A tool developed by TERRASYSTEM as a part of Carbon Farming Certification System project. Co-funded by the 2020 LIFE Programme of the European Commission under code "LIFE20 PRE IT/017"

https://c-farms.eu/

User guide for simulation functions

C-FARMs - Carbon Farming Simulator is a prototype web application for the simulation of scenarios on the sequestration and/or reduction potential of CO_2 emissions associated with the adoption of carbon farming practices. It allows analysis both at farm and regional level, in two separate sections: 'Farm Scenarios' and 'Regional Scenarios'.

The C-FARMs - Carbon Farming Simulator provides two different simulation algorithms:

- The 'IPCC - TIER 2 method' is based on the IPCC guidelines (IPCC, 2006) to assess the change in SOC stock as a function of changes in the agricultural practices (simulated by the user) and of environmental constants. Simulations with the 'IPCC- TIER 2 ' method are possible over the entire agricultural area of Lombardy.
- The 'C-FARMs method' makes the best use of the spatial integration of the most up-to-date existing geodatabases (FAO GSOC map, Climatic stratification of the Environment of Europe, Land use and soil map of the Lombardy Region): it is based on the association of the statistically evaluated SOC content and SOC sequestration potential to homogeneous areas (spatial units), derived from the stratification of climate, soil type and land use layers, and on a set of scenarios of carbon farming practices defined in dedicated actions of the project. Simulations with the "C-FARMs method" are possible on a part of the regional agricultural area (almost 54%). More information on the "C-FARMs method" can be found in the document https://c-farms.eu/wp-content/uploads/2022/11/D5-Report_Action-A4def.pdf

The table below summarises the correspondences between the crop management defined for the IPCC method and the carbon-farming treatments defined in the dedicated actions of the C-FARMs project.

Table 1

| IPCC crop type /management class		Corresponding 'CFARMs method' treatments		Specific practices descriptions
crop type	crop management	code	name	
arable land	ordinary			Ploughing, chemical fertiliser, bare fallow, removal of agricultural residues, monoculture
arable land	organic	ORG	organic agriculture	It have to include maintenance of crop residues, organic manure, extended crop rotation, cover crops, selection of better crop varieties, absence of synthetic fertilizer and herbicides
arable land	integrated			Crop rotations, reduced tillage and cover crops
arable land	set aside	LUC/SET ASIDE	set aside	Change of land use from annual to perennial crops / abandonment of arable land or change to permanent grassland
arable land	conservative practices	CONS	conservation agriculture	Combination of zero tillage or minimum tillage, maintenance of crop residues, crop rotation, cover crops
seminativo	greening			
arboreal	ordinary			Frequent tilling and/or weed control with herbicides, chemical fertiliser, pruning or burning
arboreal	organic			Spontaneous weeding, organic fertiliser, shredding of prunings
arboreal	integrated			Spontaneous weeding, shredding of pruning and pathogen control with integrated production techniques, chemical fertiliser
pasture	natural			
pasture	menaged			Renewal and/or thickening of crops
pasture	improved organic			Renewal and/or thickening of crops; Connection to zoothecnics
Poplar plantation	integrated	LUC-PP	change of land use from annual crops to poplar plantation	Spontaneous weeding, shredding of pruning and pathogen control with integrated pest management techniques, chemical fertilis

The design and development of C-FARMs – Carbon Farming Simulator were coordinated and carried out by Terrasystem with the support of FederlegnoArredo, Confagricoltura, CMCC and Università degli Studi della Tuscia di Viterbo.

Instructions for carrying out a farm-wide simulation

1. Access the FARM SCENARIOS section from the main menu
2. Click the START button to create a new simulation
3. Fill in the general data of the simulation in the GENERALITY tab and click NEXT
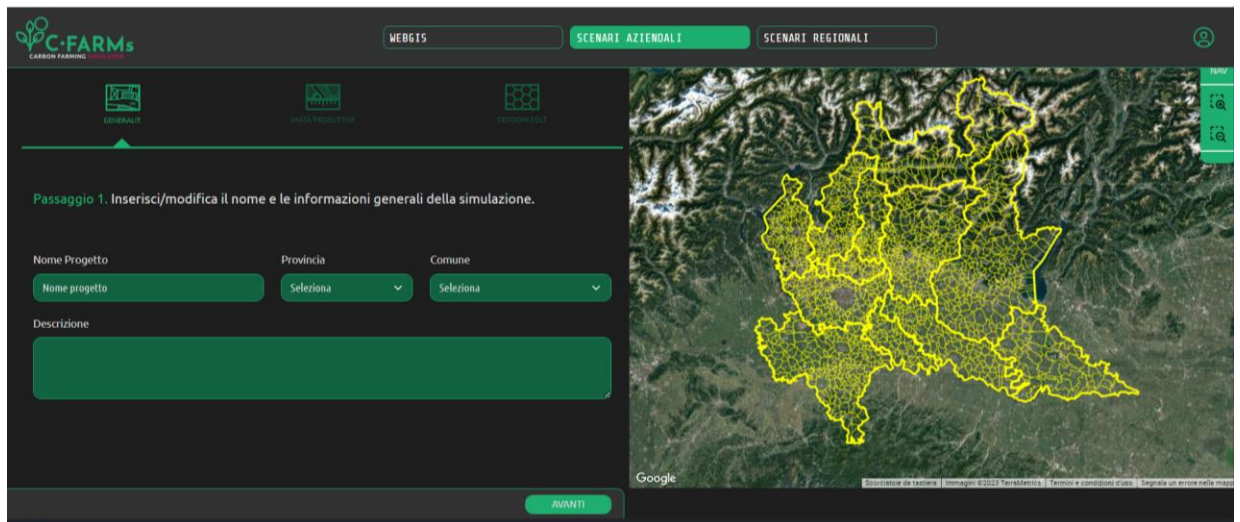
4. In the PRODUCTION UNITS tab, add, edit or delete Production Units (parcels). To add Production Units use 'Import KML' or 'Draw on map'.
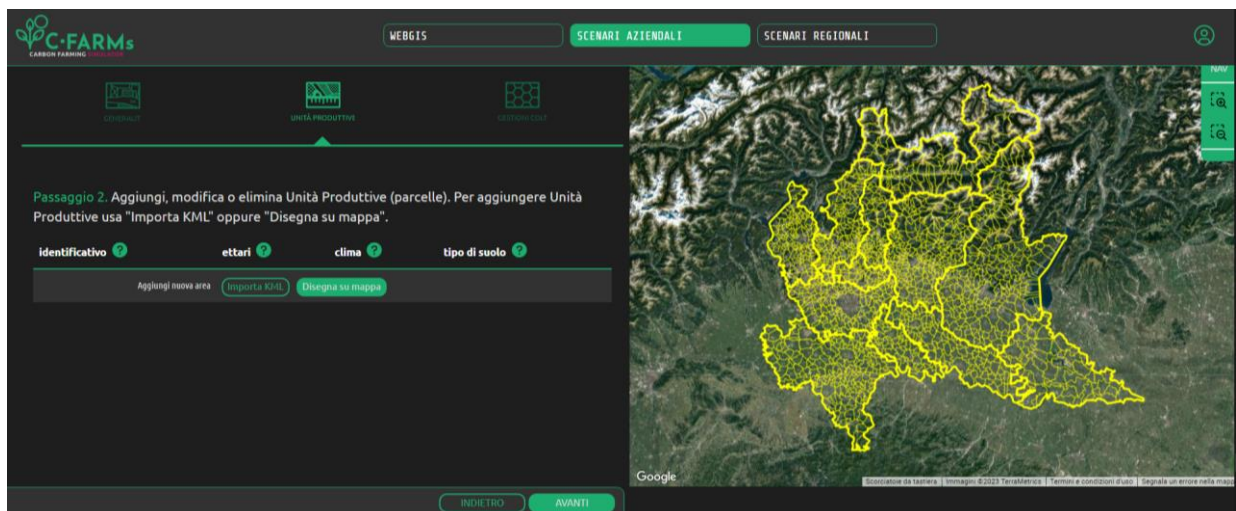

5. In the CROP MANAGEMENTS tab, for each Production Unit (UP), indicate the type of current crop type and management and make a hypothesis for their replacement in order to estimate the soil organic carbon (SOC) sequestration/reduction. Set the options on all drop-down menus presented, following these instructions (for help during compilation use the "?" button):
   - Select the current crop type and crop management, and on the selector next to it set the number of years since they have been in place.
   - If the number of years is less than 20, selectors will appear with which to indicate the crop type and management that was in place in the previous period.
   - Next, selectors will appear on a green background where you can indicate the crop type and management with which you plan to replace the current ones in order to achieve soil organic carbon sequestration (NEW CROP TYPE AND MANAGEMENT).

The selectable crop managements are to be understood as adhering to the descriptions in Table 1 of this guide, column "Specific Practices Descriptions".

At the end of the fill in you can save your data and/or click 'START SIMULATION'.
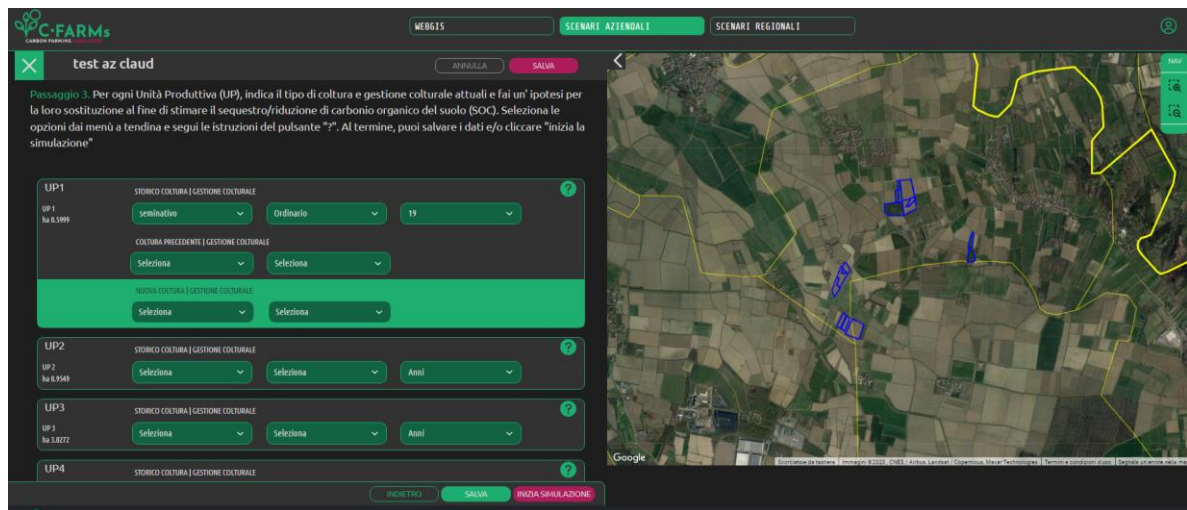
6. On the return screen (YOUR SIMULATIONS), view the simulation results by clicking on the arrow to expand the accordion.

- The tables and charts show the Soil Organic Carbon (SOC) data, explained in the two diagrams below. With the IPCC|C-FARMs buttons you can switch between the results calculated with the IPCC method and those calculated with the C-FARMs method.

Tables/charts "IPCC – TIER 2 method"	
Column header	**Data description**
SOC_{t0}	Initial SOC content
SOC_{t20}	SOC level at 20th year
ΔSOC	SOC variation at time t20 compared to time t0

Tables/charts "C-FARMs method"	
Column header	**Data description**
SOC_{t0}	Initial SOC content
SOC_{SAT}	SOC saturation level
ΔSOC_{SP}	SOC sequestration potential

- With a switch on the accordion bar, you can switch from displaying unitary values (t/ha) to total values (t).
- By clicking on a UP header, in the boxes below you can view the simulation metadata and the results relating to that single UP. You can also view a summary of this data by clicking on the UP on the map.

Simulation results screen detail - table and chart of aggregated Soil Organic Carbon present values
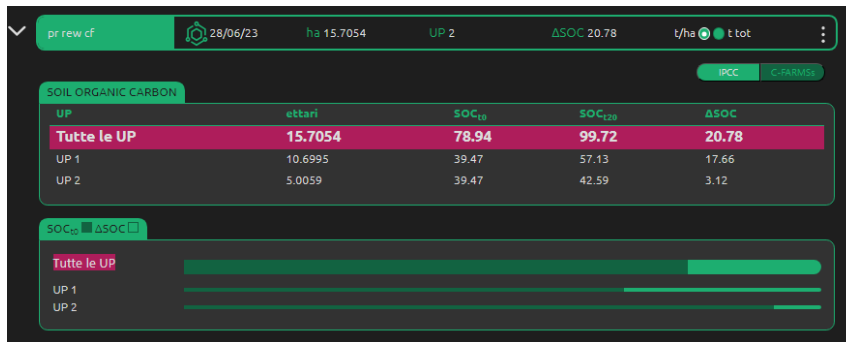

Simulation results screen detail - table and chart of the evolution of Soil Organic Carbon values over the years

Instructions for carrying out a simulation on a regional scale

1. Access the REGIONAL SCENARIOS section from the main menu.
2. Click the START button to create a new simulation.
3. Fill in the general data of the simulation in the GENERALITY tab and click on NEXT. You can carry out a simulation for the entire regional territory or alternatively for one or more provinces of your choice.
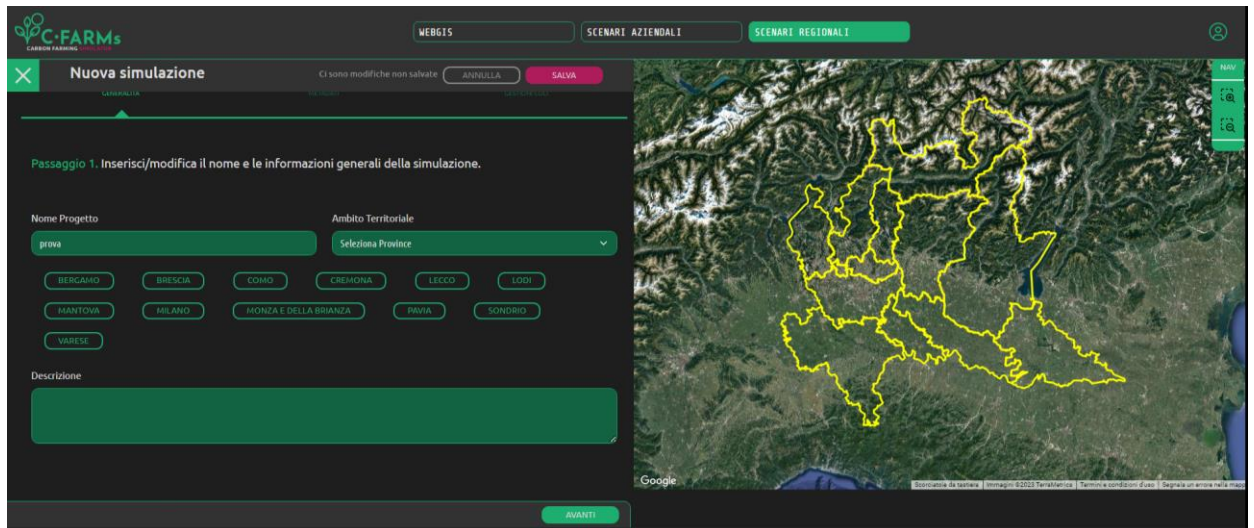
4. In the METADATA tab you will find four boxes, one for each type of crop (tree, pasture, poplar plantation, arable land). Select the crop types for which you want to simulate changes, clicking on the "Excluded" buttons to change their status to "Included". In the prospectus of each type of crop the incidences of the climate classes and soil type in the selected areas (provinces) are shown; they are pre-calculated values which are decisive in the simulation calculation.
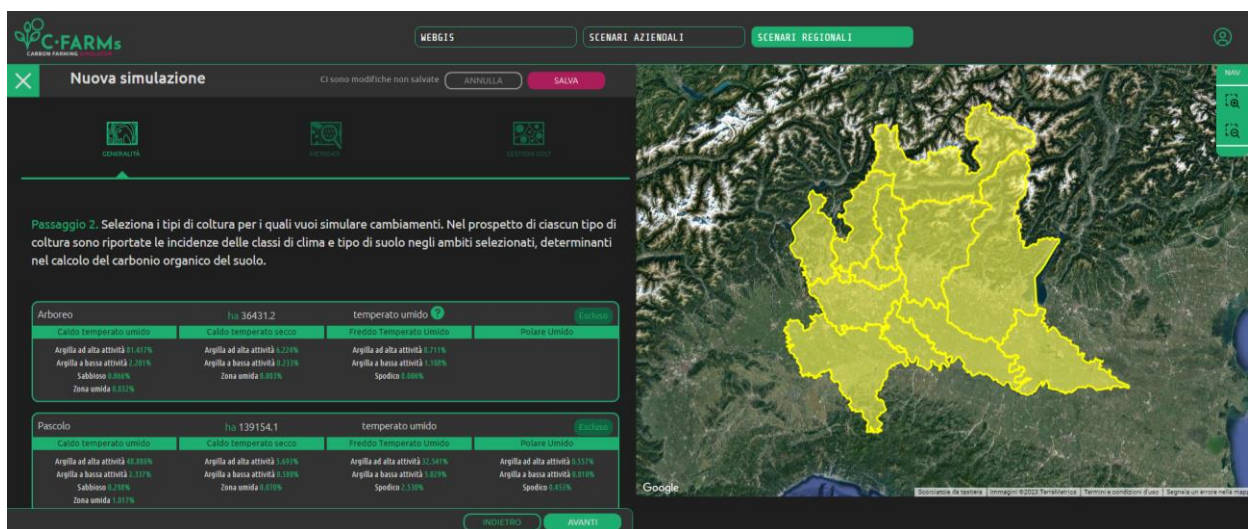
5. In the CROPS MANAGEMENT tab you will find a form for filling in the simulation inputs, for each of the crop types included in the previous step. For each of these forms you will need to do the following:

    a. The form contains one row for each current crop management; sets the % of the current surface for each management, so that the sum of all is 100%.

    b. Next to each current management you will find a "change management" pre-set to the same value as the current one: you can modify this pre-set crop management and its relative percentage and you can add further change managements by clicking the (+) button alongside. The sum of all change management percentages must be 100%.
        N.B.: the crop management that can be selected are understood to adhere to the descriptions contained in Table 1 of this guide, column "Specific practices descriptions".

    At the end of the fill in you can save the data and/or click "START SIMULATION".
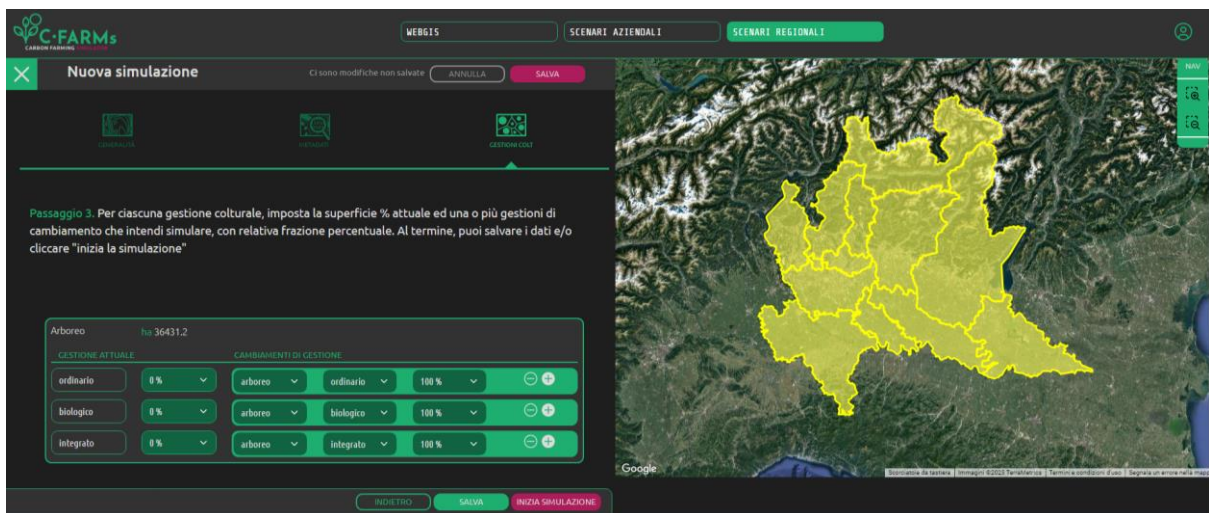
6. On the return screen (YOUR SIMULATIONS), view the simulation results by clicking on the arrow to expand the accordion.

    • The tables and charts show the Soil Organic Carbon (SOC) data explained in the diagram below.

Tables/charts "IPCC – TIER 2 method"	
Column header	Data description
SOC_{t0}	Initial SOC content
SOC_{t20}	SOC level at 20th year
ΔSOC	SOC variation at time t20 compared to time t0

    • In the first table and its associated chart you can read the SOC data relating to the types of crops "included"

- In the second table and its associated chart you can read the SOC data relating to the evolution of the SOC value over a 20-year period

Simulation results screen detail

The simulation results screen shows:

simulazione ese 17/07/23 CL 1 AT 1 ΔSOC 1008440

SOIL ORGANIC CARBON

Ambiti	$SOC_{t/ha}$	$ettari_{t0}$	SOC_{t0}	$ettari_{t20}$	SOC_{t20}	$ettari_\Delta$	ΔSOC
Tutti gli ambiti		43641.2	2016770	43641.2	3025210		1008440
seminativo ordinario	48.32	21820.6	1054260	0	0	-21820.6	-1054260
seminativo biologico	69.32	0	0	43641.2	3025200	43641.2	3025200
seminativo integrato	48.32	21820.6	1054260	0	0	-21820.6	-1054260

SOC_{t0} ◼ ΔSOC ☐

Tutti gli ambiti
seminativo ordinario
seminativo biologico
seminativo integrato

Evoluzione SOC

anno	SOC	SOC_{t20}	ΔSOC
2023	2016770	2067192.1	1008440
2024	2067192.1	2067192.1	958017.9
2025	2117614.2	2067192.1	907595.8
2026	2168036.3	2067192.1	857173.7
2027	2218458.4	2067192.1	806751.6
2028	2268880.5	2067192.1	756329.5
- - - -	- - - - - - -	- - - - - - -	- - - - - - -

- 5
+ 5

SOC_{t0} ◼ ΔSoc ☐