PROJECT: 101114119

LIFE22-CCM-IT-LIFE OLIVER

OLive tree for VERified Reduction generation

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Dissemination level	
X	PU = Public
	PP = Restricted to other programme participants (including the EC)
	RE = Restricted to a group specified by the consortium (including the EC)
	CO = Confidential, only for members of the consortium (including the EC)

METHODOLOGY FOR EMISSION REDUCTIONS AND CARBON REMOVALS CALCULATION

All changes in stock/emissions in the project must be estimated through empirical or process-based models that:

a) are public and made available by an accredited source (e.g., model developer's website, IPCC, or government agency) that provides documentation on the inputs, outputs, and how the model represents SOC dynamics;
b) are based on clearly stated sources and values for all parameters used in the model;
c) do not vary between baseline and project scenarios, similar to the parameters. Can be recalibrated or updated based on new data.

The total project GHG gas emission reductions and/or removal (expressed in tonnes of CO_2 eq) result from the combined effects of CO_2 eq reduction in the emissions and atmospheric CO_2 removal following the implementation of a carbon farming (or CF project hereafter). A reduction in the CO_2eq emissions occurs when the CO_2 eq emissions due to farming operation and inputs are lower after the CF project's implementation compared to the baseline (BL) scenario. Atmospheric CO_2 removal refers to the increase in organic carbon stocks, primarily in the soil but also in long-term biomass reservoirs (e.g., permanent structures of the tree in olive groves), relative to the BL scenario during the crediting period. Figure 1 illustrates the changes in carbon stocks (expressed as CO_2eq) and CO_2eq emissions, which should be considered in the calculations.
Total **Net emission Reductions and Removals (NRR_t),** expressed in tonnes of CO_2eq, for the crediting period of 10 years shall be calculated as:
(Eq. 1)

$$NRR_t = \sum_{n=0}^{10} [\left(CO_2eq_{emcf_n} - CO_2eq_{embl_n} \right) - \left(R_{cf_n} - R_{bl_n} \right)]$$

Where,

NRR_t = Net emission reductions and removals over the total crediting period (t CO2eq), expressed as the sum of all annual contributions;

n = year (from 0 to 10 in compliance with the crediting period);

$CO_2eq_{emcf\,n}$ = Cumulative greenhouse gases emissions (expressed in tonnes of CO_2eq) from agricultural operations and other project related emissions at year n of the CF project (Figure 1; for further details, see paragraph 2)

$CO_2eq_{embl\,n}$ = Cumulative greenhouse gases emissions (expressed in tonnes of CO_2eq) from agricultural operations at year n of the baseline scenario (Figure 1; for further details, see paragraph 2)

$R_{cf\,n}$ = Total biophysical atmospheric CO_2 removal at year n of CF project implementation. It includes the atmospheric CO_2 removal as soil organic carbon (SOC) and/or as organic carbon in the permanent woody biomass.

$R_{bl\,n}$ = Total biophysical atmospheric CO_2 removal at year n of the baseline scenario. It includes the atmospheric CO_2 removal as soil organic carbon (SOC) and/or as organic carbon in the permanent woody biomass.

Annual **Net emission Reductions and Removals (NRR_n),** expressed in tonnes of CO_2eq, evaluated for each year during the crediting period shall be calculated as:
(Eq. 2)

$$NRR_n = \left(CO_2eq_{emcf_n} - CO_2eq_{embl_n}\right) - \left(R_{cf_n} - R_{bl_n}\right)$$

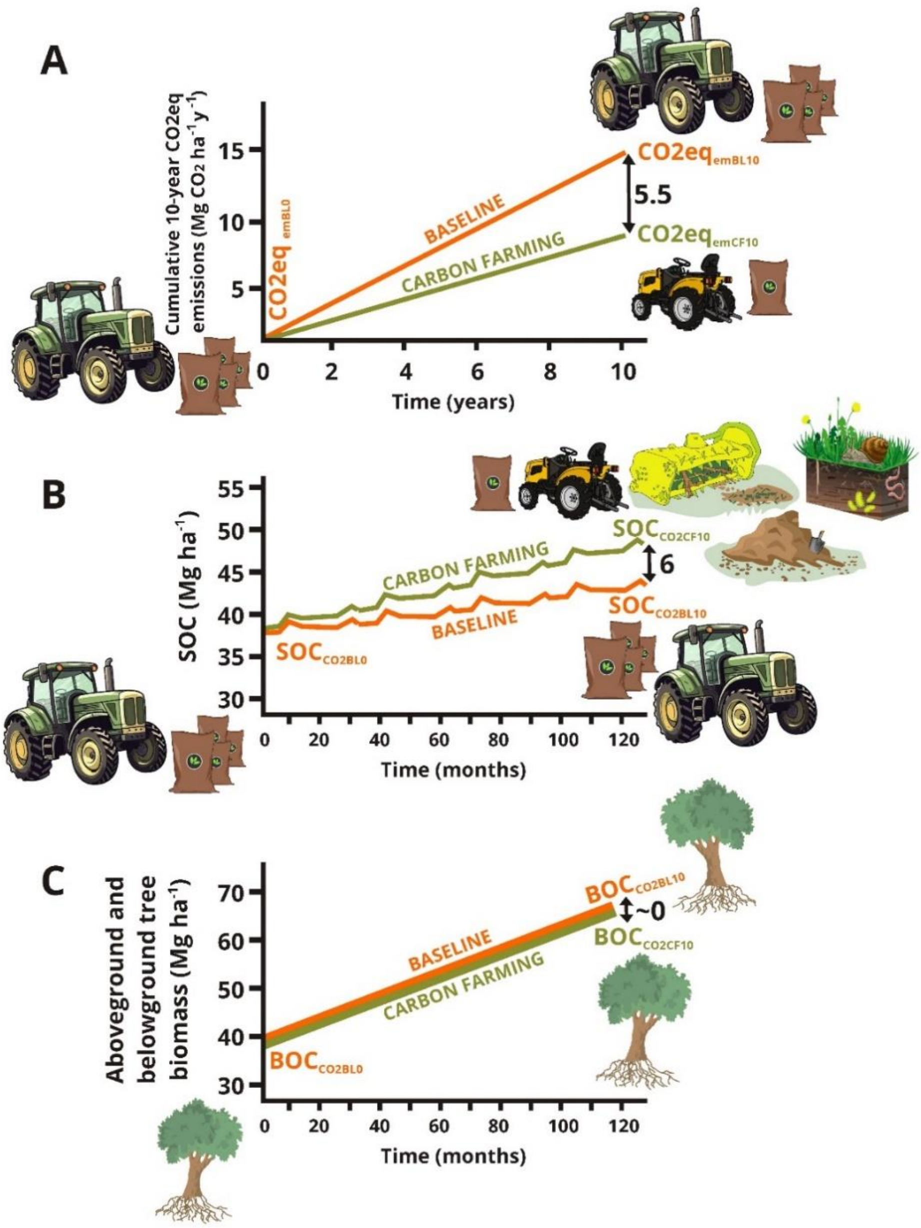

Figure 1. A visual illustration showing how the changes in: (A) the 10-years cumulative CO2 eq emissions during the olive farming operations and inputs, (B) soil organic carbon stocks (SOC), and (C) organic carbon in the permanent structure of the trees, should be consider for calculating the CO_2 sequestration after 10 years of implementation of the carbon farming project.

1. *Atmospheric CO_2eq removal* (R_{CF} and R_{BL}) quantification

Atmospheric CO_2 removal refers to the increase in organic carbon stocks, primarily in the soil but also in long-term biomass reservoirs (e.g., permanent structures of the tree in olive groves) under the BL and CF scenarios. Both are calculated following eq. 3 and 4:

$$\text{(Eq. 3)}\quad R_{cf_n} = [(SOC_{cf_n} - SOC_{cf_{n-1}}) + (BOC_{cf_n} - BOC_{cf_{n-1}})] \cdot 3.66$$

$$\text{(Eq. 4)}\quad R_{bl_n} = [(SOC_{bl_n} - SOC_{bl_{n-1}}) + (BOC_{bl_n} - BOC_{bl_{n-1}})] \cdot 3.66$$

where,
(Eq. 3)
$SOC_{cf\ n}$ = Soil Organic Carbon (SOC) stock (expressed as tonnes of SOC per hectare) within the project spatial area at a depth of 0–30 cm at year n of CF project implementation.
$SOC_{cf\ n-1}$ = Soil Organic Carbon (SOC) stock (expressed as tonnes of SOC per hectare) within the project spatial area at a depth of 0–30 cm at year n-1 of CF project implementation.
$BOC_{cf\ n}$ = Cumulative organic carbon of the biomass in the permanent tree structures (aboveground: trunks and primary branches, plus belowground: roots) at year n of CF project implementation.
$BOC_{cf\ n-1}$ = Cumulative organic carbon of the biomass in the permanent tree structures (aboveground: trunks and primary branches, plus belowground: roots) at year n-1 of CF project implementation.

(Eq. 4)
$SOC_{bl\ n}$ = Soil Organic Carbon (SOC) stock (expressed as tonnes of SOC per hectare) within the project spatial area at a depth of 0–30 cm at year n of the baseline scenario.
$SOC_{bl\ n-1}$ = Soil Organic Carbon (SOC) stock (expressed as tonnes of SOC per hectare) within the project spatial area at a depth of 0–30 cm at year n-1 of the baseline scenario.
$BOC_{bl\ n}$ = Cumulative organic carbon of the biomass in the permanent tree structures (aboveground: trunks and primary branches, plus belowground: roots) at year n of the baseline scenario.
$BOC_{bl\ n-1}$ = Cumulative organic carbon of the biomass in the permanent tree structures (aboveground: trunks and primary branches, plus belowground: roots) at year n-1 of the baseline scenario.

3.66 is the factor to convert tonnes of organic carbon into tonnes of CO_2 and come from dividing 44 (molecular weight of CO_2) by 12 (molecular weight of an atom of C).

1.1. SOC_{bl0} determination

Direct measurements of soil organic carbon (SOC) stocks are required to establish the SOC stock at the project start date (**SOC_{bl0}**) and to determine project SOC stock during each verification event throughout monitoring period.
Furthermore, **SOC_{bl0}** serves as a primary input for models used to predict changes in the stocks of SOC over 10 years for both the baseline and carbon farming scenarios. SOC stock estimates shall be:

1) unbiased and based on representative sampling, and
2) ensured for accuracy through the implementation of quality assurance and quality control procedures during measurements and analysis.

1.1.1 Soil sampling

Soil sampling must follow a stratified random sampling strategy. Each quantification unit within the project area shall be divided into strata based on factors that influence SOC stock distribution. These factors ensure that each stratum is more homogeneous than the project area as a whole, allowing for more accurate estimates of SOC variability, and better capture variability in SOC stock distribution. Detailed descriptions of how to conduct stratified random sampling are provided in Annex 3, in FAO (2020) and World Bank (2021).

To define strata, the best available data on factors influencing SOC stocks in response to project activities shall be used.

Climate, topography, historical land use, vegetation, parent material, soil texture, and soil type and areas with different annual input of organic carbon, such as below tree canopy, inter-row area with or without tree pruning mulching or cover crops, can be considered as factors determining the strata. Project-specific strata, their areas, and the sampling points within each stratum shall be documented and included as an annex to the project documentation for each verification event. Defined stratum should remain stable over time.

Sampling points should be sufficiently distant from each other to adequately capture spatial variability. Standard quality control of assurance procedures shall be applied for field data collection and data management. FAO Soils Portal or ISO 18400-104 Soil quality Sampling provide the basis for an adequate standard quality control.

The project monitoring report (see Annex 4) shall specify the sampling design (i.e.: spatial delineation, sampling intensities). Soil sampling locations should be georeferenced for re-sampling purposes. To avoid potential intra-seasonal variability, sampling and re-sampling should be conducted during the same season over time. Additionally, sampling and re-sampling should be delayed to the latest time possible after the previous application and the shortest time possible before the next application when organic amendments are applied.

Top-30 cm soil samples shall then be collected randomly within each stratum. At least 3 composite samples per stratum are required for the determination of the stock of SOC.

Sampling collection should follow the guidelines such as these of the FAO (2029, 2020) or Soil Science Division Staff (2017). Some recommendations include: i) visible organic material (e.g., tree pruning and cover crop residues) shall be removed from the soil surface before sampling, and ii) when multiple soil samples are used to create a composite soil sample, these shall be from the same depth and vigorously homogenized prior to subsampling.

1.1.2 Soil samples processing

Soil sample processing procedures shall be reported in detail, explicitly describing sieving and grinding procedures. These shall remain consistent through the entire project lifetime even if there is a change in analytical laboratory. Any coarse material shall be prevented from passing through a 2 mm sieve. Drying and sieving procedures shall follow laboratory-specific standard operating procedures and be consistent for all samples collected as part of the project, and during the entire project lifetime.

Reporting of SOC stock changes from direct measurements shall occur on an equivalent soil mass basis. Because the mass of soil in each depth layer depends on the bulk density of the respective layer, soil mass layers and soil depth layers shall be differentiated to enable a consistent comparison of SOC changes. Soil mass may be derived from bulk density measurements using soil corers.

SOC stocks and stock changes shall be reported to a minimum depth of 30 cm (or down to bedrock/hardpan where soils are shallower than 30 cm). Soils less than 30 cm deep (e.g., due to shallow bedrock or a formed hardpan) shall be sampled to the depth of the impeding layer.

1.1.3 Measurement of SOC content

Soil organic SOC content (expressed as % SOC on dry basis) with known uncertainty shall be measured in the processed soil samples using dry combustion (Dumas method) or the wet oxidation method of Walkley-Black. Project proponents shall use the services of accredited laboratories for measuring SOC in the soil samples. The project proponent shall demonstrate that soil analysis methods and procedures remain consistent even if there is a change of laboratory. Project proponents should provide the quantification of analytical error statistics (for instance, determined by repeated analyses of the same sample) to on a regular basis.

Proximal sensing techniques such as infrared spectroscopy, including near infrared (NIR), visible near infrared (Vis-NIR), and mid-infrared spectroscopy (MIR) may be used to determine SOC content where sufficient scientific progress has been achieved in calibrating and validating measurements, and uncertainty is well described.

The specificities of the applied SOC measurement, including calibration methods, shall be made available for review with not restriction through intellectual property rights.

For assuring comparability the same method of analysis for SOC content shall be applied for all analysis within one project.

1.1.4 Calculation of SOC stocks

To ensure that changes in SOC stocks do not arise solely from a temporal change in bulk density (related to CF practices), SOC stock of each stratum (e.g., stratum 1; S1) is calculated following:

$$\text{(Eq. 5)}\quad SOC \text{ stock}_{S1} \text{ [Mg SOC ha}^{-1}\text{]} = 100 \cdot BD \cdot d \cdot \text{SOC} \cdot (1\text{-}f)$$

Where:
BD = bulk density [1][Mg m^{-3}];
d = soil depth [m];
SOC = soil organic carbon content [% on dry basis]
f = fraction over one of soil particles higher than 2 mm [-].

The initial SOC stock of the project spatial area is the weighted mean of the SOC stocks of each stratum, and is calculate as:

$$\text{(Eq. 6)}\quad SOC \text{ stock [Mg SOC ha}^{-1}\text{]} = \frac{(SOC\ stock\ S1\ x\ areaS1)+(SOC\ stock\ S2\ x\ areaS2)+(SOC\ stock\ S3\ x\ areaS3)+\cdots.}{areaS1+areaS2+areaS3+\cdots..}$$

Where:
S1, S2, S3…. are the strata 1, 2 and 3, respectively,
areaS1, areaS2, areaS3, are the areas (in hectare) of stratum 1, 2 and 3.

1.2 SOC_{bln} and SOC_{cfn} estimations

Soil organic carbon (SOC) stock [tC ha^{-1}] at a depth of 0-30 cm of soil shall be projected over a 10-year period for each stratum (S1, S2, S3….) within project spatial boundaries. Projections will be conducted

[1]Bulk density must be determined applying the core, excavation, or clod methods in the field, and subsequently processing the samples in the laboratory. Best practice guidance and established standards for these methods, such as ISO 11272:2017 Soil quality — Determination of dry bulk density, must be used. Samples for bulk density, dry soil mass, and SOC content should be taken at the same time and from sampling locations within a few meters of the previous sampling point location, avoiding edge effects and disturbed areas.

for both the baseline scenario and the carbon farming project scenario using SOC simulation models. These projections shall be based on:

- the stock of soil organic carbon measured before the start of the project (***SOC_{bl0}***), which means in the baseline scenario at year 0,
- historic and projected activity data collected as inputs for the model.

The same model version, parameters/parameter sets shall be used in the baseline and project scenarios. Models may be recalibrated or revised based on new data, or a new model may be applied, provided the below requirements are met. Process-based models used to estimate SOC stock change shall be:

1. publicly available, though not necessarily free of charge, from a reputable and recognized source (e.g., the model developer's website, IPCC or government agency). Sufficient conceptual documentation of inputs, outputs and information on how the model functionally represents SOC dynamics shall be accessible to the public. Providing the source code or an API (Application Programming Interface) for independent replication of calculations is not mandatory; and
2. shown in peer-reviewed scientific studies to successfully simulate changes in SOC resulting from the changes in management practices included in the CF project description; and
3. able to support repetition of the project simulations. This includes clear versioning of the model used in the project and stable software support, as well as fully reported sources and values for all parameters used with the project version of the model. Where multiple sets of parameter values are used in the CF project, the sources of varying parameter sets and how they were applied to estimate stock change in the CF project shall be clearly identified. Acceptable sources include peer-reviewed literature and statements from appropriate expert groups that demonstrate evidence of expertise with the model via authorship of peer-reviewed model publications or authorship of reports for entities supporting climate-smart agriculture. These sources shall describe the datasets and statistical processes used to set parameter values.

All the information and supporting documents demonstrating the above shall be made available for the VVB.

Simulation results are used to predict the SOC stock for each year during the 10-years crediting period for the baseline (SOC_{bln}) and at the CF project (SOC_{cfn}) per unit area for each stratum.

1.4 BOC_{bln} and BOC_{cfn} determinations

The olive tree annually accumulates CO_2 in its permanent structure (e.g., biomass that is not leaves, flowers, or fruits, and remains on the farm for decades after tree pruning or as firewood biomass harvesting). If no additional increase in annual CO_2 accumulation in the permanent woody biomass is expected after the CF project implementation compared to the baseline, carbon stocks in aboveground and belowground woody biomass within the project's spatial boundary do not necessarily need to be included in the calculations, as no change in carbon stocks in trees is expected compared to the baseline. However, if the project includes the planting of other woody crops, an increase in the aboveground and belowground woody permanent biomass is expected and should be quantified or estimated.

2. $CO_2eq_{embl\,n}$ and $CO_2eq_{emcf\,n}$ estimations

Annual olive farming GHG emissions shall be quantified for each activity in the project area during the monitoring period following IPCC Guidelines (2006, 2019). Greenhouse gases emission sources from olive farming include:

i. direct GHG emissions from the farming operations (primarily but not exclusively from the fossil fuels consumed during the use of farm machinery for soil management, cover crops clearance, tree pruning, harvesting, fertilizer and plant protection product applications and irrigation),

ii. direct GHG emissions (mainly as N_2O emissions, resulting from the application of chemical and/or organic fertilizers, cover crops, tree pruning residues, and livestock grazing in cover crops managed by livestock)

iii. indirect GHG emissions (e.g. from the production and transportation of inputs such as organic and chemical fertilizers and plant protection products).

Required activity data, estimation methods, and general procedures to estimate CO_2eq emissions during the crediting period could be derived from the IPCC Guidelines for National Greenhouse Gas Inventories for the Agriculture, Forestry, and Other Land Use (AFOLU) sector (IPCC, 2006, 2019) for croplands.
GHG emissions should be quantified annually (with n varying from year 0 to year 10) for both baseline scenario (***$CO_2eq_{embl\ n}$***) and CF project (***$CO_2eq_{emcf\ n}$***) for all relevant activities involving greenhouse gas emissions. All emissions shall be expressed in CO_2-equivalent units (CO_2eq).
For each year, the emissions related to the project and baseline scenarios shall be calculated by summing the emissions from all activities using the following equations:
(Eq. 7)

$$CO_2eq_{emcf_n} = \sum_{j=0}^{J} A_{cfj} \cdot EF_j \quad with\ 1 \leq j \leq J\ activities\ involving\ GHG\ emissions$$

(Eq. 8)

$$CO_2eq_{embl_n} = \sum_{j=0}^{J} A_{blj} \cdot EF_j \quad with\ 1 \leq j \leq J\ activities\ involving\ GHG\ emissions$$

Where:
A_{bl} = is an activity involving GHG emissions evaluated in the baseline scenario;
A_{cf} = is an activity involving GHG emissions evaluated in the carbon farming scenario;
EF = is an emission factor related to a specific activity.

References

ISO 14064. International Organization for Standardization. Greenhouse Gases –Part 3: specification with guidance for the validation of greenhouse gas assertions, first edition (2006).

IPCC, 2006. Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme. Volume 4- Agriculture, Forestry and Other Land Use. Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.

Soil Science Division Staff. 2017. Soil survey manual. C. Ditzler, K. Scheffe, and H.C. Monger (eds.). USDA Handbook 18. Government Printing Office, Washington, D.C.

ISO 18400. Soil quality — Sampling —Part 104: Strategies (2018).

IPCC, 2019. Bartram, D., Short, M.D., Ebie, Y., Farkaˇs, J., Gueguen, C., Peters, G.M., Zanzottera, N.M., Karthik, M., Masuda, S.,. Volume 5. Waste. Chapter 6 Wastewater Treatment and Discharge. 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change. Geneva, Switzerland.

FAO, 2019. Handling and preparation of soil samples for chemical and physical analyses. FAO, Rome.

FAO, 2020. A protocol for measurement, monitoring, reporting and verification of soil organic carbon in agricultural
landscapes – GSOC-MRV Protocol. Rome. https://doi.org/10.4060/cb0509en