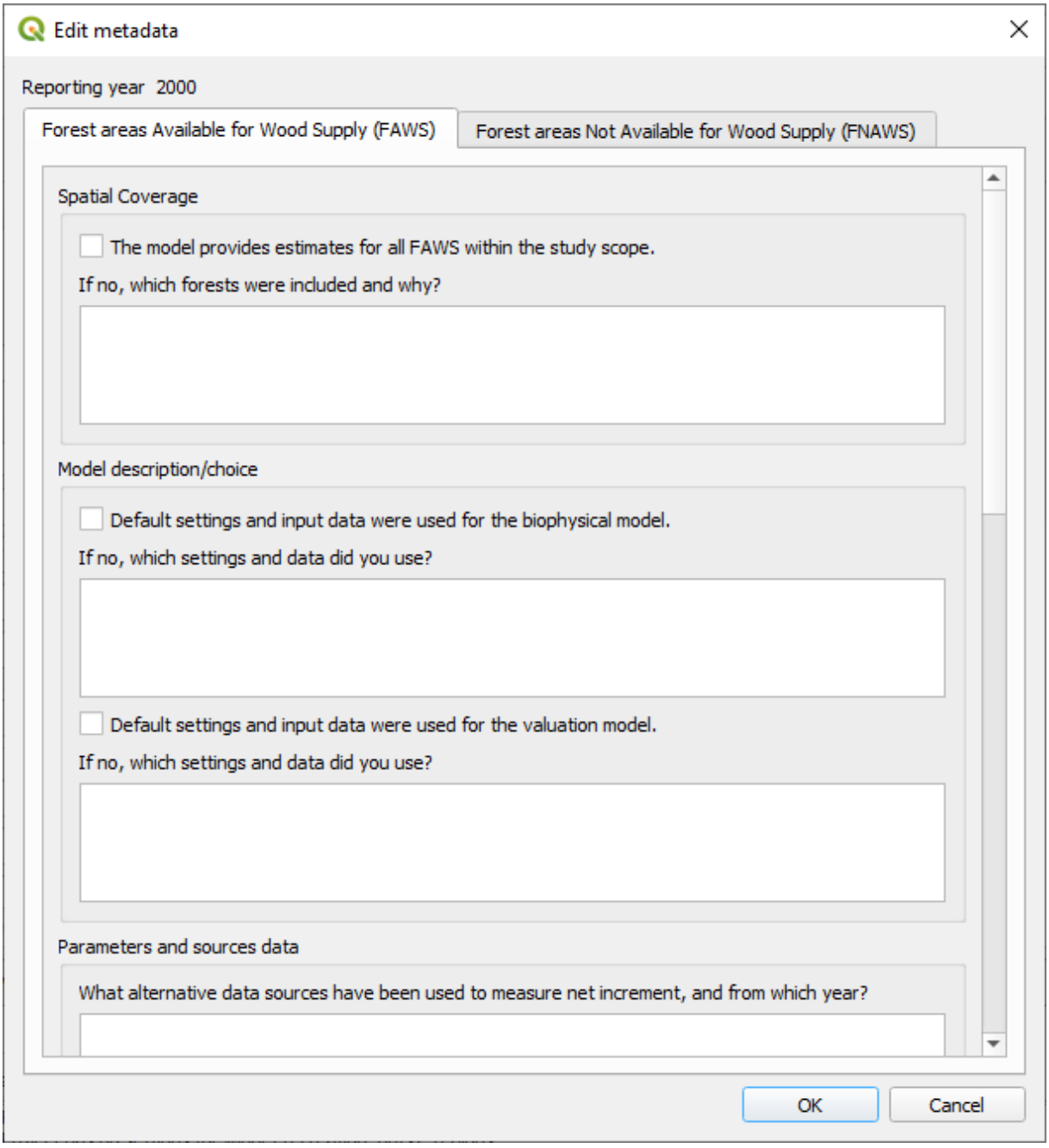


Figure 9: Wood provision metadata questionnaire.

Note: Metadata handling in the INCA tool is still under development. The current form is a proof of concept; comments are welcome. Nevertheless, detailed file metadata is included in all raster files following the CF-4 standard.

Output

After a successful run, the output directory contains the following files and directories:

- **config.yaml**: a single configuration file which contains the settings used to generate these results as outlined in the previous section.

- **maps:** Subdirectory containing maps for wood provision flow in physical and monetary terms:
    - **wood-provision_map_use_1000-m3_yyyy.tif**

- **SUTs**: Subdirectory containing Excel spreadsheets with supply and use tables:
    - **wood-provision_report_SUT_physical_1000-m3_yyyy.xlsx**

- **statistics:** Subdirectory containing the same supply and use data in physical and monetary terms, formatted as CSV files for easier automatic processing.

- **TEMP:** Subdirectory containing the raster of pixel weights used to for spatial distribution, **wood-provision_map_proxy_yyyy.tif**.

The map **wood-provision_map_use_1000-m3_yyyy.tif** will be automatically added to the Layers window and available for viewing. Each type of forestry is reported separately and will be diplayed in the name.

Data source and handling of missing data

The physical supply of wood provision is based on the sum of flow ‘net annual increment’ for indicator ‘forest available for wood supply’ (NAI-FAWS), and ‘removals’ for ‘forest not available for wood supply’ (RMOV-FNAWS), both taken from the *for_vol_efa* dataset. For many member states, the data in these tables is incomplete, and we fill the data gaps as follows:

- For NAI-FAWS, missing values are replaced by the corresponding value of the net annual increment for indicator ‘forest’. Remaining gaps for a given member state and year are filled by taking the average from the last previous year and the first next year for which data is available. For member states for which no data is available at all, reports will be empty.
- **For NAI-OWL-AWS,** missing values are replaced by the corresponding value of the net annual increment for indicator ‘forest’. Remaining gaps for a given member state and year are filled by taking the average from the last previous year and the first next year for which data is available. For member states for which no data is available at all, reports will be empty.
- For RMOV-FNAWS, missing values are assumed to be zero.

Updates

1.1:

- Supply/Use of timber is now split in NAI-FAWS, NAI-OWL-AWS and RMOV_other. Removals are not addded to net annual increments any longer.

1.0:

- No changes

Beta 3:

- Service adjusted to handle different data areas and reporting areas.

Beta 2:

- The service was renamed from ‘Timber Provision’.
- Physical supply of wood provision is now based on Eurostat dataset *for_vol_efa*.
- The user has more options to adjust the spatial distribution, using a combination of the provided proxy, the ecosystem type map, and a weight raster.
- A progress bar was added.

References

Eurostat, Guidance note on wood provision – Draft II, ENV/EA/TF/2022_3/4, 21-22 June 2022.

La Notte, A., Vallecillo Rodriguez, S., Garcia Bendito, E., Grammatikopoulou, I., Czucz, B., Ferrini, S., Grizzetti, B., Rega, C., Herrando, S., Villero, D., Zurbaran Nucci, M. and Maes, J., Ecosystem Services Accounting – Part III - Pilot accounts for habitat and species maintenance, on-site soil retention and water purification, EUR 30856 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-42052-1, doi:10.2760/707, JRC126566.

Vallecillo Rodriguez, S., La Notte, A., Kakoulaki, G., Kamberaj, J., Robert, N., Dottori, F., Feyen, L., Rega, C. and Maes, J., Ecosystem services accounting - Part II Pilot accounts for crop and timber provision, global climate regulation and flood control, EUR 29731 EN, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-02905-2, doi:10.2760/631588, JRC116334.

5.2 Soil Retention

On site soil erosion from rainfall is regarded as one of the major causes of environmental degradation. However, healthy ecosystems can also halt soil erosion and contribute to the maintenance of soil quality and therefore of ecological processes.

Methodology

INCA calculates the potential of ecosystems to reduce soil erosion by rain, the demand (or need) for soil retention by ecosystems, the amount of soil retained by ecosystems (flow), the unmet demand (areas with an ecosystem deficit to retain soil) and the monetary value of the service provided by ecosystems per member state. More information can be found in [Maes et al., 2021] and [LaNotte et al., 2021].

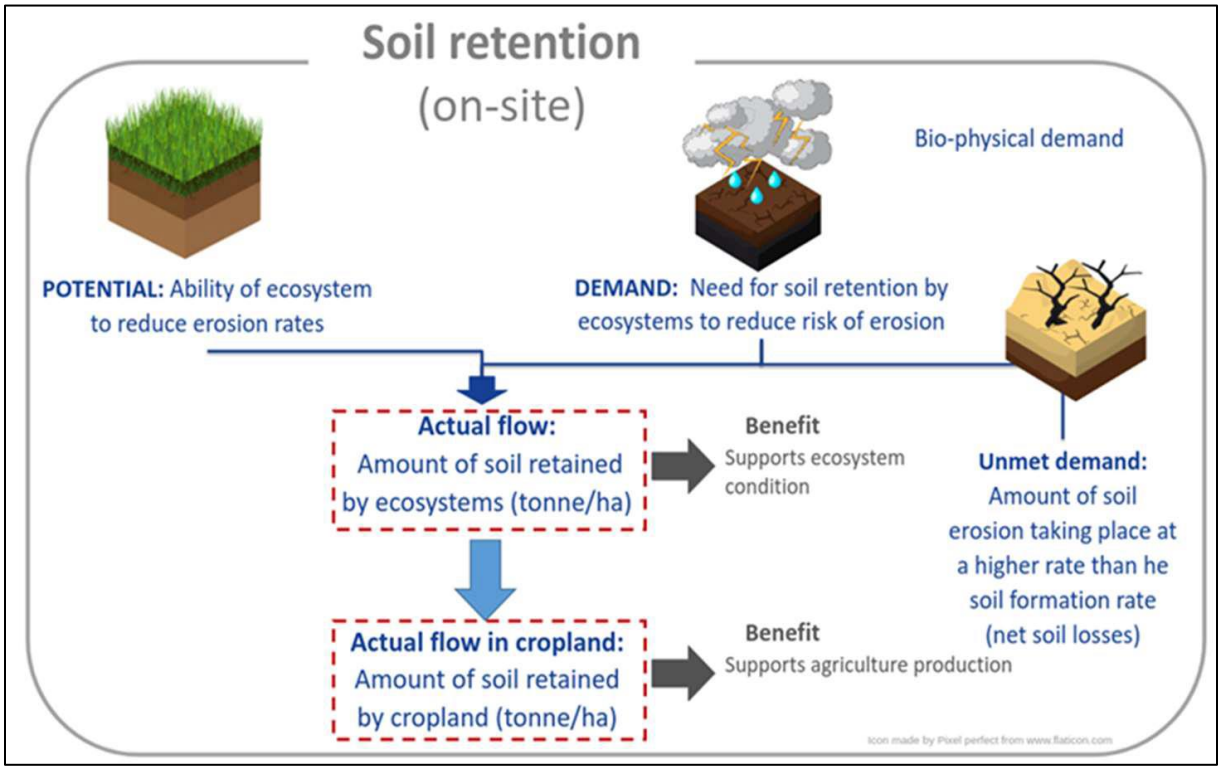


Figure 8: Soil retention flows from different ecosystem types (from 2021, LaNotte et al.)

Note, that no specific Guidance Note for ecosystem accounting of Soil Retention is available, and hence the INCA method as reference above is implemented.

Configuration

An annual soil retention calculation requires the following specific settings (see Figure 9) for the biophysical and monetary valuation part of the service.

Bio-physical part:

- **C-Factor**: raster dataset (preferred: GeoTiff) representing the vegetation cover factor (dimensionless) derived from (i) crop information and farm structure survey for cropland areas and (ii) from fraction of vegetation cover for non-cropland area's. Values in range [0.0001 , 0.55].

- **K-Factor**: raster dataset (preferred: GeoTiff) representing the soil erodibility (tonne·h ha·MJ^{-1}·mm^{-1} ha^{-1}). Values in range [0 , inf].

- **LS-Factor**: raster dataset (preferred: GeoTiff) representing the topographic factor (dinmesionless) representing the slope length and angle. Values in range [0 , 99].

- **P-Factor:** raster dataset (preferred: GeoTiff) representing the anthropogenic support practices (dimensionless) to reduce soil loss considering contour farming, maintenance of stone walls and grass margins. Values in range [0 , 1].

- **R-Factor:** raster dataset (preferred: GeoTiff) representing the rainfall erosivity (MJ·mm·ha^{-1}·h^{-1}). Values in range [0 , inf].

- **Average soil formation factor**: Either keep the EU-wide default average factor of 1.4 tonnes/hectare/year, or choose a more suitable value for the specific reporting regions.

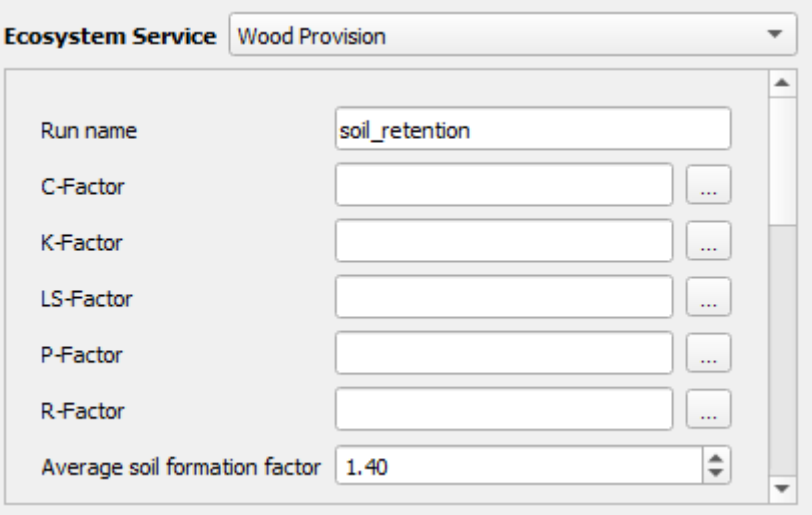


Figure 9: INCA Plugin 'Soil Retention' interface.

Output

After a successful run, the output directory contains the following files and directories:

- **config.yaml**: a single configuration file which contains the settings used to generate these results as outlined in the previous section.
- **additional_results:** Subdirectory containing maps for soil retention potential, mismatch, mismatch and erosion (Note: currently only for 'data regions' and not cut&masked to the reporting regions):
    - **Soil-retention_map_mismatch_tonnes_yyyy.tif**
    - **Soil-retention_map_erosion_tonnes_yyyy.tif**
    - **Soil-retention_map_demand_tonnes_yyyy.tif**

    - **Soil-retention_map_potential_ratio_yyyy.tif**
- **maps:** Subdirectory containing maps for soil retention flow in physical and monetary terms for the reporting regions:
    - **Soil-retention_map_use_tonnes_yyyy.tif**
- **statistics**: Subdirectory containing use data in physical and monetary terms, formatted as CSV files for easier automatic processing. Note: no unit transformation is applied and the short-names for the ecosystem types is used).
    - **Soil-retention_statistics_physical_tonnes_yyyy.csv**
- **SUTs:** Subdirectory containing the Use-and-Supply tables formatted as Microsoft Excel files. Note: unit transformation applies, and the ecosystem long-names are used.
    - **Soil-retention_report_SUT-physical_tonnes_yyyy.xlsx**
- **TEMP:** Subdirectory containing temporary files to run the model
    - Annual ecosystem raster files at level 1 for the data regions
    - Automatically adapted (reprojected, resampled and/or cut) input raster files
    - Intermediate raster files for monetary valuation (N-retained, P-retained, BulkSoil-retained)
    - all raster files of the ‘map’ folder in the original data region extent (original model run)
    - generated ‘data areas’ and ‘reporting areas’ vector and raster files based on specified run parameters

The map **Soil-retention_map_use_tonnes_yyyy.tif** will be automatically added to the Layers window and available for viewing.

Metadata

This version of the tool does not yet include a metadata form for the soil retention service. Nevertheless, detailed file metadata is included in all raster files following the CF-4 standard.

Limitations

- resampling of input dataset with lower resolution can lead to artefacts.
- The progress bar for soil retention runs is not updated.

Updates

1.0:

- No changes

Beta 3:

- Retention rate is given now as a CSV file instead of a raster file. This allows for easier adaptations of the region-specific values
- The prices only have to be provided in nominal value
- The price tables for N, P, and bulksoil have be combined into one table
- The model uses region specific deflator values instead to use fixed “real” prices over the whole area

Beta 2:

- All CSV input files adjusted to the standard format described in appendix 7.3.

- Adjusted for the new Study scope selection method: inputs ‘extent’ and ‘eu_members’ are not required anymore. NUTS shape and ecosystem type map are obtained from the study scope settings.

References

La Notte, A., Vallecillo Rodriguez, S., Garcia Bendito, E., Grammatikopoulou, I., Czucz, B., Ferrini, S., Grizzetti, B., Rega, C., Herrando, S., Villero, D., Zurbaran Nucci, M. and Maes, J., Ecosystem Services Accounting – Part III - Pilot accounts for habitat and species maintenance, on-site soil retention and water purification, EUR 30856 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-42052-1, doi:10.2760/707, JRC126566.

Maes, Joachim; Vallecillo, Sara; La Notte, Alessandra; Zurbaran, Mayra (2021): INCA - Soil Retention. European Commission, Joint Research Centre (JRC) [Dataset] PID: http://data.europa.eu/89h/2e120644-aee8-42f0-811a-c2bede08c604

5.3 Nature-based tourism

The INCA nature-based tourism ecosystem service is based on a spatial biophysical model that classifies the land according to the opportunities available for nature-based tourism and regional overnight. The user should be aware that this service is different from the nature-based daily recreation service, as originally developed in the KIP-INCA reports.

Methodology

In a first step of the methodology as described in Eurostat 2022, tourism statistics on overnight stays are used[1]. Tourism statistics can be used for different types of areas where overnight stays take place. Tourism statistics by default are split by degree of urbanisation[2].

In a second step, the proportion of overnight stays per region that can be attributed to ecosystems (the ecosystem contribution) is determined based on the type of area where overnight stays took place (e.g., degree of urbanisation as distinguished in tourism statistics) or based on contribution percentages defined per geographic data area. If contribution percentages for a geographic data area are provided, these override the attribution based on the type of area. We obtain the use table by aggregating the total number of overnight stays attributed to ecosystems per reporting area (e.g. member state). Overnight stays from residents of the reporting country are assigned to household consumption and stays from residents of a foreign country are assigned to exports.

In a third step, the amount of overnight stays attributed to ecosystems (nature based tourism) is spatially distributed among ecosystem types (the ecosystem type contribution) using a weighted distribution. Users can provide weights based on the INCA ecosystem type (this can be used to give a higher or lower weight per ecosystem type or to exclude specific ecosystem types by giving a weight of 0), and 3 optional maps labelled ‘accessibility’, ‘facilities’ and ‘landscape attractiveness’ (these maps may be left out, in which case they will not influence the spatial distribution). The provided weights per pixel are multiplied to obtain a single weight map, which is then rescaled so the sum of weights per data area equals 1. The final map of overnight stays is then obtained by multiplying the rescaled weight of each pixel by the total number of overnight stays for that data area. The result is a spatial distribution of the overnight stays, where the sum of the values for all pixels in an area is equal to the total use for that area obtained in step 1.

Finally, the values of the generated map are aggregated by ecosystem type and by reporting area to create a supply table.

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[1] https://ec.europa.eu/eurostat/databrowser/product/page/TOUR_OCC_NIN2D

[2] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Degree_of_urbanisation

Configuration

The following settings must be provided to calculate the Nature based tourism account:

Step 1: Tourism Statistics

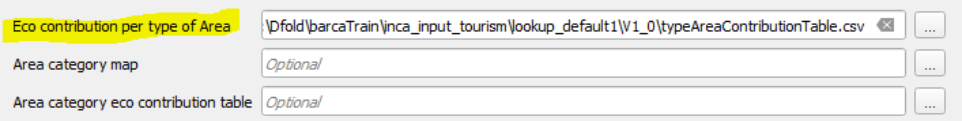
- **Overnight stays:** A CSV file with data on the number of overnight stays per NUTS-2 region. The file must have the following columns:
    - **DataAreaCode:** Region NUTS_ID.
    - **Year**: Year to which the data refers.
    - **CountryOfResidence:** Visitors' country of residence. Values must be either 'Foreign country' or 'Reporting country'.
    - **TypeOfArea:** We can assign a different ecosystem contribution to nature-based tourism depending on the area where overnight stays take place (a higher contribution in natural areas, lower in urban areas). Users may define their own set of area types, as long as values in this column match values in the TypeOfArea column of the 'Eco contribution per type of Area' input.
    - **OvernightStays:** The number of overnight stays.

  Note: The example input datset 'overnight_stays_2018.csv' contains tourism data for EU-27 members at NUTS-2 level grouped by degree of urbanisation. When using this file, make sure that the data area shapefile contains matching NUTS-2 regions. When using an 'Eco contribution per area' dataset, the same matching NUTS-2 identifiers should be used.

Step 2: Ecosystem contribution

- **Eco contribution per type of area:** An optional CSV (see default input data: typeAreaContributionTable.csv) file describing the proportion of overnight stays that should be attributed to ecosystems, depending on the type of the area, and the visitors' country of residence. By default, INCA uses area types 'Cities', 'Towns and suburbs' and 'Rural areas', and attributes all visits to ecosystems (contribution percentage of 1.0 or 100%). The file must have the following columns:
    - **TypeOfArea:** Users may define their own set of categories, as long as the categories used in the Overnight Stays input match the categories used here.
    - **CountryOfResidence**: Visitors' country of residence, either 'Foreign country' or 'Reporting country'.
    - **ContributionPercentage**: Proportion of overnight stays to attribute to ecosystems for this type of area and country of residence (value between 0.0 and 1.0).

This file can be specified in the Tool in the area marked in Yellow below:

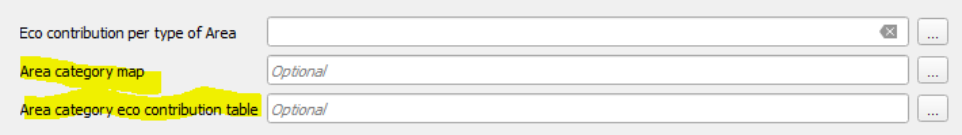


- **Eco contribution per area:** An optional step is to assign the contribution percentages via geographical areas. This is done in 2 steps. First, a raster map is provided containing

geographical areas (by default, we use the recreation potential map (see default input data: RP_2018_uint8.tif, or any other year). Secondly, a CSV file is provided converting the values present in the map into contribution percentages (see default input data: data_area_weights.csv). This CSV file should contain following data

-
    - **Code:** contains the value in the categorical map to which a weight should be assigned. In the default method, these are the RP categories**.**
    - **Weight:** The contribution percentage that should be assigned the the categorical code.

These files can be specified in the tool in the areas marked in yellow below. First field for the raster map, second field for the CSV file:



-

Step 3: Attribution to ecosystem types

Next, the user can configure the maps and weights used to generate a spatial distribution of the overnight stays.CSV tables of weights are used to transform a categorical map, such as the ecosystem type map, into a map of weights . All weight tables must have the following 2 colums:

- **Code:** contains the value in the categorical map to which a weight should be assigned. For the **ecosystem type weights**, this column should contain values 1 to 12, corresponding to the 12 INCA ecosystem types (see appendix 7.6).
- **Weight:** the weight to assign to pixels which belong to this category.

To distribute the overnight stays according to the level 1 ecosystem type, the **Ecosystem type weights** table may be used (see default input data : ecosystem_type_weights.csv). By default,

all ecosystem types receive the same weight, leading to a uniform distribution of results across the entire data area if no other weights are used.

For **Accessibility**, **Facilities** and **Landscape attractiveness** maps, the user can configure

- no map, in which case this input will have no effect on the result (default option);
- a map of weights, in which case INCA will directly use the values in the provided map;
- a categorical map together with a table, of weights per category, in which case INCA will transform the categorical map into a weight map (you could use the RP maps, combined with CSV files, as also provided in the default input data:
    - accessibility_weights.csv
    - attractiveness_weights.csv
    - facility_weights.csv.

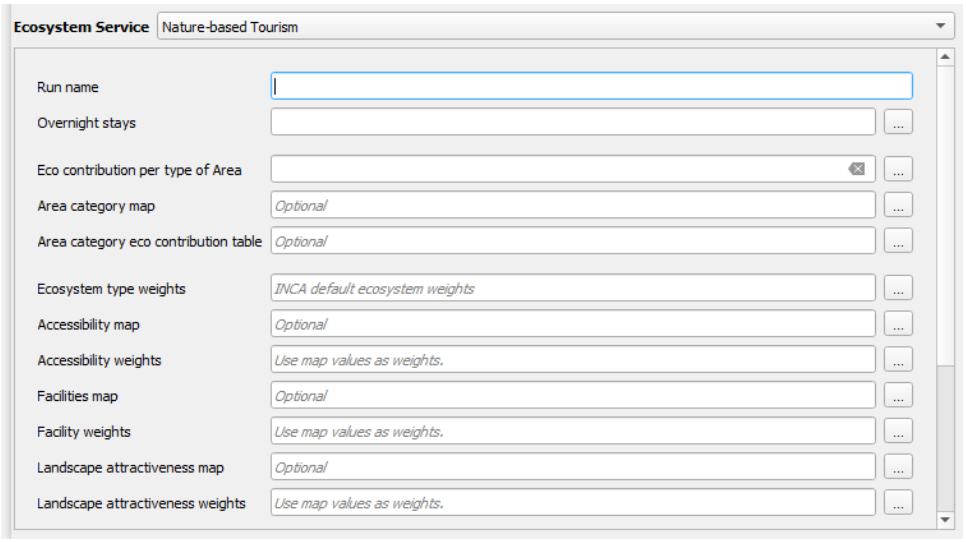


Figure 10: INCA plugin 'Nature-based tourism' interface

Output

After a successful run, the output directory contains the following files and directories:

- **config.yaml**: A configuration file which contains the settings used to generate these results as outlined in the previous section.

- **maps:** Subdirectory containing maps for nature-based tourism service in physical terms:
    - tourism_map_supply_amountOvernightStays-foreign_yyyy.tif
    - tourism_map_supply_amountOvernightStays-national_yyyy.tif

- **statistics**: Subdirectory containing supply and use tables formatted as CSV files for easier automatic processing.

- **SUTs**: Subdirectory containing Excel spreadsheets with supply and use tables:
    - tourism_SUT_supply_amountOvernightStays_yyyy.csv
    - tourism_SUT_use_amountOvernightStays_yyyy.csv

- **TEMP:** Subdirectory containing intermediate results, mainly the rasters of classes and pixel weights used for spatial distribution:
    - ecosystem_types_yyyy.tif
    - tourism_map_clc-reclass-weights_yyyy.tif
    - tourism_map_access-reclass-weights_yyyy.tif
    - tourism_map_attract-reclass-weights_yyyy.tif
    - tourism_map_weights_yyyy.tif
    - tourism_map_weight-proportional_yyyy.tif

Default configurations

The methodology follows the guidelines as defined in Eurostat, 2022. The two default configuration settings described in the guidelines are provided with input files grouped in separate input folders and specific yaml files providing links to the different input files. Both settings build on the same tourism statistics (Overnight stays) file as a first step.

Default 1 (config_default1.yaml):

The ecosystem contribution percentage is determined by the degree of urbanisation. This option is based on fixed contribution percentages defined for different types of degree of urbanisation (cities 20%, towns and suburbs 60%, rural areas 90%).

The ecosystem type contribution is based on a weighted distribution whereby results from the Recreation Potential Map3, developed by the JRC, are used. The map is based on two components: the ecosystem-based potential and the human inputs. The index of human inputs depends on the proximity to roads and residential areas. We consider this index as a proxy for accessibility. The ecosystem-based potential is based on three components: Suitability of land to support recreation, the presence of natural riparian zones and the presence of water nature-related elements. We consider this index as a proxy for landscape attractiveness. We do not consider an additional indicator for facilities.

Default 2 (config_default2.yaml):

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3 Vallecillo S, La Notte A, Polce C, Zulian G, Alexandris N, Ferrini S, Maes J. 2018. Ecosystem services accounting: Part I - Outdoor recreation and crop pollination, EUR 29024 EN; Publications Office of the European Union, Luxembourg, doi:10.2760/619793, JRC110321. JRC Publications Repository - Ecosystem services accounting: Part I - Outdoor recreation and crop pollination (europa.eu)

Zulian G, Paracchini M, Maes J, Liquete Garcia M. ESTIMAP: Ecosystem services mapping at European scale. EUR 26474. Luxembourg (Luxembourg): Publications Office of the European Union; 2013. JRC87585. JRC Publications Repository - ESTIMAP: Ecosystem services mapping at European scale (europa.eu)

Zulian G, La Notte A, 2022. How to account for nature-based tourism in Europe. An operational proposal. One Ecosystem 7: e89312. https://doi.org/10.3897/oneeco.7.e89312

We apply the Recreation Potential Map (RP), developed by JRC to select locations with medium and high opportunities for recreation close and proximal to roads and settlements (categories 5,6,8,9 of RP). We assume the ecosystem contribution percentage is equal to the share of the area of all selected ecosystems in each NUTS 2 region. This share is included in the Eco contribution table per area.

The spatial allocation to ecosystem types is based on a uniform distribution among the selected ecosystems in step 2 within the NUTS2 regions.

Metadata

This version of the tool does not yet include a metadata form for the nature-based tourism service. Nevertheless, detailed file metadata is included in all raster files following the CF-4 standard.

Limitations

- The methodology and tables reflect the current state of the guidance document as presented to the task force in June 2022. Parameters used to determine the ecosystem contribution and attribute stays to ecosystems are still under development, in collaboration with Joint Research Centre. Two default options were presented in this guidance document. Both can be tested with different settings.
- The current implementation requires more memory for larger areas of interest. Therefore, regular personal computers may not have sufficient memory to process more than two member states (or two member states who are located far apart, which may also cause the total region of interest to span a large area) in a single run. This will be addressed in future INCA versions.

Updates

1.0

- Default ‘type of area’ ecosystem attribution and ecosystem type attractiveness tables were adjusted. By default all types of areas now have an ecosystem contribution of 100%, and all ecosystem types are used during spatial disaggregation.
- The service was renamed from ‘Recreation’ to ‘Nature-based tourism’.

Beta 3:

- Service was adjusted to accommodate different data and reporting area datasets.

Beta 2:

- this service is new in beta-2 release

References

Eurostat, Guidance note on recreation-related ecosystem services – Second Proposal, ENV/EA/TF/2022_3/6, 21-22 June 2022.

5.4 Global climate regulation

The global climate regulation service includes carbon net sequestration (uptake) and carbon retention (storage). The service is quantified in biophysical terms for both carbon net sequestration and carbon retention, and for the carbon net sequestration in monetary terms.

Methodology

The carbon net sequestration is based on the INCA model which is based on the GHG (LULUCF) inventories, as shown in Figure 11. More details can be found in [2019, Vallecillo et al.] and [2021, LaNotte et al.]. The INCA model as shown in Figure 11 is applied at data region scale and the actual flow is calculated as 'net sequestration' by using both carbon uptakes and carbon emissions into account. The Guidance note (2022, Eurostat-1) is implemented and the user can either use European or National GHG inventories for the calculation and monetary evaluation of the carbon net sequestration. Additional emissions from sources like unmanaged forests, unmanaged wetlands and non-reported peatlands can be optionally incorporated in the net sequestration calculation.

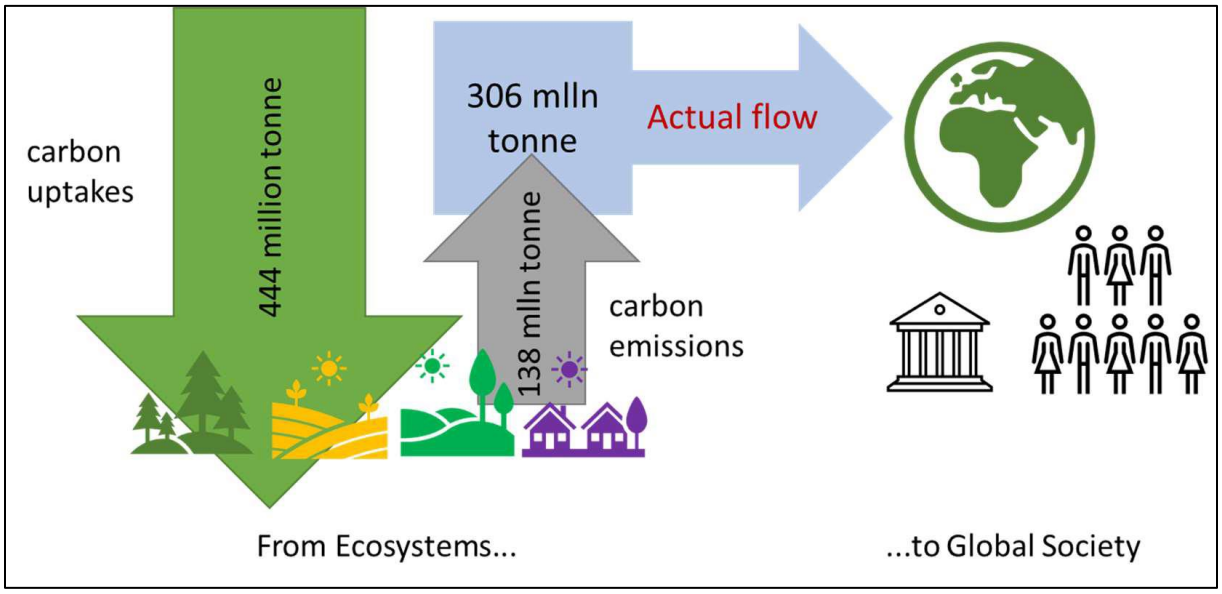


Figure 11: Carbon sequestration as an ecosystem contribution to global society (from 2021, LaNotte)

The carbon retention follows the current available Guidance Note (2022, Eurostat-1). The user can generate the annual carbon closing stock via the GAIN-LOSS or STOCK-DIFFERENCE method. The usage of GAIN-LOSS method splits into two sub-methods for the generation of the carbon opening stock: (a) generation of a carbon opening stock reference based on a simple Look-Up-Table model - each ecosystem class at Level-2 (see EU extent typology, 2022, Eurostat-2) is assigned a value for Above-ground biomass, Below-ground biomass and Soil Organic Carbon; (b) load of an existing carbon opening stock in LULUCF categories and kilotonne CO2 unit (Note: the carbon closing stock of the previous year can here load as the opening stock of the current year). The carbon closing stock is then generated by adding the

annual carbon net sequestration and reducing it by the annual Wood harvest. For the STOCK-DIFFERENCE method the existing carbon closing stocks in LULUCF categories and kilotonne CO2 unit can be load and are transferred to the correct ecosystem types and carbon unit.

Note: the usage of the offered carbon retention mode GAIN-LOSS_BASE-MAP in combination with the GAIN-LOSS mode allows annual updates of an established carbon reference stock, e.g. establishment of a national reference carbon opening stock for the year 2024 and with usage of national GHG inventories annual carbon closing stock can be generated and therefore used as carbon opening stock for the following year.

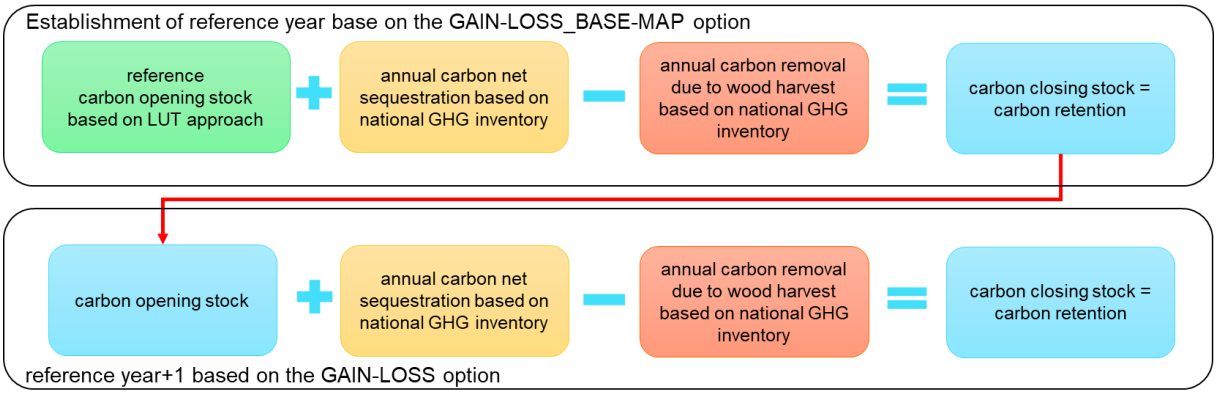


Figure 12: generation of annual carbon closing stocks based on the GAIN-LOSS method

Configuration

The following settings must be provided to calculate the annual Global Climate Regulation account (see Figure 13) for the biophysical and monetary valuation of the carbon net sequestration and biophysical valuation of the carbon retention.

Biophysical part of the carbon net sequestration:

- **GGE statistics**: Provide a file containing Eurostat dataset 'Greenhouse gas emissions by source sector' (https://ec.europa.eu/eurostat/web/products-datasets/-/env_air_gge) in the tab-separated format (tsv) for LULUCF (sector CRF4), or an equivalent dataset (e.g. national GHG inventory) with the same structure as the EUROSTAT GGE dataset.

- **Productivity proxy map**: raster dataset (preferred GeoTiff) representing the spatial distribution of the ecosystem service use. The pixel values should be a suitable proxy for the amount of gross primary productivity in each location (for example: annual dry matter productivity). **Note**: The raster file will be automatically reprojected, resampled and cut to the data area extent if needed.

- **Unmanaged forest map**: An optional raster dataset (preferred GeoTiff) to provide carbon sequestration values for unmanaged forest land. The pixel values are addressed in kilotonnes CO2 emissions per pixel with zero for managed land (use same unit as in GHG inventories, where negative values represent sinks and positive values emissions). The carbon sequestered by unmanaged forest land will be added to the GHG reported

for forest (CRF4A). You can provide the unmanaged forest GHG emissions either as map or as table, but not both.

- **Unmanaged forest table**: An optional CSV file to provide carbon sequestration values for unmanaged forest land. The values are addressed in kilotonnes CO2 emissions (use same unit as in GHG inventories, where negative values represent sinks and positive values emissions). The carbon sequestered by unmanaged forest land will be added to the GHG reported for forest (CRF4A). Required columns: 'NUTS_ID' and 'unmanaged_forests'. **Note**: the NUTS_ID represent the chosen data regions (missing regions will be set to zero). You can provide the unmanaged forest GHG emissions either as map or as table, but not both.
- **Unmanaged wetland map**: An optional raster dataset (preferred GeoTiff) to provide carbon sequestration values for unmanaged inland and coastal wetlands. The pixel values are addressed in kilotonnes CO2 emissions per pixel with zero for managed wetlands (use same unit as in GHG inventories, where negative values represent sinks and positive values emissions). The carbon sequestered by unmanaged wetlands will be added to the GHG reported for inland wetlands and coastal wetlands separately. You can provide the unmanaged wetland GHG emissions either as map or as table, but not both.
- **Unmanaged wetland table**: An optional CSV file to provide carbon sequestration values for unmanaged inland and coastal wetlands. The values are addressed in kilotonnes CO2 emissions (use same unit as in GHG inventories, where negative values represent sinks and positive values emissions). The carbon sequestered by unmanaged wetlands will be added to the GHG reported for inland wetlands and coastal wetlands separately. Required columns: 'NUTS_ID', 'unmanaged_wetland_inland', and 'unmanaged_wetland_coastal'. **Note**: the NUTS_ID represent the chosen data regions (missing regions will be set to zero). You can provide the unmanaged forest GHG emissions either as map or as table, but not both.
- **Non-reported peatland map**: An optional raster dataset (preferred GeoTiff) to provide carbon sequestration values for non-reported peatlands in grasslands and heathland-shrub ecosystems. The pixel values are addressed in kilotonnes CO2 emissions per pixel with zero for managed wetlands (use same unit as in GHG inventories, where negative values represent sinks and positive values emissions). The carbon sequestered by non-reported peatlands will be added to the GHG reported for grassland and heathland-shrub ecosystems separately. You can provide the non-reported peatland GHG emissions either as map or as table, but not both.
- **Non-reported peatland table**: An optional CSV file to provide carbon sequestration values for non-reported peatlands in grasslands and heathland-shrub ecosystems. The values are addressed in kilotonnes CO2 emissions (use same unit as in GHG inventories, where negative values represent sinks and positive values emissions). The carbon sequestered by non-reported peatlands will be added to the GHG reported for grassland and heathland-shrub ecosystems separately. Required columns: 'NUTS_ID', 'peatland_grass', and 'peatland_heathland-shrub'. **Note**: the NUTS_ID represent the

chosen data regions (missing regions will be set to zero). You can provide the non-reported peatland GHG emissions either as map or as table, but not both.

Biophysical part of the carbon net sequestration:

- **Retention calculation method**: A drop down list to select the carbon retention computation mode. The following modes are available:

    - Gain-Loss baseline stock: Calculates a baseline carbon closing stock based on a baseline reference carbon opening stock (based on the ecosystem map and the biomass per ecosystem type as specified in the carbon stock table (see below)) and the changes in carbon stock as per LULUCF reporting in the national GHG inventory (carbon net sequestration and carbon removal by wood harvest).

    - Gain-loss: Calculates a carbon closing stock based on a given carbon opening stock (load from provided table and spatially disaggregated by a proxy (see below)) and the changes in carbon stock as per LULUCF reporting in the national GHG inventory (carbon net sequestration and carbon removal by wood harvest).

    - Stock-difference: Generates thecarbon closing stock based on information on carbon stocks in the years for which the GHG inventory was established (load from provided carbon closing stock table and spatially disaggregated by a proxy (see below)).

- **Opening stock table**: A CSV file providing the carbon opening stock in kilotonnes CO2 for all LULUCF (sector CRF4) to use in the GAIN-LOSS method. **Note**: stocks are given as positive values and NOT as emissions. Required columns: 'NUTS_ID', 'CRF4A', 'CRF4B', 'CRF4C', 'CRF4D', 'CRF4E', and 'CRF4F'. **Note**: the NUTS_ID represent the chosen data regions (missing regions will be set to zero).
- **Opening stock proxy map**: Optional raster dataset (preferred GeoTiff) representing the spatial distribution of the carbon opening stock. The pixel values should be a suitable proxy for the amount carbon stock in each location (for example: biomass content). **IMPORTANT**: if this raster dataset is not provided the opening stock will be spatially disaggregated by the level-1 ecosystem distribution (all pixel values for an ecosystem in the same region get the same value).

- **Carbon stock table**: A CSV file with data on carbon stock for Above-ground biomass, Below-ground biomass and Soil Organic Carbon per hectare and ecosystem type at level 2. This dataset is used in the gain-loss baseline stock option to generate the carbon opening stock. **Note:** all Ecosystem Types at level-2 must be included in this table (missing data should be set to zero). The file must have the following columns:

    - ecosystem_type_L2: Ecosystem extent Level-2 typology numbers (x.y)

    - AGB: Above Ground Biomass per Ecosystem Level-2 type expressed in tons Carbon per hectare
    - BGB: Below Ground Biomass per Ecosystem Level-2 type expressed in tons Carbon per hectare
    - SOC: Soil Organic Carbon per Ecosystem Level-2 type expressed in tons Carbon per hectare
- **Harvest wood proxy map**: Optional raster dataset (preferred GeoTiff) representing the spatial distribution of the carbon removal due to wood harvest (LULUCF category CRF4G). The pixel values should be a suitable proxy for the amount of harvested wood (for example: harvest production map). **IMPORTANT**: if this raster dataset is not provided the carbon removal due to wood harvest will be spatially disaggregated by the level-1 ecosystem distribution (all pixel values for an ecosystem in the same region get the same value).

- **Closing stock table**: A CSV file providing the carbon closing stock in kilotonnes CO2 for all LULUCF (sector CRF4) to use in the STOCK-DIFFERENCE method. **Note**: stocks are given as positive values and NOT as emissions. Required columns: 'NUTS_ID', 'CRF4A', 'CRF4B', 'CRF4C', 'CRF4D', 'CRF4E', and 'CRF4F'. **Note**: the NUTS_ID represent the chosen data regions (missing regions will be set to zero).
- **Closing stock proxy map**: Optional raster dataset (preferred GeoTiff) representing the spatial distribution of the carbon closing stock. The pixel values should be a suitable proxy for the amount carbon stock in each location (for example: biomass content). **IMPORTANT**: if this raster dataset is not provided the closing stock will be spatially disaggregated by the level-1 ecosystem distribution (all pixel values for an ecosystem in the same region get the same value).

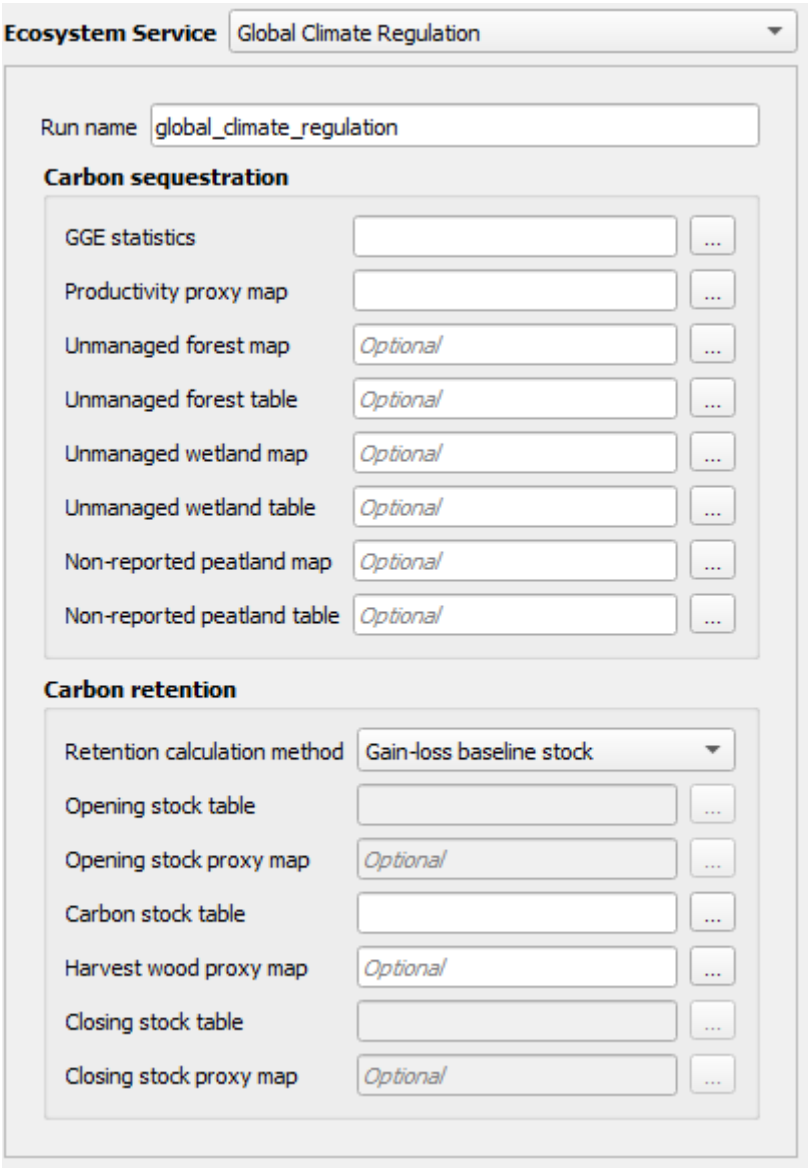


Figure 13: INCA plugin 'Global Climate Regulation' interface

Output

After a successful run, the output directory contains the following files and directories:

- **config.yaml**: a single configuration file which contains the settings used to generate these results as outlined in the previous section.
- **additional_results**: Subdirectory containing a table in CSV format representing the carbon closing stock in kilotonnes CO2 and per LULUCF categories (sector CRF4). This file can be used as carbon opening stock for the following year in the gain-loss method.
    - **Closing-stock_GAIN-LOSS_CO2-kilotonne_yyyy.csv**
- **maps:** Subdirectory containing maps for soil retention flow in physical and monetary terms for the reporting regions:
    - **carbon-retention_map_closing-stock_tonnes_yyyy.tif**
    - **carbon-sequestration_map_use_tonnes_yyyy.tif**

- **statistics**: Subdirectory containing use data in physical and monetary terms, formatted as CSV files for easier automatic processing. Note: no unit transformation is applied and the short-names for the ecosystem types is used).
    - **carbon-retention_statistics_physical_tonnes_yyyy.csv**
    - **carbon-sequestration_statistics_physical_tonnes_yyyy.csv**
- **SUTs**: Subdirectory containing the Use-and-Supply tables formatted as Microsoft Excel files. Note: unit transformation applies and the ecosystem long-names are used.
    - **carbon-retention_report_SUT-physical_tonnes_yyyy.xlsx**
    - **carbon-sequestration_report_SUT-physical_tonnes_yyyy.xlsx**
- **TEMP:** Subdirectory containing temporary files to run the model
    - Annual ecosystem raster files at level 1 and 2 for the data regions
    - Automatically adapted (reprojected, resampled and/or cut) input raster files
    - Intermediate raster files for the carbon opening stock and the wood-harvest
    - the net sequestration statistics for the 'data areas'
    - all raster files of the 'map' folder in the original data region extent (original model run)
    - generated 'data areas' and 'reporting areas' vector and raster files based on specified run parameters

The map **carbon-sequestration_map_use_tonnes_yyyy.tif** and **carbon-retention_map_closing-stock_tonnes_yyyy.tif** will be automatically added to the Layers window and available for viewing.

Metadata

This version of the tool does not yet include a metadata form for the global climate regulation service. Nevertheless, detailed file metadata is included in all raster files following the CF-4 standard.

Limitations

- resampling of input dataset with lower resolution can lead to artefacts.
- The progress bar is not updated during global climate regulation service calculations.
- If the data regions != reporting region, the uncertainty of reported statistics will strongly correlate to the chosen proxies to spatial disaggregate the data.

Updates

1.0:

- No changes

Beta 3:

- Complete redesign of the model and compliance with the Guidance Note from October 2022
- Removal of carbon net sequestration operation modes

- Implementation of unmanaged forest, unmanaged wetlands and non-reported peatland emissions in the net sequestration calculation
- usage of a wood harvest proxy to spatially disaggregate the carbon removal due to wood harvest

Beta 2:

- this service is new in beta-2 release

References

Eurostat-1, Guidance note for Global Climate Regulation services in the EU – Third draft, ENV/EA/TF/2022_3/3, 21-22 June 2022.

Eurostat-2, Guidance note for ecosystem extent accounts in the EU – Final draft, ENV/EA/TF/2022_3/2_rev.1, 24-25 March 2022.

La Notte, A., Vallecillo Rodriguez, S., Garcia Bendito, E., Grammatikopoulou, I., Czucz, B., Ferrini, S., Grizzetti, B., Rega, C., Herrando, S., Villero, D., Zurbaran Nucci, M. and Maes, J., Ecosystem Services Accounting – Part III - Pilot accounts for habitat and species maintenance, on-site soil retention and water purification, EUR 30856 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-42052-1, doi:10.2760/707, JRC126566.

Vallecillo, S; La Notte, A; Kakoulaki, G; Roberts, N; Kamberaj, J; Dottori, F; Feyen, L; Rega, C; Maes, J. *Ecosystem services accounting. Part II-Pilot accounts for crop and timber provision, global climate regulation and flood control*, EUR 29731 EN, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-02905-2, doi:10.2760/631588, JRC116334.

5.5 Crop provision

The INCA tool calculates the supply-and-use table in physical (thousands of tonnes) terms and in experimental monetary (millions of EUR) terms for the crop provision service. The crop provision account is defined as the ecosystem contributions to plant growth as approximated by the amount of harvested crops for different uses.

The tool provides also maps (rasters) where these supply values are distributed on the map according to the chosen proxy.

Methodology

For the crop provision ecosystem service, the original INCA approach calculates the actual flow per member state (NUTS level 0). The flow in physical units is based on the crop yield statistics and disentangles the ecosystem from the human inputs, using the 'emergy' approach. [Vallecillo et al., 2019]. This ecosystem contribution coefficients was provided for 13 crop types for the period 2004-2008 and was found not scalable due to lack of data for further use.

The Guidance Note (Eurostat, 2022 October) acknowledges that more work is required on 'ecosystem contribution' and therefore follows the SEEA EA recommendation to use the 'harvest approach' as a simple alternative. The reporting on crop provision could include optional data on relevant variables (nutrients, water, soil retention, etc.) either as memo items or as voluntary variables in the condition accounts.

As explained in the Guidance Note, two data sources can be used to account for crop provision, and hence are supported as input to the INCA tool:

- Material Flow Accounts (MFA)
- Agriculture Statistics (APRO_CPSH1)

The compilation of crop provision accounts based on geo-spatial data is not yet supported, however geo-spatial data is required as a proxy to generate the voluntary crop provision maps. The INCA tool supports four levels of geospatial proxies:

- No additional proxy, here the Ecosystem Extent map is used to disaggregate the crop production statistics for cropland and grassland;
- Crop type maps as a proxy, here the crop type map is used to disaggregate the crop production statistics per crop type. Crop statistics which are not defined in the crop type map will be grouped and mapped on the Ecosystem Extent class;
- Crop yield maps as a proxy, here the crop yield map is used to disaggregate the crop production statistics;
- Crop type and crop yield maps as a proxy; the most accurate disaggregation possible.

Furthermore an additional geospatial proxy can be given to further distinguish the yield per pixel:

- Productivity maps as proxy, here the yield per crop type (or ecosystem type) is distributed per pixel a ratio of the productivity map.

The INCA tool is made compliant to the guidance note and hence uses the 'harvest approach' and does the actual reporting (output) in MFA codes. If agriculture statistics are used as an input, they are automatically converted via a look-up table to MFA, including subtraction of 'crops under glass' from the crop harvest; area to harvest conversion according to the lookup table, and calculation of crop residues based on the lookup table.

Configuration

The specific settings (see Figure 14) for crop provision are:

- **calculation method**: A drop-down list of 'Material Flow' or 'Agriculture Statistics' mode, referring to the data source used as input.
- **crop lookup table**: A CSV file with data on mapping of crop types and ecosystem types. Note a default lookup table is included in the tool. The file must have the following comma separated columns:
    - *code_mfa*: MFxxx code (e.g. MF117 for Vegetables).
    - (optional) *label_mfa*: textual description of MFA code without any 'comma' signs in string
    - *code_apro*: apro_cpsh1 code (e.g. V3100 for Tomatoes). Note if code_mfa is left blank, the code_apro will not be used and hence the crop statistic will not be used.
    - (optional) *label_apro*: textual description for aro_cpsh1
    - *code_convert*: 1 if metric is provided in area, 2 if residuals are to be calculated, 0 if in 1000-tonnes
    - *yield_factor* : factor to convert area to yield or convert yield to residuals
    - *ecosystem_type_L1*: assignment of code_x to artificial, cropland or grassland ecosystem types level-1
    - *(optional) code_val*: monetary valuation code (e.g. 01500 for Grain maize), should match the identifiers in the crop pricing table (see below).
    - (optional) *label_val*: textual description of valuation code
    - (mandatory if crop type proxy) *code_croptype*: digital number of raster crop type that represents production statistic (e.g. 100 for Barley)
    - (mandatory if crop yield proxy) *code_CAPRI*: code of yield raster crop type that represents production statistic (e.g. SUGB for sugar beet)
- **crop yield table**:
    - (in material flow mode) Provide a file containing Eurostat dataset (env_ac_mfa) in the tab-separated uncompressed format (tsv), or an equivalent dataset with the same structure. Note: if using a custom dataset instead of the full Eurostat table, it should include the "Domestic extraction (DE)" environmental indicator and all MF11 (Crops) and MF12 (Crop residues) materials.
    - (in agriculture statistics mode) Provide a file containing Eurostat dataset Crop production in EU standard humidity (apro_cpsh1) in the tab-separated uncompressed format (tsv), or an equivalent dataset with the same structure.
- **crop type proxy**. An optional raster (geotiff) to provide crop types. The pixel values are expressed with a crop type code and are to be mapped in the crop lookup table (see

above). Preferably all crops as provided by the crop yield table are included, and if not the remainder crops are mapped to a class 'other crops'.

- **crop yield proxy**: An optional raster (geotiff) to provide crop yields. The pixel values are expressed in tons crop production per hectare with zero for no crop or no yield.
- **crop productivity proxy**: An optional raster (geotiff) representing the spatial distribution of the ecosystem service use. The pixel values should be a suitable proxy for the amount of gross primary productivity in each location (for example: annual dry matter productivity). **Note**: The raster file will be automatically reprojected, resampled and cut to the data area extent if needed.

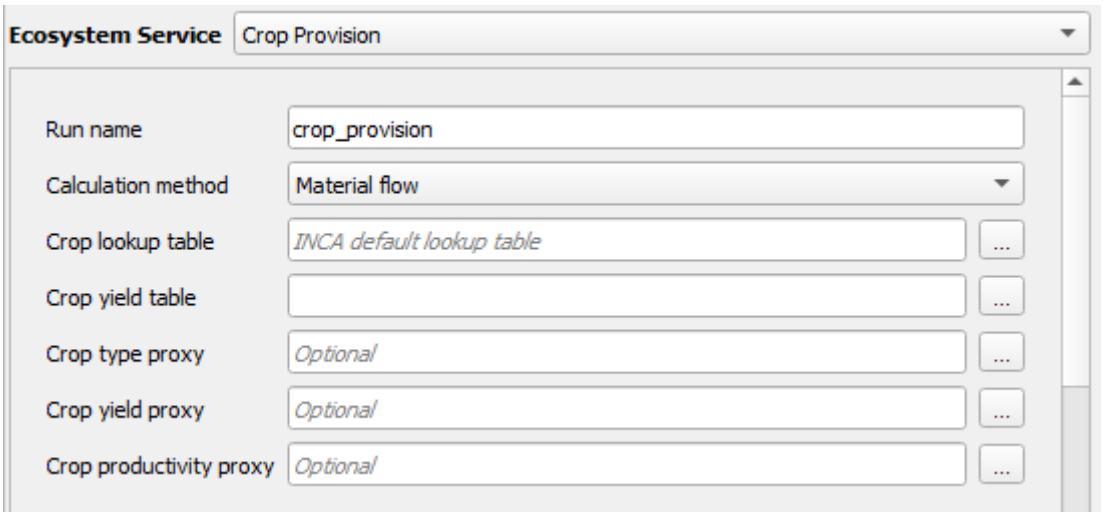


Figure 14: INCA Plugin 'Crop Provision' interface.

Output

After a successful run, the output directory contains the following files and directories:

- **config.yaml**: a single configuration file which contains the settings used to generate these results as outlined in the previous section.

    - **maps:** Subdirectory containing maps for crop provision service in physical, expressed in tonne/ha and (optionally) monetary terms, expressed in euro/ha : **crop-provision_map_use-tonne_yyyy.tif**

- **SUTs**: Subdirectory containing 'collapsed' Excel spreadsheets with supply and use tables in physical, expressed in thousand tonnes, and (optionally) monetary terms, expressed in Million Euro:
    - **crop-provision_report_SUT-physical_1000-tonne_yyyy.xlsx**, an aggregated Supply-Use table. The rows depict the aggregated value per NUTS reporting zone.
    - **crop-provision_report_SUT-physical_1000-tonne_yyyy_[NUTS].xlsx**, a Material-Flow Supply-Use table. The rows depict the Material Flow values. One excel sheet per NUTS reporting zone. The files can be seen as a further breakdown of the aggregated table.

- **additional_results**: Subdirectory containing 'full' supply and use tables in CSV format for physical and (optionally) monetary terms;
    - **crop-provision_map_use_1000-tonne_yyyy.csv**. Note this csv file can be loaded in Microsoft Excel and can be converted in a detailed SUT table through a pivot table showing detailed MFA accounting tables for each NUTS reporting zone.

- **TEMP:** Subdirectory with temporary outputs during the account generation (e.g. raster files for selected areas, etc.).

The map **crop_provision_map_use_1000-tonne_yyyy.tif** will be automatically added to the Layers window and available for viewing.

Metadata

This version of the tool does not yet include a metadata form for the crop provision service.

Limitations

- monetary valuation is experimental, and only available in agriculture statistics mode through a command line option (expert use)
- the accounts are generated through the 'harvest approach', hence 100% attribution of production statistic to ecosystem service
- no optional (memo) data is generated

Updates

1.1:

- addition of mapping of crops under glass to artificial ecosystem
- calculation fixes are applied in the conversion of area to yield
- reporting of detailed MFA accounting rows in XLS per reporting zone
- crop type map is added in the geospatial mapping
- a productivity proxy option is added in the geospatial mapping

1.0:

- fix in hidden "emergy" mode

Beta 3:

- this service is new in beta-3 release

References

Eurostat, Guidance note on crop provision ecosystem services – Fourth Proposal – for written consultation by the Environmental accounts working groups (WG EA and MESA), October 2022.

Vallecillo Rodriguez, S., La Notte, A., Kakoulaki, G., Kamberaj, J., Robert, N., Dottori, F., Feyen, L., Rega, C. and Maes, J., Ecosystem services accounting - Part II Pilot accounts for crop and timber provision, global climate regulation and flood control, EUR 29731 EN, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-02905-2, doi:10.2760/631588, JRC116334.

5.6 Air filtration

For the air filtration ecosystem service, INCA calculate the amount of PM10 particle pollution filtered out of air per member state (NUTS level 0). The amount of air filtration is determined by the LAI and the amount of pollution.

The INCA tool calculates a supply-and-use table in physical (thousands of tonnes) terms, as well as maps (rasters) where the supply values are distributed on the map according to the chosen proxy

Methodology

PM10 air filtration is considered independent of wind speed. As such deposition velocity per leaf area index (LAI) is a constant. These two factors (deposition velocity and LAI) are multiplied with the amount of pollution present. In a final step a unit correction factor is applied based on the time resolution used. All timesteps are summed to obtain the total air filtration.

DISCLAIMER: current version of the model has followed a fast-track approach and is still in verification. It is expected that the model will be updated in the next version of the tool.

Configuration

The specific settings:

- **Input data frequency:** A drop-down list of 'Monthly', 'Seasonal' or 'Yearly' referring to the ferequency of the input raster.
- **Leaf Area Index rasters:** Folder container LAI rasters, starting with number 01_PM, etc. Folder needs to contain numbers corresponding to selected time resolution. (monthly: 01 -> 12; seasonal: 01 -> 04; yearly: 01)
- **PM10 rasters:** Location of the PM 10 pollution rasters, starting with number 01_PM, etc. Folder needs to contain numbers corresponding to selected time resolution (monthly: 01 -> 12; seasonal: 01 -> 04; yearly: 01). The values of the pixels should be in kilogram per cubic metre.

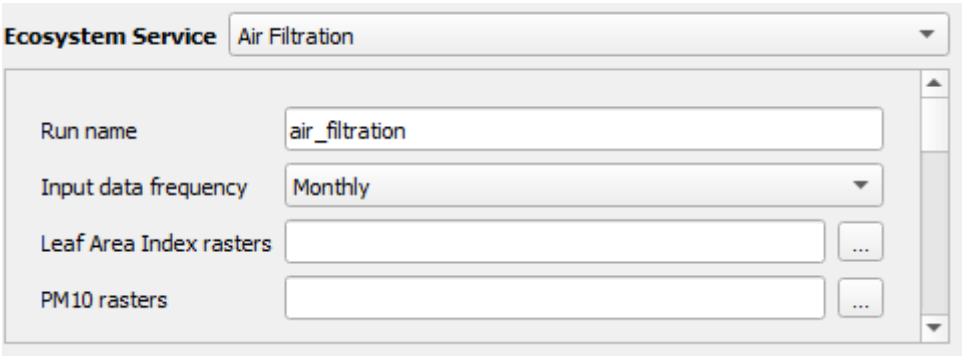


Figure 15: INCA Plugin 'Air Filtration' interface.

Output

After a successful run, the output directory contains the following files and directories:

- **config.yaml**: a single configuration file which contains the settings used to generate these results as outlined in the previous section.

- **maps:** Subdirectory containing maps for air filtration service in physical terms:
    - **Air-filtration_map_use_tonnes_yyyy.tif**

- **SUTs**: Subdirectory containing 'collapsed' Excel spreadsheets with supply and use tables in physical terms:
    - **air-filtration_report_SUT-physical_1000-tonnes_yyyy.xlsx**
    -
- **additional_results**: Subdirectory containing 'full' supply and use tables in CSV format for physical and (optionally) monetary terms;
    - **air-filtration_map_use_1000-tonne_yyyy.csv**

- **TEMP:** Subdirectory with temporary outputs during the account generation (e.g. raster files for selected areas, etc.).

Metadata

This version of the tool does not yet include a metadata form for the air filtration service. Nevertheless, detailed file metadata is included in all raster files following the CF-4 standard.

Limitations

At this moment the maximum input data frequency is monthly.

The deposition velocity in principle the Bark Area Index is also needed, in the original formula (LAI+BAI), but this value is not widely available and it is assumed negligible. In fact it will be zero for non woody plants. Hence only LAI was used.

Updates

1.0:

- The option to calculate air filtration for PM2p5 was removed from the interface.

Beta 3:

- this service is new in beta-3 release

References

JRC, VITO. Notes air filtration fall 2022.

5.7 Flood control

Methodology

The flood control service closely adheres to the methodology described in [2019, Vallecillo et al.] and [2020, Vallecillo et al.] as shown inFigure 16 below.

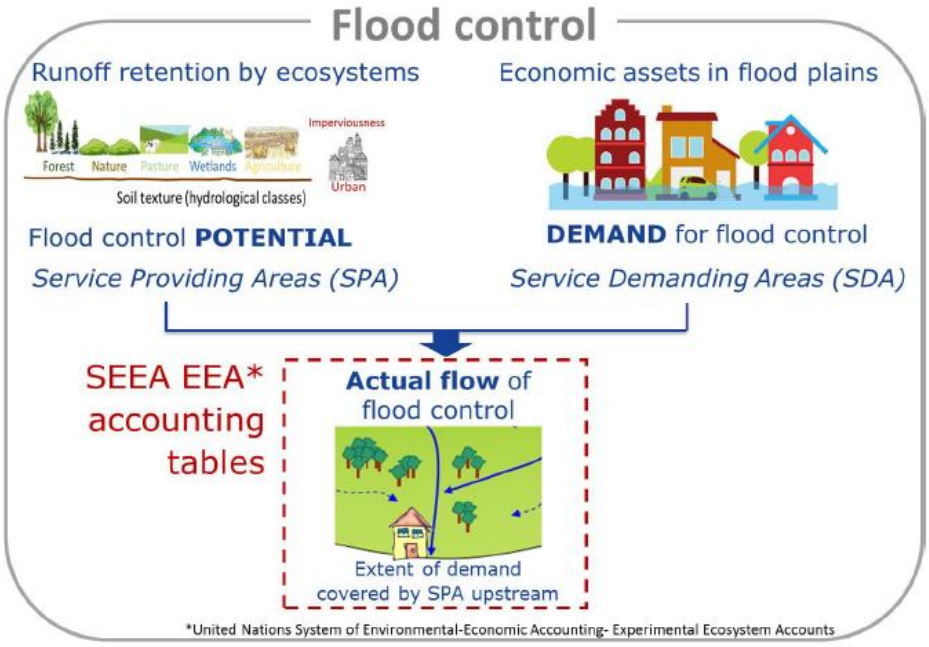


Figure 16. Scheme of the main components of flood control by ecosystems (from Vallecillo et al., 2019)

Compared with the original methodology, the following minor adjustments were applied:

- Whenever the original method distinguishes between sets of CORINE land cover types, the INCA plugin uses corresponding sets of INCA level 2 ecosystem types instead. These ecosystem types are chosen such that, for a flood control calculation based on CORINE land cover data and using the standard mapping to INCA level 2 ecosystem types, the sets of ecosystem types coincide with the land cover classes referred to in [2020, Vallecillo at al.], as much as possible.
- The supply table contains supply from the standard INCA level 1 ecosystem types (see Annex §7.1 and §7.6).
- The use table calculates use in terms of the INCA economic sectors (see Annex §7.3).

With these changes, users can run the flood control calculation based on custom land cover maps, as long as the corresponding mappings to INCA level 2 ecosystem types and standard industrial sectors, as well as a curve number table based on this land cover classification are provided.Note: the example input data provided with the plugin contains a special set of land cover maps for the flood control service. These maps, called 'CLC_roads' correspond to the CORINE accounting land cover maps used for the other services, with main and secondary roads (based on OpenStreetMap) superimposed, with landcover value 1. A custom ecosystem translation table for level 2 ecosystem types (CORINE_roads_ecosystem_mapping_L2.csv) is provided as well, where land cover value 1 is assigned to the 'Continuous urban fabric'

ecosystem type. It is possible to calculate the flood control account using the plain CORINE land cover maps, but this will ignore the effect of roads on surface runoff, as well as the contribution of roads to the demand, which may have a significant impact on results.

Configuration

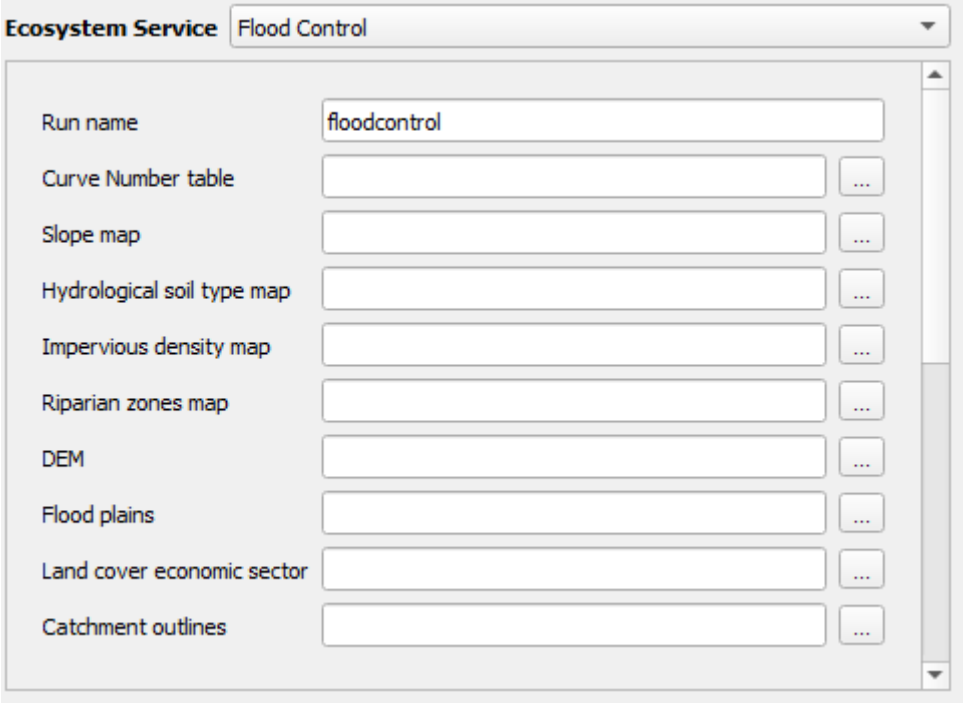


Figure 17: INCA Plugin 'Flood Control' interface.

The specific settings for the flood control service are

- **Curve Number table:** A CSV table file containing the Curve Number, a measure of precipitation runoff, depending on land cover type and hydrological soil type. The table must have columns 'landcover_id', 'Soil' and 'CN'. 'landcover_id' and 'Soil' should be integers which correspond to the values in the land cover map and the Hydrological soil type map input rasters.
- **Slope map**: A raster file containing terrain slope expressed as a percentage.
- **Hydrological soil type map**: A raster file describing the hydrological soil type.
- **Impervious density map**: A raster file with the impervious density expressed as a percentage.
- **Riparian zones map**: A mask for riparian zones, where the value 1 signifies that a pixel belongs to a riparian zone.
- **DEM**: Height map which will be used to model flow accumulation.
- **Flood plains**: A raster file describing the maximum extent of flooding to consider. Only those areas where the flood plains map has a positive value, are taken into account when calculating flood control demand.
- **Land cover economic sector**: In order to attribute flood control use to economic sectors, we need a mapping from land cover types to economic sector. Provide a CSV

file with columns ‘landcover_id’ and ‘Economic Unit’. Values in the ‘landcover_id’ column should correspond to values from the land cover map input file, and the ‘Economic Unit’ values should correspond to the INCA standard economic units (see Table 4).

- **Catchment outlines**: The flood control account module also produces a geopackage containing statistics of potential, demand, use and mismatch per catchment. Provide an vector file (shp or gpkg) of catchment outlines.

Output

After a successful run, the output directory contains the following files and directories:

- **SUTs**: directory containing supply and use tables in .xlsx format:
  - flood-control_report_SUT-physical_hectare_<year>xlsx: Hectares which benefit from flood control by ecosystems.
- **statistics**: CSV files of supply and use in monetary and physical terms for easier automatic processing.
  - **maps**: this subdirectory contains use maps in physical terms:
    - flood-control_map_use-Agricultural_hectare_<year>.tif
    - flood-control_map_use-Artificial_hectare_<year>.tif
    - flood-control_map_use_hectare_<year>.tif

    And maps of the “mismatch”: the number of hectares of demand which are not covered by supply (mismatch = pixel area - use):

    - flood-control_map_mismatch-Agricultural_hectare_<year>.tif
    - flood-control_map_mismatch-Artificial_hectare_<year>.tif
    - flood-control_map_mismatch_hectare_<year>.tif
- **additional_results**:
  - flood-control_map_potential_<year>.tif A map showing how well a given location retains flood water (flood retention score).
  - flood-control_map_SPA_<year>.tif: Pixels which contribute to the supply of flood control.
  - flood-control_map_demand-LC_<year>.tif: economic assets located in flood plains (or industrial sectors in case it also include agriculture and build-up areas)
  - flood-control_table_catchment-demand_ha<year>.gpkg, flood-control_table_catchment-potential_ha<year>.gpkg, flood-control_table_catchment-use-mismatch-value<year>.gpkg: GPGK files of the provided catchmnent outlines, with extra attributes containing total potential, demand, use and mismatch per catchment.
  - flood-control_table_landcover-retention-factors_<year>.csv, Mean and std deviation of the retention score per land cover type, as described in [Vallecillo et al., 2020].
  - flood-control_table_SPA-thresholds_<year>.csv. Mean and std deviation of resulting flood retention thresholds per ecosystem category, as described in [Vallecillo et al., 2020].

- **TEMP**: Additional intermediate maps. Contains results of flow accumulation per ecosystem type, among others.

Limitations

- The flow accumulation calculations which are part of the flood control algorithm require a large amount of computer memory, proportionate to the size of the selected regions. A calculation for the whole EU requires around 100GB of memory, and is therefore not possible on a regular personal computer. To run a calculation for a single member state, 8GB of memory is still a minimum requirement.
- Ecosystems in one region may contribute to flood control in another region in the same catchment. When limiting the calculation to specific member states, the flow accumulation calculation is limited to the territory of those member states as well, so contributions to flood control from regions outside the selected area of interest are not taken into account.
- In the beta-3 version, monetary evaluation in nominal terms can't be calculated if data areas and reporting areas are not identical.

Updates

Beta3: This service is new in the beta 3 release.

1.0:

- Rice fields are now excluded from the flood control demand calculation.
- Service providing areas (SPA) are now selected based on the threshold values calculated during the current calculation, instead of fixed threshold values which are set by the user. When comparing results from different calculations, the user should keep in mind that the selection criterion for SPA depends on the area of interest used for the calculation.

References

Vallecillo Rodriguez, S., La Notte, A., Kakoulaki, G., Kamberaj, J., Robert, N., Dottori, F., Feyen, L., Rega, C. and Maes, J., Ecosystem services accounting - Part II Pilot accounts for crop and timber provision, global climate regulation and flood control, EUR 29731 EN, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-02905-2, doi:10.2760/631588, JRC116334

Vallecillo S., Kakoulaki, G., La Notte, A., Feyen L., Dottori, F. and Maes, J., Accounting for changes in flood control delivered by ecosystems at the EU level, Ecosystem Services, Volume 44, 2020, 101142, ISSN 2212-0416, doi:10.1016/j.ecoser.2020.101142

6 Error handling

Before starting the calculation, the INCA tool performs a number of checks to verify, among others,

- if all required settings are provided
- if input maps satisfy the required constraints (e.g. study scope fits inside the map's extent, different maps have matching resolution and extent, etc).
- if the input data has the expected file format
- if all required columns are present in CSV files.

When such a check fails, the INCA tool will show an 'INCA configuration error' message describing the problem, and highlight the setting for which the check failed in red (see Figure 18 for an example).

Even if the initial checks of the provided configuration succeed, INCA may still detect an error during the calculation. In this case, an 'INCA error' window will appear, with a message describing the problem (see Figure 19 for an example). If it is unclear how to fix the problem, please contact INCA support (ESTAT-ECOSYSTEMS@ec.europa.eu).

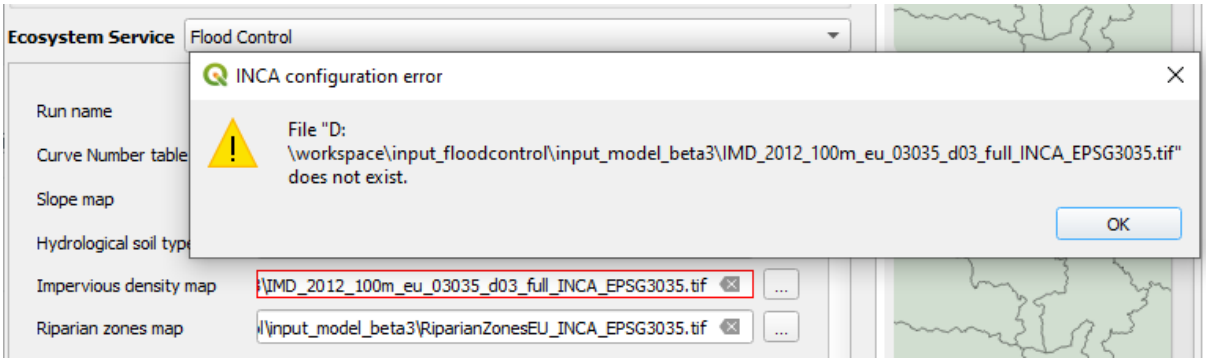


Figure 18: INCA configuration error. The input field for 'Impervious density map' is highlighted to indicate the likely cause of the error.

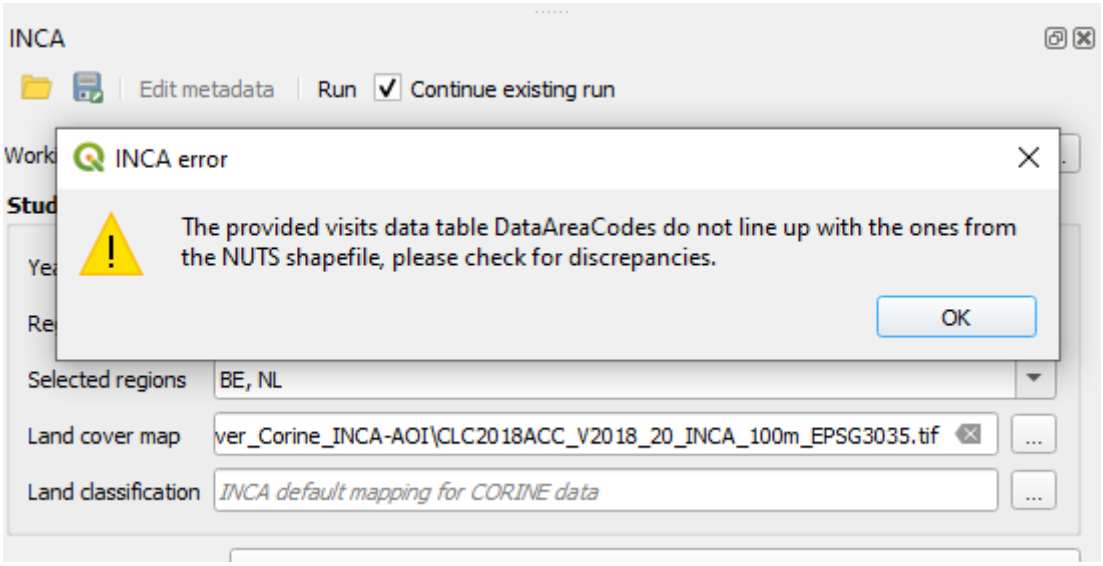


Figure 19: INCA error

Finally, INCA may also detect

- an error during the computation for which no error message is foreseen, or
- a bug.

In this case, a window with an 'INCA unexpected error' is shown, with a message that may not provide sufficient information to remedy the problem (see Figure 20). We recommend to contact INCA support, and provide them the log file, which contains further diagnostic information that should help track down the problem.

Error handling will be further improved in future releases, which should reduce the number of 'unexpected error' messages.

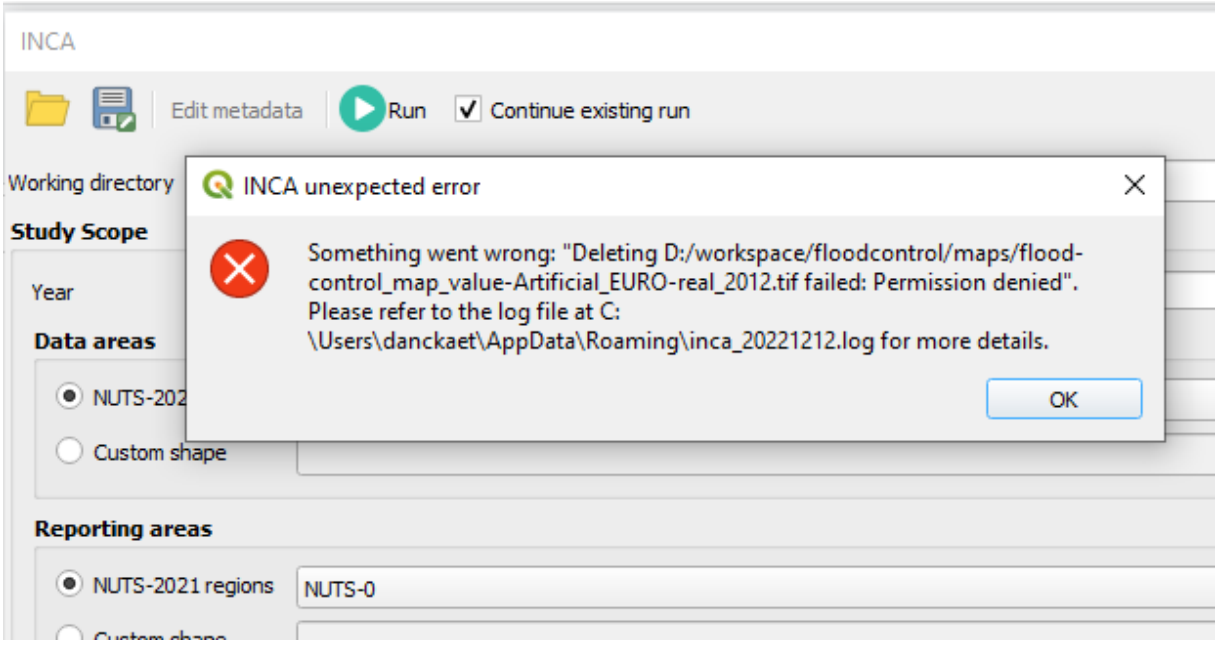


Figure 20: INCA unexpected error.

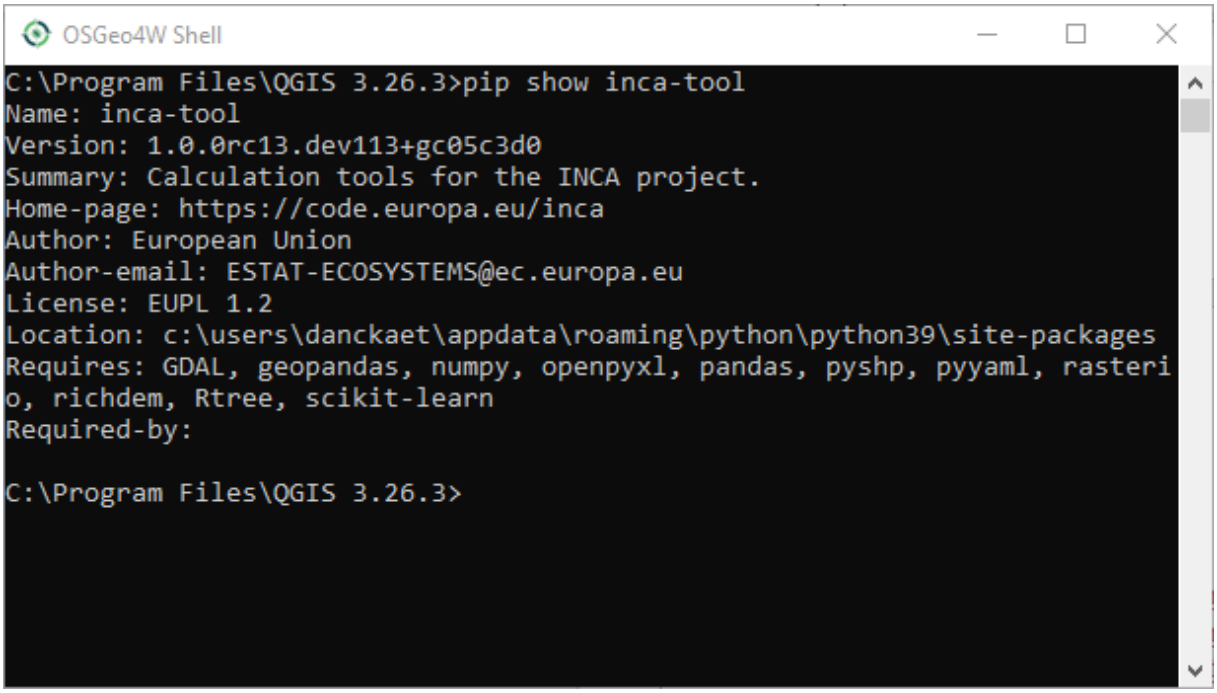
7 Annex, tabular formats

7.1 Command line interface

In addition to the QGIS plugin, a command line interface for INCA is available as well. After installation of the INCA plugin, the command line interface can be used from the OSGeo4W shell, which is found in the windows start menu.

You may have to add the INCA installation directory to the %PATH% environment variable in order to run the inca command line interface:

1. Run '**`pip show inca-tool`**' to find the inca-tool installation directory.



2. The key '`Location`' contains the installation directory of the inca-tool package. On windows, the **`inca`** command line tool is found in the '`Scripts`' subdirectory of the parent directory. e.g. if the location is `C:\Users\<username>\AppData\Roaming\Python\Python39\site-

pacakges', the **inca** command line tool is found in 'C:\Users\<username>\AppData\Roaming\Python\Python39\Scripts'.

3. Add the directory to %PATH% using the command **`set PATH=C:\Users\<username>\AppData\Roaming\Python\Python39\Scripts`** (replace by the directory obtained from step 2 if needed).

You should now be able to run the inca command. Try **`inca -h`** to get an overview of command line options, or **`inca <service_name> -h`** to get specific options for that service (e.g. **`inca crop_provision -h`**).

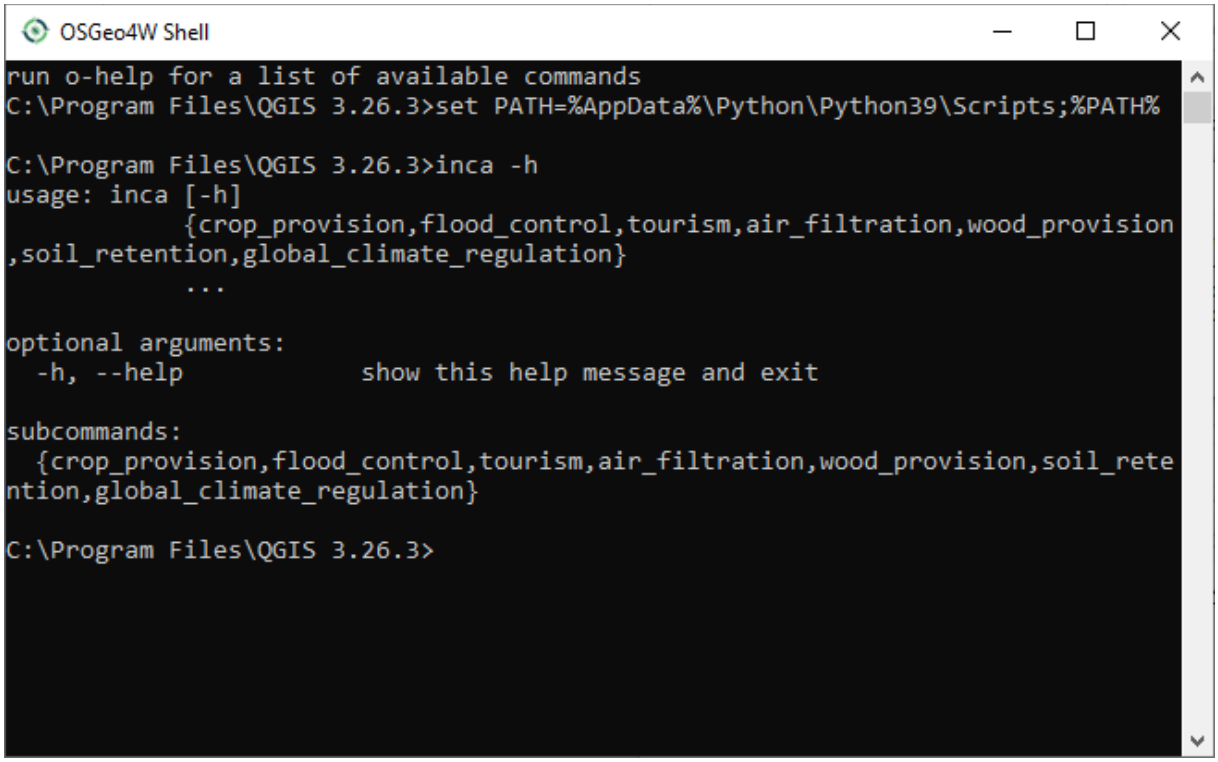


Figure 21: INCA command line interface in the OSGeo4W Shell.

7.2 INCA standard ecosystem types

INCA accounts are based on 12 level 1 (L1) ecosystem types according to the European ecosystem typology.

Table 2: INCA level 1 ecosystem types

number	Ecosystem type	Abbreviation
1	Settlements and other artificial areas	URB
2	Cropland	CRP
3	Grassland (pastures, semi-natural and natural grassland)	GRS
4	Forest and woodland	WOO

5	Heathland and shrub	HEA
6	Sparsely vegetated ecosystems	SVL
7	Inland wetlands	WET
8	Rivers and canals	RIC
9	Lakes and reservoirs	LAR
10	Marine inlets and transitional waters	MTR
11	Coastal beaches, dunes and wetlands	CBD
12	Marine ecosystems (offshore coastal shelf and open ocean)	MAE

These 12 level 1 ecosystem types are further divided into 48 level 2 (L2) types according to the European ecosystem typology.

Table 3: INCA level 2 ecosystem types

number	Ecosystem type
1.1	Continuous settlement area
1.2	Discontinuous settlement area
1.3	Infrastructure
1.4	Urban greenspace
1.5	Other artificial areas
2.1	Annual cropland
2.2	Rice fields
2.3	Permanent crops
2.4	Agro-forestry areas
2.5	Mixed farmland
2.6	Other farmland
3.1	Sown pastures and fields (modified grasslands)

3.2	Natural and semi-natural grasslands
4.1	Broadleaved deciduous forest
4.2	Coniferous forests
4.3	Broadleaved evergreen forest
4.4	Mixed forests
4.5	Transitional forest and woodland shrub
4.6	Plantations
5.1	Tundra
5.2	Heathland and (sub-)alpine shrub
5.3	Sclerophyllous vegetation
6.1	Bare rocks
6.2	(Semi-)desert and other sparsely vegetated areas
6.3	Ice sheets glaciers and perennial snow fields
7.1	Inland marshes on mineral soils
7.2	Mires bogs and fens
8.1	Rivers
8.2	Canals ditches and drains
9.1	Lakes
9.2	Artificial reservoirs
9.3	Geothermal pools and wetlands (Iceland)
10.1	Coastal lagoons
10.2	Estuaries and bays
10.3	Intertidal flats
10.4	Deepwater coastal inlets

11.1	Artificial shorelines
11.2	Coastal dunes beaches and sandy and muddy shores
11.3	Rocky shores
11.4	Coastal saltmarshes and salines
12.1	Marine macrophytes
12.2	Coral reefs
12.3	Shellfish beds and reefs
12.4	Subtidal sand beds and mud plains
12.5	Subtidal rocky substrates
12.6	Continental and island slopes
12.7	Deepwater benthic and pelagic ecosystems
12.8	Sea ice

7.3 INCA standard economic sectors

The INCA use tables distinguish the economic sectors according to European statistical standards.

Table 4: INCA economic sectors

Economic sector	Abbreviation
Intermediate consumption by industries	P2
Government final consumption	P3_S13
Households final consumption	P3_S14
Gross capital formation	P5
Exports	P6

7.4 CSV format

For input and output of tabular data, INCA uses comma-separated value files with the following format:

- The first line contains the column names.
- Columns are separated by ‘,’.
- Floating point values use ‘.’ as a decimal separator.
- Text fields containing ‘,’ are surrounded by double quotes.

For an example, see the default land classification table given in Figure 26.

7.5 Editing TSV files

A number of ecosystem service account modules rely on data provided by Eurostat as TSV files. For users who want to ingest data from different sources, we provide some guidelines on how to edit these files using either Microsoft Excel, or Python scripts.

Using Python scripts

Users who are familiar with Python and the Pandas package may use INCA’s builtin functions to read a TSV file into Pandas DataFrame, and save a DataFrame as a TSV file. From the Python environment where INCA was installed, you may run a script such as the one shown in Figure 22.

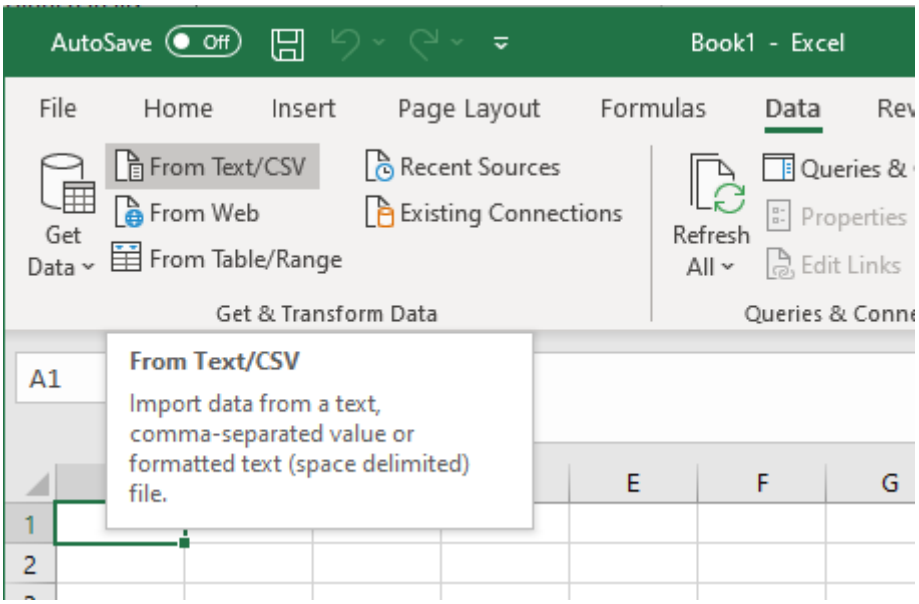
```
from inca.estat import read_tsv, write_tsv

df = read_tsv('path/to/file.tsv')

# ... modify DataFrame df as desired ...

write_tsv(df, 'path/to/file_edited.tsv')
```

Figure 22: Example Python script to modify TSV files.

Using Microsoft Excel

We demonstrate the steps required to import and export TSV data using Microsoft Excel. As similar approach can be used in LibreOffice Calc.

In the ribbon, click “Data” > “From Text/CSV”.



This will open the 'Import Data' dialog. In the filename filter field, select 'All Files (*.*)' so .tsv files are shown. Navigate to the location of the .tsv file you wish to edit, and open it. In this example, we will work with Eurostat's for_vol_efa.tsv.

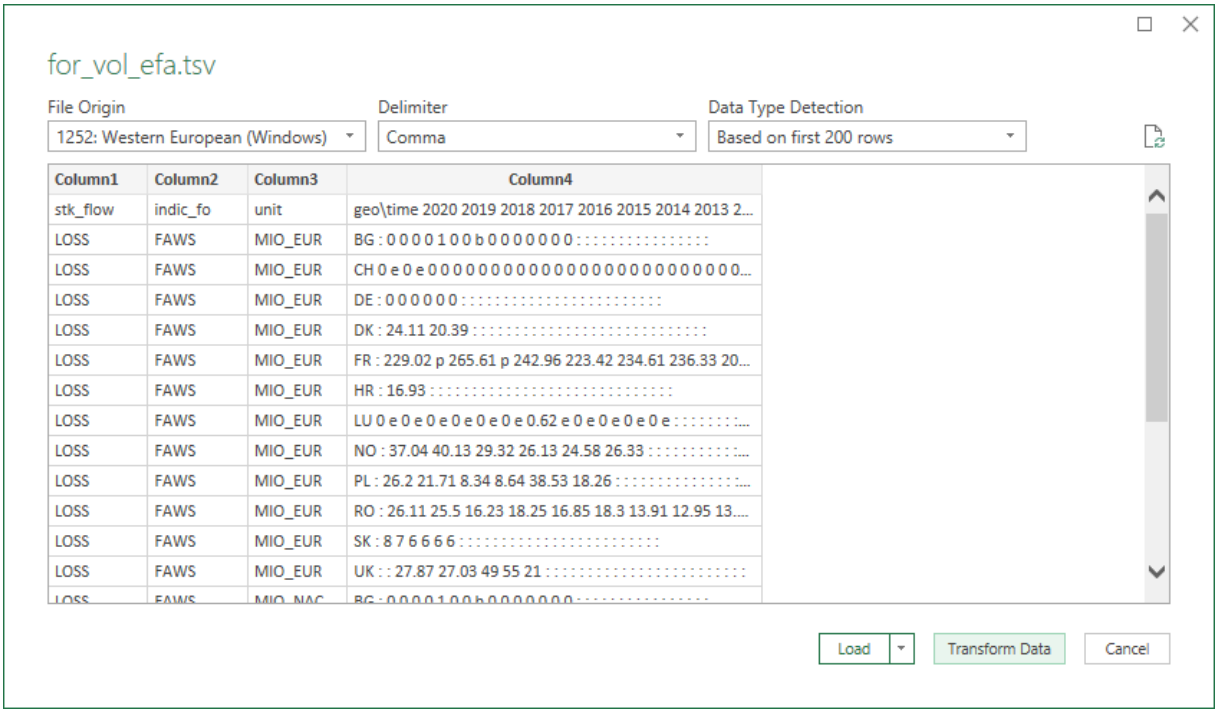


Figure 23: Import preview for for_vol_efa.tsv, click 'Transform Data' for more options.

When you have opened the file, Excel will show a preview of the resulting table. As you can see in Figure 23, the data for the different years is not placed in separate columns as it should be. To solve this, open the Power Query Editor by clikcing 'Transform Data'.

In the Power Query Editor, the input file has been split into columns using the comma as a delimiter by default. TSV files use comma's to separate the index levels, and tab characters to separate the actual data. Therefore final column in the current preview contains the last index

level (country label), as well as the actual data for every year, joined by Tab characters. To correctly split the data into a separate column for each year, right-click the last column header (Column4 in our example), and select ‘Split Column’ > ‘By Delimiter…’. In the Split Column By Delimiter dialog, select delimiter ‘Tab’.

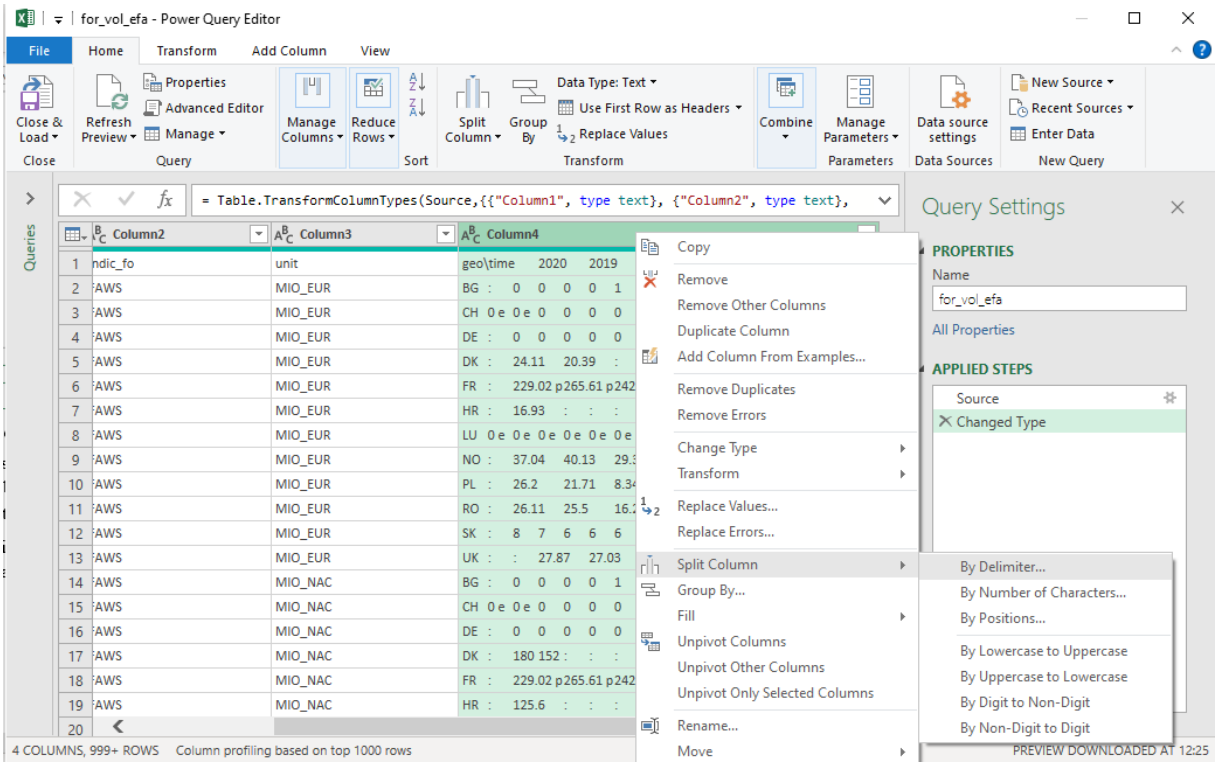
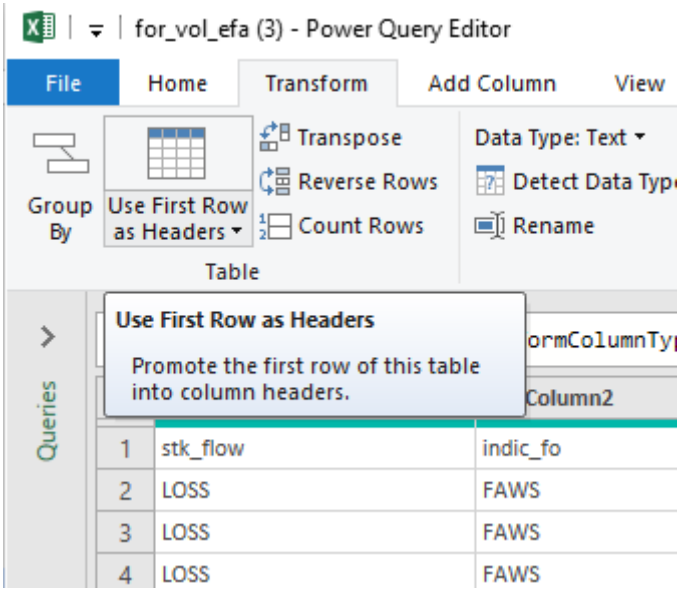


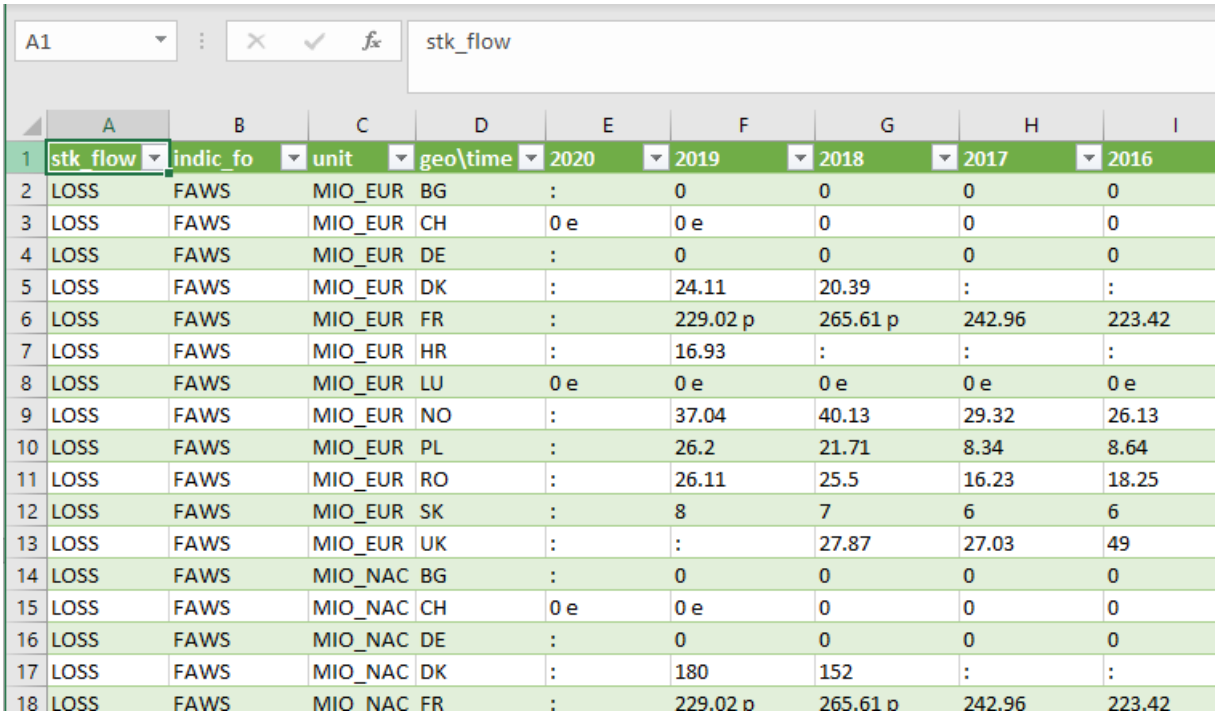
Figure 24: Splitting the last column into multiple fields.

At this point, all the input data should be split into multiple fields.

As a final step, tell the Power Query Editor that the first line of the input file contains the labels for the data columns. In the ribbon, click ‘Transform’ > ‘Use First Row as Headers’:



Now, click ‘Home’ > ‘Close & Load’ in the Power Query Editor to load the data into your sheet as a table.



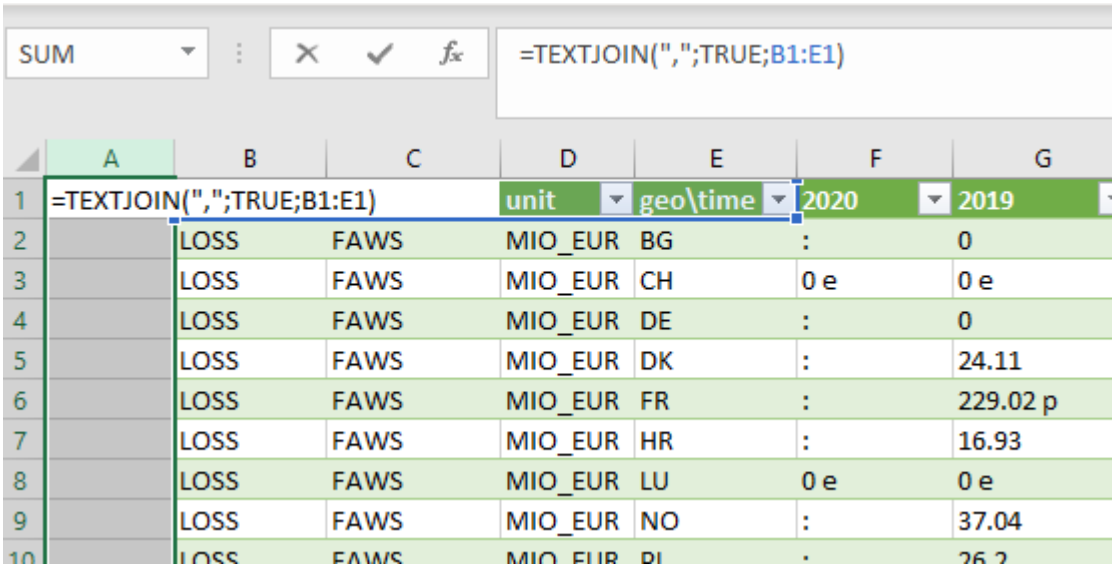
	A	B	C	D	E	F	G	H	I
1	stk_flow	indic_fo	unit	geo\time	2020	2019	2018	2017	2016
2	LOSS	FAWS	MIO_EUR	BG	:	0	0	0	0
3	LOSS	FAWS	MIO_EUR	CH	0 e	0 e	0	0	0
4	LOSS	FAWS	MIO_EUR	DE	:	0	0	0	0
5	LOSS	FAWS	MIO_EUR	DK	:	24.11	20.39	:	:
6	LOSS	FAWS	MIO_EUR	FR	:	229.02 p	265.61 p	242.96	223.42
7	LOSS	FAWS	MIO_EUR	HR	:	16.93	:	:	:
8	LOSS	FAWS	MIO_EUR	LU	0 e	0 e	0 e	0 e	0 e
9	LOSS	FAWS	MIO_EUR	NO	:	37.04	40.13	29.32	26.13
10	LOSS	FAWS	MIO_EUR	PL	:	26.2	21.71	8.34	8.64
11	LOSS	FAWS	MIO_EUR	RO	:	26.11	25.5	16.23	18.25
12	LOSS	FAWS	MIO_EUR	SK	:	8	7	6	6
13	LOSS	FAWS	MIO_EUR	UK	:	:	27.87	27.03	49
14	LOSS	FAWS	MIO_NAC	BG	:	0	0	0	0
15	LOSS	FAWS	MIO_NAC	CH	0 e	0 e	0	0	0
16	LOSS	FAWS	MIO_NAC	DE	:	0	0	0	0
17	LOSS	FAWS	MIO_NAC	DK	:	180	152	:	:
18	LOSS	FAWS	MIO_NAC	FR	:	229.02 p	265.61 p	242.96	223.42

Figure 25: Result of importing for_vol_efa.tsv.

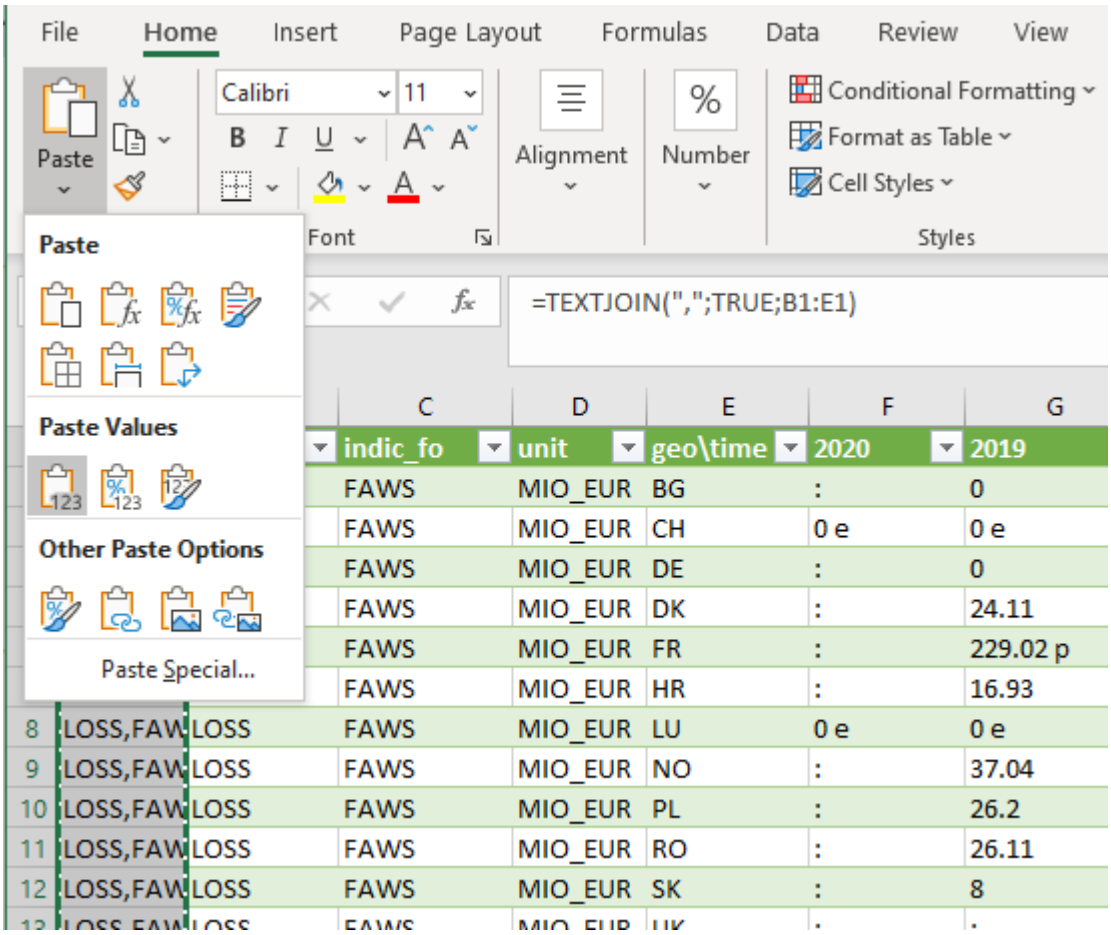
You can now edit data in this table as you wish. After making the desired changes, the data should be saved as a TSV file again. To do this, we have to join the index columns (in our example, the columns ‘stk_flow, ‘indic_fo’, ‘unit’ and ‘geo\time’) using ‘,’ again, and then save the result as a tab-separated text file.

There is no user-friendly option to join columns using a ‘,’ in Excel. Instead, we will create a new column, fill it using a formula, and then remove the old split columns:

1. Insert a new column at the beginnig of the sheet (right-click the first column, and choose ‘Insert’.
2. In the top cell of the new column, insert the formula ‘TEXTJOIN(“,”;TRUE;<Range of columns>)’. In our example, the range of columns to join is ‘B1:E1’, from ‘stk_flow’ to ‘geo\time’:



3. Now, we need to fill the entire first column using this formula. Select the column, and in the ribbon, click ‘Home’ > ‘Fill’ > ‘Down’.
4. Now, we need to remove the split versions of the index columns. Before we can do that, replace the formula, which still refers to the other columns, by the resulting values: select the column, click ‘Copy’, and then click ‘Paste’ > ‘Paste Values’:



5. Now we can safely delete the split version of the index columns:

	A	B	C	D	E	F	
1	stk_flow,i	2020	2019	2018	2017	2016	2015
2	LOSS,FAW	:	0	0	0	0	1
3	LOSS,FAW	0 e	0 e	0	0	0	0
4	LOSS,FAW	:	0	0	0	0	0
5	LOSS,FAW	:	24.11	20.39	:	:	:
6	LOSS,FAW	:	229.02 p	265.61 p	242.96	223.42	234.61
7	LOSS,FAW	:	16.93	:	:	:	:
8	LOSS,FAW	0 e	0 e	0 e	0 e	0 e	0 e
9	LOSS,FAW	:	37.04	40.13	29.32	26.13	24.58
10	LOSS,FAW	:	26.2	21.71	8.34	8.64	38.53
11	LOSS,FAW	:	26.11	25.5	16.23	18.25	16.85
12	LOSS,FAW	:	8	7	6	6	6
13	LOSS,FAW	:	:	27.87	27.03	49	55
14	LOSS,FAW	:	0	0	0	0	1
15	LOSS,FAW	0 e	0 e	0	0	0	0
16	LOSS,FAW	:	0	0	0	0	0
17	LOSS,FAW	:	180	152	:	:	:
18	LOSS,FAW	:	229.02 p	265.61 p	242.96	223.42	234.61
19	LOSS,FAW	:	125.6	:	:	:	:
20	LOSS,FAW	0 e	0 e	0 e	0 e	0 e	0 e
21	LOSS,FAW	:	364.9	385.18	273.49	242.78	220

6. This version of the table can now be saved as a tab-separated file, to be read by INCA. Click ‘File’ > ‘Save As’, and in the file format drop-down menu, select ‘Text (Tab Delimited) (*.txt)’.

7.6 Land classification tables

Users can provide their own land cover maps, together with a classification table mapping each distinct land cover map values to one of the twelve level 1 INCA ecosystem types, or one of the level 2 INCA ecosystem types. The mapping should be provided as a CSV file following the format described in appendix 7.3, with columns ‘landcover_id’, which contains the values of the input land cover map, and ‘ecosystem_type_L1’ or ‘ecosystem_type_L2’, which contains the number of the corresponding ecosystem type (see §7.1). If the CSV file contains extra columns, they are ignored by the INCA tool.

If no custom mapping is provided, INCA assumes the land cover map contains CORINE data, and uses the default mapping described by the following table (see also limitations in §4.1):

```
ecosystem_type_L2,landcover_id,name_ecosystem_type,name_landcover
1.1,111,Continuous settlement area,Continuous urban fabric
1.2,112,Discontinuous settlement area,Discontinuous urban fabric
1.3,1,Infrastructure,Roads
1.3,121,Infrastructure,Industrial or commercial units
1.3,122,Infrastructure,Road and rail networks and associated land
1.3,123,Infrastructure,Port areas
1.3,124,Infrastructure,Airports
1.3,131,Infrastructure,Mineral extraction sites
1.3,132,Infrastructure,Dump sites
1.3,133,Infrastructure,Construction sites
1.4,141,Urban greenspace,Green urban areas
1.4,142,Urban greenspace,Sport and leisure facilities
2.1,211,Annual cropland,Non-irrigated arable land
2.1,212,Annual cropland,Permanently irrigated land
2.2,213,Rice fields,Rice fields
2.3,221,Permanent crops,Vineyards
2.3,222,Permanent crops,Fruit trees and berry plantations
2.3,223,Permanent crops,Olive groves
2.4,244,Agro-forestry areas,Agro-forestry areas
2.5,241,Mixed farmland,Annual crops associated with permanent crops
2.5,242,Mixed farmland,Complex cultivation patterns
2.5,243,Mixed farmland,"Land principally occupied by agriculture, with
significant areas of natural vegetation"
3.1,231,Sown pastures and fields (modified grasslands),Pastures
3.2,321,Natural and semi-natural grasslands,Natural grasslands
4.1,311,Broadleaved deciduous forest,Broad-leaved forest
4.2,312,Coniferous forests,Coniferous forest
4.4,313,Mixed forests,Mixed forest
4.5,324,Transitional forest and woodland shrub,Transitional woodland-shrub
5.2,322,Heathland and (sub-)alpine shrub,Moors and heathland
5.3,323,Sclerophyllous vegetation,Sclerophyllous vegetation
6.1,332,Bare rocks,Bare rocks
6.2,333,(Semi-)desert and other sparsely vegetated areas,Sparsely vegetated
areas
6.2,334,(Semi-)desert and other sparsely vegetated areas,Burnt areas
6.3,335,Ice sheets glaciers and perennial snow fields,Glaciers and perpetual
snow
7.1,411,Inland marshes on mineral soils,Inland marshes
7.2,412,Mires bogs and fens,Peat bogs
8.2,511,Canals ditches and drains,Water courses
9.1,512,Lakes,Water bodies
10.1,521,Coastal lagoons,Coastal lagoons
10.2,522,Estuaries and bays,Estuaries
10.3,423,Intertidal flats,Intertidal flats
11.2,331,Coastal dunes beaches and sandy and muddy shores,"Beaches, dunes,
sands"
11.4,421,Coastal saltmarshes and salines,Salt marshes
11.4,422,Coastal saltmarshes and salines,Salines
```

Figure 26: Example mapping of land cover values to level 2 ecosystem types. The extra columns 'name_ecosystem_type' and 'name_landcover' containing the ecosystem type label and the CORINE land cover type label are purely informative, and will be ignored by the INCA tool.

7.7 Deflator table

INCA uses tables tracking yearly inflation per reporting region in order to calculate the monetary value of ecosystem services in terms of price levels for the reference year 2000. These tables should be provided in the standard CSV format, with columns

- **NUTS_ID**: the id of the regions (should match the id's of the regions selected for processing).
- **2000**, **2001**, …: columns containing the price index per region for the different years. In order for INCA to be able to correct prices for inflation with respect to the year 2000, the provided table should contain at least a column for the year 2000 and for the year currently being evaluated.

```
NUTS_ID,2000,2006,2012,2018
BE,100,112.3235016,124.0666972,135.6005265
BG,100,135.2831379,183.94214130000003,208.4522062
CZ,100,114.4101364,123.9490148,136.7902612
DK,100,114.1937986,130.2287045,136.01684269999998
DE,100,106.064978,114.5289261,126.5240981
EE,100,140.51649719999998,188.2253179,223.9701349
IE,100,125.2716528,121.12028,136.0284118
EL,100,120.6502738,134.2191159,128.2641657
ES,100,126.6402225,134.1371953,138.93290969999998
FR,100,112.22884209999998,121.6894631,127.2536268
HR,100,125.3785804,147.8220055,153.8618459
IT,100,117.3957,129.80885049999998,137.6786739
LV,100,150.58104330000003,199.9366301,223.5001547
LT,100,116.1861438,148.4925919,166.34757380000005
LU,100,120.4320007,143.3466438,157.6566042
HU,100,141.4966534,175.14808480000005,212.0952222
NL,100,116.932714,125.5579276,133.8681571
AT,100,111.0398781,123.6115158,137.1943184
PL,100,115.8570961,139.2278986,146.5749572
PT,100,122.0272954,129.2158604,142.69876340000005
RO,100,298.2135583999999,465.2471395,575.7852295
SI,100,132.4799505,149.7931868,161.4836097
SK,100,128.3954869,136.55566069999998,140.4567489
FI,100,107.0596378,122.3000825,133.23531359999998
SE,100,108.7994117,121.8448303,135.6690601
CY,100,118.3535066,136.23726499999998,134.65969109999997
MT,100,116.198002,133.3866979,154.7851531
```

Figure 27: Example deflator table for EU-27 member states for the years 2000, 2006, 2012 and 2018.

7.8 Default datasets

The tables below show the default datasets to generate accounts for the EU-27 member states for the years 2000, 2006, 2012 and 2018. Users are advised to replace the datasets, where possible, with more precise national data.

Table 5: Default datasets for INCA 1.0 service models, part 1A

Id	Dataset	file type	file name	ZIP package name	pre-processed in inca	origin	years (data input)			
							2000	2006	2012	2018
1	NUTS classification (Nomenclature of territorial units for statistics)	shapefile	NUTS_RG_01M_2021_3035_LEVL_y.shp	generic; also embedded in plug_in	no	Eurostat https://ec.europa.eu/eurostat/web/gisco/geodata/reference-data/administrative-units-statistical-units/nuts#nuts21				2021
2	Accounting CORINE Land-cover v20	raster	CLC20yyACC_V2018_20.tif	generic	no	European Environment Agency https://www.eea.europa.eu/data-and-maps/data/corine-land-cover-accounting-layers	x	x	x	x
3	CORINE land cover maps with OpenStreetMap roads	raster	CLCyyyyACC_OSM_roads_INCA_EPSG303	tourismrecreation	Merged CLCACC with OSM roads	European Environment Agency https://www.eea.europa.eu/data-and-maps/data/corine-land-cover-accounting-layers OpenStreetMap	x	x	x	x
4	Nights spent at tourist accommodation establishments by degree of urbanisation and by NUTS 2 regions	tabular	overnight_stays_2018.csv	tourismrecreation	no	Eurostat				x
5	Recreaton Potential	raster	RP_yyyy_uint8.tif	tourismrecreation	yes	JRC	x	x	x	x
6	Volume of timber over bark	tabular	for_vol_efa.tsv	woodprovision	no	Eurostat https://ec.europa.eu/eurostat/web/products-datasets/-/for_vol_efa	x	x	x	x
7	Mask for Natura 2000 areas and areas with very steep slopes	raster	forestry_mask_<year>.tif	woodprovision	Masking forest pixels for Natura 2000 protected areas and steep slopes	https://www.eea.europa.eu/data-and-maps/data/natura-12 https://land.copernicus.eu/imagery-in-situ/eu-dem	x	x	x	x
8	Dry matter production v2.0.1	raster	DMP_<year>_annual-total_INCA.tif	woodprovision	Temporal aggregated from 10-days to annual	Copernicus Global Land https://land.copernicus.eu/global/products/dmp	x	x	x	x
9	Digital Elevation Model	raster	dt1_dem_INCA_EPSG3035_100m.tif	floodcontrol	Resampled to 100m	Copernicus Land https://land.copernicus.eu/imagery-in-situ/eu-dem			2010	
10	Material flow accounts	tabular	env_ac_mfa.tsv	cropprovision	no	Eurostat https://ec.europa.eu/eurostat/databrowser/product/view/ENV_AC_MFA	x	x	x	x
11	Crop production in EU standard humidity by NUTS2 regions	tabular	apro_cpsh1.tsv	cropprovision	no	Eurostat https://ec.europa.eu/eurostat/databrowser/view/apro_cpshr/default/table?lang=en	x	x	x	x
12	European Crop map	raster	not applicable yet	cropprovision	no	https://publications.jrc.ec.europa.eu/repository/handle/JRC125312				x
13	CAPRI crop yield map at HSU	raster	ECYield_nograss_tonha_F.tif	cropprovision	no	https://www.capri-model.org/docs/capri_documentation.pdf	x		2008	

Table 6: Default datasets for INCA 1.0 service models, part 2A

Id	Dataset	file type	file name	ZIP package name	pre-processed in inca	origin	years (data input)				accounts						
							2000	2006	2012	2018	crop provision	wood provision	global climate regulation	air filtration	soil retention	flood control	nature-based tourism recreation
14	Leaf Area Index	raster	xx_LAI_average.tif	airfiltration	Temporal aggregated from 10-days to montly, seasonal and yearly	Copernicus Global Land https://land.copernicus.eu/global/products/lai	x	x	x	x				x			
15	PM 2.5 pollution	raster	xx_pm2p5_average.tif	airfiltration	Temporal aggregation from monthly to seasonal and yearly (at 0.75°)	Copernicus Atmosphere Monitoring https://ads.atmosphere.copernicus.eu/cdsapp#!/dataset/cams-global-reanalysis-eac4-monthly?tab=overview		x	x	x				x			
16	PM 10 pollution	raster	xx_pm10_average.tif	airfiltration	Temporal aggregation from monthly to seasonal and yearly (at 0.75°)	Copernicus Atmosphere Monitoring https://ads.atmosphere.copernicus.eu/cdsapp#!/dataset/cams-global-reanalysis-eac4-monthly?tab=overview		x	x	x				x			
17	Wind speed	raster	xx_wind_average_INCA.tif	airfiltration	Temporal aggregation from monthly to seasonal and yearly (at 0.1°)	Copernicus Climate Service https://cds.climate.copernicus.eu/cdsapp#!/dataset/insitu-gridded-observations-europe?tab=overview		x	x	x				x			
18	Greenhouse gas emissions by source sector	tabular	env_air_gge.tsv	globalclimateregulation	no	European Environment Agency https://ec.europa.eu/eurostat/databrowser/view/sdg_13_10/default/table?lang=en	x	x	x	x			x				
19	Unmanaged forest map	raster	dummy_GGE_unmanaged_forests.csv	globalclimateregulation	no	not applicable							x				
20	Unmanaged wetland table	raster	dummy_GGE_unmanaged_wetlands.csv	globalclimateregulation	no	not applicable							x				
21	Non-reported peatland table	raster	dummy_GGE_nonreported_peatlands.csv	globalclimateregulation	no	not applicable							x				
22	Carbon stock table	tabular	dummy_*-tock_table_C02_kilotonne.csv	globalclimateregulation	no	not applicable							x				
23	Harvest wood proxy map	raster	carbon-retention_average-wood-productio	globalclimateregulation	no	https://datadryad.org/stash/dataset/doi:10.5061/dryad.mk067			2015				x				
24	C- factor	raster	soil-retention_cfactor_<year>_EU27_100m_EPSG3035.tif	soilretention	derived from Copernicus fraction of green vegetation cover + agriculture farm structure, resampled to 100m	https://land.copernicus.eu/global/products/fcover https://ec.europa.eu/eurostat/databrowser/view/EF_MP_PRAC/default/table?lang=en&category=agr.ef.ef_mp	x	x	x	x					x		
25	Soil erodibility (K factor)	raster	soil-retention_K-factor_EU27_500m_EPSG3035_filled.tif	soilretention	original dataset gap filled	https://esdac.jrc.ec.europa.eu/content/soil-erodibility-k-factor-high-resolution-dataset-europe#tabs-0-description=0			2014						x		
26	Support Practices factor (P factor)	raster	soil-retention_P-factor_EU27_500m_EPSG3035_filled.tif	soilretention	original dataset gap filled and values below 0 rescaled	https://esdac.jrc.ec.europa.eu/content/support-practices-factor-p-factor-eu			2014						x		
27	Rainfall erosivity (R factor)	raster			To be downloaded by user	https://esdac.jrc.ec.europa.eu/content/rainfall-erosivity-european-union-and-switzerland			2014						x		
28	Slope length and Steepness factor (LS factor)	raster			To be downloaded by user	https://esdac.jrc.ec.europa.eu/content/ls-factor-slope-length-and-steepness-factor-eu			2014								
29	Curve Number based on CORINE land cover and hydrological soil type.	raster	soil_CORINE_CN.csv	floodcontrol		JRC										x	
30	CORINE land cover to economic sector mapping	raster	CORINE_economic_units.csv	floodcontrol												x	
31	Slope map	raster	dt1_slope_INCA_EPSG3035_100m_Byte.tif	floodcontrol	slope calculated from dem	Copernicus										x	
32	Hydrological soil type map	raster	hydro_soilgroup_INCA_EPSG3035.tif	floodcontrol	soil texture reclassified to hydrological	JRC										x	
33	Impervious density map	raster	IMD_yyyy_100m_eu_03035_*tif	floodcontrol		Copernicus	2006	x	x	x						x	
34	Riparian zones map	raster	RiparianZonesEU_INCA_EPSG3035.tif	floodcontrol	rasterized	JRC										x	
35	Flood maps per return period	raster	floodMapEU_rp*y.tif	floodcontrol		JRC										x	
36	Catchment outlines	shapefile	RiverBasin_EU27.shp	floodcontrol		JRC										x	

Table 7: Default datasets for INCA 1.0 service models, part 1B

Id	Dataset	accounts						
		crop provision	wood provision	global climate regulation	air filtration	soil retention	flood control	nature-based tourism recreation
1	NUTS classification (Nomenclature of territorial units for statistics)	x	x	x	x	x	x	x
2	Accounting CORINE Land-cover v20	x	x	x	x	x	x	x
3	CORINE land cover maps with OpenStreetMap roads						x	
4	Nights spent at tourist accommodation establishments by degree of urbanisation and by NUTS 2 regions							x
5	Recreaton Potential							x
6	Volume of timber over bark		x					
7	Mask for Natura 2000 areas and areas with very steep slopes		x					
8	Dry matter production v2.0.1		x	x				
9	Digital Elevation Model		x				x	
10	Material flow accounts	x						
11	Crop production in EU standard humidity by NUTS2 regions	x						
12	European Crop map	x						
13	CAPRI crop yield map at HSU	x						

Table 8: Default datasets for INCA 1.0 service models, part 2B

Id	Dataset	accounts						
		crop provision	wood provision	global climate regulation	air filtration	soil retention	flood control	nature-based tourism recreation
14	Leaf Area Index				x			
15	PM 2.5 pollution				x			
16	PM 10 pollution				x			
17	Wind speed				x			
18	Greenhouse gas emissions by source sector			x				
19	Unmanaged forest map			x				
20	Unmanaged w etland table			x				
21	Non-reported peatland table			x				
22	Carbon stock table			x				
23	Harvest w ood proxy map			x				
24	C- factor					x		
25	Soil erodibility (K factor)					x		
26	Support Practices factor (P factor)					x		
27	Rainfall erosivity (R factor)					x		
28	Slope length and Steepness factor (LS factor)							
29	Curve Number based on CORINE land cover and hydrological soil type.						x	
30	CORINE land cover to economic sector mapping						x	
31	Slope map						x	
32	Hydrological soil type map						x	
33	Impervious density map						x	
34	Riparian zones map						x	
35	Flood maps per return period						x	
36	Catchment outlines						x	

Table 9: Default datasets for INCA 1.0 service models, optional monetary part

Id	Dataset	file type	file name	ZIP package name	pre-processed in inca	origin	years (data input)			
							2000	2006	2012	2018
m1	deflator table	tabular	deflator_table.csv, deflator_table_nuts2.csv	monetary	no	not applicable				
m2	Unit values at basic prices (from Eurostat)	tabular	aact_uv01_adapted.tsv	monetary	outliers removed	https://ec.europa.eu/eurostat/databrow ser/view /AACT_UV01/default/table?lang=en&category=agr.aact.aact_uv				
m3	Carbon sequestration pricing table	tabular	annual_prices_carbon.csv	monetary	no	JRC	x	x	x	x
m4	LUCAS topsoil nutrient content - Nitrogen	raster			To be dow nloaded by user	https://esdac.jrc.ec.europa.eu/content/chemical-properties-european-scale-based-lucas-topsoil-data			2014	
m5	LUCAS topsoil nutrient content - Phosphorous	raster			To be dow nloaded by user	https://esdac.jrc.ec.europa.eu/content/chemical-properties-european-scale-based-lucas-topsoil-data			2014	
m6	EU Retention ratios	tabular	soil-retention_LUT_EU_retention_ratios.csv	monetary	no	https://w w w .capri-model.org/docs/capri_documentation.pdf		2008		
m7	Annual nutrient and bulk soil prices	tabular	soil-retention_LUT_annual_nutrient-and-bulksoil_prices_20221205.csv	monetary	no	JRC				2022
m8	Damage functions	tabular	damage_EU_all.xlsx	monetary	no	JRC		2007		
m9	Roundw ood, fuelw ood and other basic products	tabular	for_basic_adjusted.tsv	monetary	outliers removed	https://ec.europa.eu/eurostat/w eb/products-datasets/-/for_basic	x	x	x	x
m10	Supply and use of products w ithin forestry	tabular	for_sup_cp_adjusted.tsv	monetary	outliers removed	https://ec.europa.eu/eurostat/databrow ser/view /for_sup_cp/default/table	x	x	x	x

Id	Dataset	accounts						
		crop provision	wood provision	global climate regulation	air filtration	soil retention	flood control	nature-based tourism recreation
m1	deflator table	x	x	x		x	x	x
m2	Unit values at basic prices (from Eurostat)	x						
m3	Carbon sequestration pricing table			x				
m4	LUCAS topsoil nutrient content - Nitrogen					x		
m5	LUCAS topsoil nutrient content - Phosphorous					x		
m6	EU Retention ratios					x		
m7	Annual nutrient and bulk soil prices					x		
m8	Damage functions						x	
m9	Roundw ood, fuelw ood and other basic products		x					
m10	Supply and use of products w ithin forestry		x					