FARM CULTIVATION PROTOCOL

WP 4 Pilot project implementation

Activity 4.2 Pilot project preliminary actions

GECO2 – Green Economy and CO2

Safety and resilience | SO 2.1

Work Package:	**4. Pilot project implementation**
Activity:	**4.2 Pilot project preliminary actions**
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1 Introduction

Farm cultivation protocol explains the principles on which the carbon stored in the field can be conserved and increased and greenhouse gas emissions (GHG) reduced.

This protocol is part of GECO2 operational documents:

a. Farm cultivation protocol;

b. Calculation System protocol;

c. Market (and farm contracts).

Cultivation protocol represents the technical guidelines to design agricultural projects addressed to improve carbon stocks and reduce carbon emissions and losses. The project aims to regenerate carbon in soils and to increase, where possible, the biomass of the agriculture ecosystems (in order to recover ecological system services). A farm carbon project involves the setting up of specific project management activities on the eligible lands with the aim to remove carbon from the atmosphere by increasing the amount of carbon added to the soil and in long-term plant biomass.

GECO2's approach follows this operational flux:

- A current carbon balance related only to the experimental agricultural field is calculated;
- An experimental field farm baseline is defined;
- GECO2 controlling activities with farmers is established;
- The project calculator, created to evaluate the effects of carbon capture practices chosen by the farmer, is applied ;
- Limits and the errors of calculation results are assessed in order to properly define the credits produced;
- Produced credits are published in the market platform

Carbon farming protocol is integrated with the Calculation System protocol and its operational tool (CAFÉ).

Calculator has the objective of evaluating the carbon credits that can be produced by the agricultural companies.

GECO2 project constitutes a direct contribution to the achievement of the SDGs (Sustainable Development Goals) fixed by the 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, addressed to provide a shared blueprint for peace and prosperity for people and the planet, now and into the future.

In particular GECO2 appears in line the following objectives:

- SDG 1: No poverty – enhancing soil health/SOC content increases agricultural productivity, reducing erosion and fight desertification, thus improving farmers' incomes.

- SDG 2: Zero Hunger – adopting SSM (Sustainable Soil Management) increases food production in both quantity and quality (especially micronutrients, soil ecology and biodiversity).

- SDG 3: Good health and wellbeing – SSM addresses the issue of farm and soil pollution, which is crucial for SOC sequestration and especially soil and human health.

- SDG 6: Clean water and sanitation – SSM enhances the capacity of soils and grass to filter and store water, thus contributing to improved access to and quality of water.

- SDG 12: Responsible consumption and production – SSM enhances natural soil fertility and biodiversity, thus reducing the use of fertilizers, increasing natural fertilization (residuals recycling, green mulch), filed capacity to store water (reducing consumption) and soils' capacity of denaturing of pollutants, thus reducing their persistence in the environment.

- SDG 13: Climate action – Biodiversity and SOC-focused SSM greatly contributes to both climate change mitigation and adaptation.

- SDG 15: Life on land – SOC-focused SSM is a key tool for increasing farm biodiversity in soil and vegetation, reducing biodiversity loss, increasing pollinator resources and niches, achieving land degradation neutrality.

The choice of the valuing practices adopted by the cultivation protocol was based on the carbon balance scheme (following IPCC practices for LULUCF[1] and international standard ISO 14064[2]), which includes both field emissions and carbon storage[3].

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[1]https://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html

[2]https://www.iso.org/obp/ui#iso:std:iso:14064:-1:ed-2:v1:en

[3]see for definitions in letterature of agriculture sustainability:

Campbell, B. M., D. J. Beare, E. M. Bennett, J. M. Hall-Spencer, J. S. I. Ingram, F. Jaramillo, R. Ortiz, N. Ramankutty, J. A. Sayer, and D. Shindell. 2017. Agriculture production as a major driver of the Earth system exceeding planetary boundaries. Ecology and Society 22(4):8. https://doi.org/10.5751/ES-09595-220408

De Luca, A.I.; Iofrida, N.; Leskinen, P.; Stillitano, T.; Falcone, G.; Strano, A.; Gulisano, G. (2017). Life cycle tools combined with multi-criteria and participatory methods for agricultural sustainability: Insights from a systematic and critical review. Sci. Total Environ. 595, 352–370.

De Olde, E.M.; Moller, H.; Marchand, F.; McDowell, R.W.; MacLeod, C.J.; Sautier, M.; Halloy, S.; Barber, A.; Benge, J.; Bockstaller, C.; et al. (2017),. When experts disagree: The need to rethink indicator selection for assessing sustainability of agriculture. Environ. Dev. Sustain. 19, 1327–1342.

Giampietro, M., (2003). Multi-scale integrated analysis of agroecosystems, CRC Press, Boca Raton, 437 p.

Kociszewski, K. (2018) : Sustainable development of agriculture: Theoretical aspects and their implications, Economic and Environmental Studies (E&ES), ISSN 2081-8319, Opole University, Faculty of Economics, Opole, Vol. 18, Iss. 3, pp. 1119-1134, http://dx.doi.org/10.25167/ees.2018.47.5. https://www.econstor.eu/bitstream/10419/193133/1/ees_18_3_05.pdf

Küstermann, B., M. Kainz, K.-J. Hülsbergen, (2008). Modeling carbon cycles and estimation of greenhouse gas emissions from organic and conventional farming systems, Renewable Agriculture and Food Systems 23(01):38 - 52. DOI: 10.1017/S1742170507002062;

Häni, F. J. L. Pintér and H. R. Herren (Eds.) (2007). Sustainable Agriculture: From Common Principles to Common Practice, Proceedings and outputs of the first Symposium of the International Forum on Assessing Sustainability in Agriculture (INFASA), March 16, 2006, Bern, Switzerland. Published by the International Institute for Sustainable Development, Winnipeg, Manitoba, 248 p. ISBN 978-1-894784-05-4, https://www.iisd.org/system/files/publications/infasa_common_principles.pdf

The farming project is oriented to prioritize building soil health as a way to adapt and mitigate climate change. The project builds a farm regenerative system, increasing both soil and biomass carbon.

At the end of the computation, a budget is determined, specifying which procedural components have the most impact on the final result. The operational specifications refer to the algorithms inserted in calculation system protocol.

In order to avoid overestimations, buffer and prudential credit calculation criteria have been adopted. The final results might not correspond exactly to quantity of farm carbon potentially stocked but are prudently reduced[4].

General assumptions, limitations and precautions used in modelling farm system (i.e. application of carbon balance per each field) are shown in the carbon calculation system protocol.

Lampridi, M.; Sørensen, C.L.; Bochtis, D., (2019). Agricultural Sustainability: A Review of Concepts and Methods. Sustainability 11, 5120.

New-bold, T., Hudson, L., Hill, S. et al. Global effects of land use on local terrestrial biodiversity. Nature 520, 45–50 (2015). https://doi.org/10.1038/nature14324

[4]Funtowicz, S.O. J.R. Ravetz (2008) Values and uncertainties, In G.H. Hadorn, H. Hoffmann-Riem, S. Biber-Klemm, W. Grossenbacher-Mansuy, D. Joye, C. Pohl, U. Wiesman, E. Zemp (Eds.), Handbook of transdisciplinary research, Springer, Dordrecht, pp. 361-368

Refsgaard, JC JP Van der Sluijs, J Brown, P Van der Keur,(2006). A framework for dealing with uncertainty due to model structure error, Advances in water resources 29 (11), 1586-1597.

SAPEA, Science Advice for Policy by European Academies. (2019). Making sense of science for policy under conditions of complexity and uncertainty. Informs the European Commission Group of Chief Scientific Advisors' Scientific Opinion 7 (Ortwin Renn, Chair), Berlin: SAPEA. 182 p. https://doi.org/10.26356/MASOS https://researchrepository.ucd.ie/bitstream/10197/11477/2/MASOS-ERR-%20published.pdf

Van Der Sluijs, J.P., M. Craye, S.O. Funtowicz, P. Kloprogge, J. Ravetz, J. Risbey (2015). Combining quantitative and qualitative measures of uncertainty in model-based environmental assessment: the NUSAP system, Risk Analysis: An International Journal 25 (2), 481-492.

2 GECO2 project approach

GECO2's approach, chosen to operationally achieve the project objectives and oriented to market experimentation, is based on the following points:

- A current carbon balance related only to the experimental agricultural field;
- Definition of an experimental field farm baseline;
- Establishing GECO2 controlling activities with farmers

2.1 Carbon Balance (CO2e emission and sequestration items)

Farm experimental field balance is based on a carbon balance between emissions (greenhouse gas emissions from sources) and removals (sequestration of carbon dioxide by sinks)[5].

The balance refers to the following factors: energy (electricity generation, direct combustion, transport and fugitives), industrial processes for agrochemicals, waste, agriculture, and land use, land-use change and forestry (LU, LUCF).

Farm ecosystems create emissions and removals of CO2 from live vegetation, watering, debris, soil stock and release caused by land management practices and land-use change.

In addition to these emissions other greenhouse gases are emitted in farming activities. Those emissions are considered in the carbon balance as CO2 equivalent. Emissions consist in the methane (CH4) and nitrous oxide (N2O) emissions related to agricultural land uses, including CH4 emissions from enteric fermentation and manure management, and N2O emissions from agricultural soils.

Farm selection procedure it is defined according to the following conditions:

- Project management activities implemented.

[5]Ontl, T. A. & Schulte, L. A. (2012) Soil Carbon Storage. Nature Education Knowledge 3(10):35. https://www.nature.com/scitable/knowledge/library/soil-carbon-storage-84223790/

At least tree of ten of 'project management activities' has to be implemented in the project. Tree of them has to be implemented per each farm during the GECO2 experimentation year. Project management activities include: existing and new regeneration practices; existing agrochemical reduction programs; recycling farm biomass; reduced agrochemical and energy consumptions.

- Each farm must define the project selected field or fields (patch or patches).
- Preliminary carbon footprint, using the calculator (carbon fixing elaborator, CAFE) is needed in order to evaluate the actual balance. Only farmers having a minimal sequestration rate of 0,5 CO2e ton per ha per year can participate to GECO2 project[6].
- For modelling carbon stocks and emissions the calculator is used.

Input forms must be filled in by farmers with the support of qualified experts provided by the project. Algorithms on which the calculator (CAFE) is based, estimates the farm carbon credits/debts according with information and answers given. Starting from the CAFÉ balance results, CAFE evaluates the carbon credits produced by each farm in accordance with project selected practices.[7]

[6]Lal, R., 2008. Carbon sequestration. Philosophical Transactions of the Royal Society B 363, 815-830. see for a general discussion: Lal, R., 2004. Soil carbon sequestration impact on global climate change and food security. Science 304, 1623-1627

[7]References: Stockholm Environment Institute & Greenhouse Gas Management Institute prepare an Offset Guide. The guide is for companies and organizations seeking to understand carbon offsets and how to use carbon offsets in voluntary greenhouse gas (GHG) reduction strategies. It is also an educational resource for technical experts in academia and government. Further, this guide explains what role purchases of other environmental commodities, like renewable energy certificates (RECs) and emission allowances, can serve in claiming GHG emission reductions. https://www.offsetguiderg

The potential of farmer's CO2e sequestration capacity is estimated on a carbon balance basis. A farm carbon balance is the difference between CO2e absorbed by ecosystems (via photosynthesis) and CO2 loss to the atmosphere.

Carbon balance is calculated taking into account the adopted cultivation practices and using the operational schemes fixed by the carbon calculation system (see Calculation system protocol) and following the main reference standard of credit market[8].

Farm project's carbon balance (following the same general scheme launched by ISO 14064-1, G.4: Amortizing changes in carbon stocks over time[9]), includes:

- direct emissions;

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[8] The Stockholm Environment Institute takes into account the following CO2e credits offset market critical issues:

Additionality: Additionality is context-specific. In U.S., for example, low-till/ no-till is increasingly common practice. Frequently, for individual landowners, carbon revenues for these project types are too low to play a decisive role in changing practice. Programmatic approaches (where many landowners are aggregated together under a single project) are more likely to be additional.

Double Counting, Permanence: Quantification of net GHG reductions in biological systems is inherently more uncertain than for many other project types; diverse and uncontrolled implementation environments make measurement, monitoring, and verification more difficult. Leakage risk can be a significant issue for tillage projects (to the extent crop yields are affected).

Permanence: Risk of reversal (i.e., non-permanent reductions) is a concern for all carbon storage projects.

Co-benefits/ harms Benefits: Both biochar and tillage projects can enhance soil productivity and reduce erosion, increasing farmers' yields and reducing impact on aquatic ecosystems.Reference: Broekhoff, D., Gillenwater, M., Colbert-Sangree, T., and Cage, P. 2019. "Securing Climate Benefit: A Guide to Using Carbon Offsets." Stockholm Environment Institute & Greenhouse Gas Management Institute, 59 p. Offsetguide.org/pdf-download/

Geco2 has considered all these elements in the project design and organization.

[9]https://www.iso.org/obp/ui/#iso:std:iso:14064:-1:en

- indirect emissions;
- biogenic emissions and removals.

GECO2 protocol is focused on GHG emissions of farming and farm products. GHG balance is the inventory of greenhouse gases in the frame of partial life cycle assessment. System boundaries are farm gate (cradle-to-farm- gate). All processes downstream from the farm gate are excluded.

Inventory of greenhouse gases (GHG) is an analysis related to the farmers activities, carried out through the preparation of an inventory of climate-altering emissions. This analysis expresses the total emissions generated by farmer activities and allows producers to understand the areas of intervention in order to reduce the impact on the climate[10].

Data collected for the carbon balance include agriculture practices [11] both quantitative consumable inputs (e.g., diesel, gasoline, electricity, seed, wire, and fertilizers) and outputs (e.g., products and wastes) and farm operation data (e.g., tillage operations, irrigation systems, residues, and inter-row management)[12].

Inventory is made by the calculator. It includes organic and mineral fertilizers, evaluating their direct and direct carbon footprint. It also evaluates the carbon stock in soil as a function of the percentage of

[10] In accordance with the Kyoto Protocol Principles, the greenhouse gases to be included in the analysis are: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), sulfur hexafluoride (SF6) and perfluorocarbons (PFCs).

[11] see for example: Scandellari, F.; G Caruso; G Liguori; F Meggio; A Palese; D. Zanotelli; G Celano; R Gucci ; P Inglese ; A Pitacco, and M. Tagliavini, 2016. European Journal of Horticultural Science, 81(2), 106-114.

[12] see for example: Foucherot, C. & Bellassen, V., 2011. Carbon Offset Projects in the Agricultural Sector. Climate Report, n 11. 40 p. https://www.researchgate.net/publication/265583385_Carbon_Offset_Projects_in_the_Agricultural_Sector

organic matter, the physical characteristics of the soil, the C / N ratio, the N, P2O5 and K2O content and the methods of applying fertilizers.

Calculator assess the amount of biogenic removals as of carbon sequestered (carbon offset[13]) in soil and in (long term) plant biomass.

In particular, the following elements are considered:

- Sequestration in woody biomass. Biomass production is dependent of natural growth and improvements and agricultural practices producing plant dry matter.
- Sequestration of organic carbon in soil. As they grow, plants take up carbon and return it to the soil, where it is broken down in the form of soil carbon.

From a general point of view the practices improving carbon stocks considered by the project are the following:

1) Reduction of soil tillage[14] (from conventional to minimum tillage, or no tillage);

[13]Wikipedia contributors, "Carbon offset," Wikipedia, The Free Encyclopedia, https://en.wikipedia.org/w/index.php?title=Carbon_offset&oldid=982032791 (accessed October 30, 2020).

[14]Lal, R. & Kimble, J.M.., 1997. Conservation tillage for carbon sequestration. Nutrient Cycling in Agroecosystems. 49. 243-253.

Sainju, U. M. 2016. A global meta-analysis on the impact of management practices on net global warming potential and greenhouse gas intensity from cropland soils. PLoS ONE 11:e0148527. doi: 10.1371/journal.pone.0148527

2) Integration with other tree crops and orchards. This increases the agroecosystem biomass introducing new trees or shrubs[15]. The carbon stock increase as biomass production (woody biomass CO2e stock including vineyard biomass, shrubs, [16], [17]);

3) Use of cover crops (yes or not); If herbaceous perennial crops, year of establishment of perennial crops[18];

4) Bio products and organisms[19] (fungi, AMF: the use has to take into account and including indirect emission by product carbon footprint or an estimation of);

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[15]Chatterjee, N., P.K.Ramachandran. Nair, S. Chakraborty, V. D. Nair, 2018, Changes in soil carbon stocks across the Forest-Agroforest-Agriculture/Pasture continuum in various agroecological regions: A meta-analysis,Agriculture, Ecosystems & Environment,266,55-67,

[16]Frison, E., Jeremy, C. & Hodgkin, T.. 2011. Agricultural Biodiversity Is Essential for a Sustainable Improvement in Food and Nutrition Security. Sustainability. 3. 10.3390/su3010238.

Conversa, G., Lazzizera, C., Bonasia, A. et al., 2020.Exploring on-farm agro-biodiversity: a study case of vegetable landraces from Puglia region (Italy). Biodiversity and Conservation, 29, 747–770.

[17]ELN-FAB 2012. Functional agrobiodiversity: Nature serving Europe's farmers. – Tilburg, the Netherlands: ECNC-European Centre for Nature Conservation, https://ec.europa.eu/environment/nature/natura2000/platform/documents/functional_agrobiodiversity_eln-fab_publication_en.pdf

Conant, R. T., Cerri, C. E. P., Osborne, B. B., and Paustian, K. 2016. Grassland management impacts on soil carbon stocks: a new synthesis. Ecol. Appl. 27, 662–668. doi: 10.1002/eap.1473

[18]Poeplau, C., and Don, A., 2015. Carbon sequestration in agricultural soils via cultivation of cover crops–a meta-analysis. Agric. Ecosyst. Environ. 200, 33–41.

[19]Nichols, K.A. and S.F. Wright. 2004. Contributions of soil fungi to organic matter in agricultural soils. In F. Magdoff and R. Weil (eds.) Functions and Management of Soil Organic Matter in Agroecosystems. CRC Press, p. 179-198.
Wang, W., Zhong, Z., Wang, Q, Fu . Y. & X. He , 2017. Glomalin contributed more to carbon, nutrients in deeper soils, and

5) Use of ground rock dust blends as a soil improver[20];

6) Compost addition (including his carbon footprint or an estimation of)[21];

7) Manure addition[22];

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differently associated with climates and soil properties in vertical profiles. Scientific Reports, 7, 13003. https://doi.org/10.1038/s41598-017-12731-7

Wright S.F., Nichols K., 2002. Glomalin: Hiding place for a third of the world's stored soil carbon. Agricultural Research, 50: 4–7.

see also: https://www.ars.usda.gov/ARSUserFiles/30640500/Glomalin/Glomalinbrochure.pdf

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Balogh-Brunstad, Z., Kent Keller, C., Thomas Dickinson, J., Stevens, F., Li, C. and Bormann, B. (2008). Biotite weathering and nutrient uptake by ectomycorrhizal fungus, Suillus tomentosus, in liquid-culture experiments. Geochimica et Cosmochimica Acta, 72(11), pp.2601--2618.

Husson, O. 2013. Redox potential (Eh) and pH as drivers of soil/plant/microorganism systems: a transdisciplinary overview pointing to integrative opportunities for agronomy. Plant and Soil, 362(1-2), pp.389--417.

Imaya, A., Yoshinaga, S., Inagaki, Y., Tanaka, N., Ohta, S.2010. Volcanic ash additions control soil carbon accumulation in brown forest soils in Japan. Soil Science & Plant Nutrition Volume 56, Issue 5, pages 734–744,

Pierson-Wickmann, A., Aquilina, L., Martin, C., Ruiz, L., Mol'enat, J., Jaffrezic, A. and Gascuel- Odoux, C., 2009. High chemical weathering rates in first-order granitic catchments induced by agricultural stress. Chemical Geology, 265(3), pp.369--380. Sikora, L. J. , 2004. Effects on basaltic mineral fines on composting. Waste Management , 24 (2), 139-142.

van Straaten, P. 2006. Farming with rocks and minerals: challenges and opportunities. Anais da Academia Brasileira de Ciencias , 78 (4), 731-747.

21

Paustian K., Larson E., Kent J., Marx E., Swan A. 2019, Soil C Sequestration as a Biological Negative Emission Strategy, Frontiers in Climate, 1, https://www.frontiersin.org/article/10.3389/fclim.2019.00008

Ryals, R., and Silver, W. L. (2013). Effects of organic matter amendments on net primary productivity and greenhouse gas emissions in annual grasslands. Ecol. Appl. 23, 46–59. doi: 10.1890/12-0620.1

22

Jarecki, M.and R. Lal, 2003. Crop Management for Soil Carbon Sequestration. Critical Reviews in Plant Sciences - 22. 471-502.

8) Crop residues incorporation (organic mulches or pruning addition to soil)[23]

9) Biochar (external) and other pyrolysis products[24] incorporation[25] (including his carbon footprint or an estimation of);

10) Farm edge and rows, trees and shrubs (high, medium, low biomass

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Paustian K., Larson E., Kent J., Marx E., Swan A. 2019, Soil C Sequestration as a Biological Negative Emission Strategy, Frontiers in Climate, 1, https://www.frontiersin.org/article/10.3389/fclim.2019.00008

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Wood vinegar, liquid smoke, pyrolysis water, smoke water, wood distillate or Mokusaku, is an amber liquid produced through the natural act of carbonization during charcoal/biochar production. Wood vinegar is acidic with a pH of around 2.5 – 3.0 and contains a multitude of organic compounds: the major components aside from water include acetic acid and methanol. Nikhom (sd) reports that wood vinegar yield per metric ton of air dry wood is 314 kg. The product contains approximately 200 components. These include: Alcohol (methanol, butanol, amylalcohol), Acid (acetic, formic, propioinic, valeric) , Neutral substances such as formaldehyde, acetone, furfural, valerolactone , Phenols (syringol, cresol, phenol), Basic substances such as ammonia, methyl amine, pyridine.

He also describes quality wood vinegar as having the following characteristics (most of which may require special laboratory instruments or methodology to determine): pH of approximately 3.0, Specific gravity between 1.005-1.050, Color ranging from pale yellow to bright brown to reddish brown, Transparent, Smoky odor, Dissolved tar content: less than 3 percent, Ignition residue: less than 0.2 percent by weight.

Nikhom L. (sd). "Wood Vinegar." Wood and Pulp Research Program, Coordinating Office TRF, Faculty of Forestry, Kasetsart University, accessed September 25, 2019, http://www.authorstream.com/Presentation/Cannes-50452-Woodvinegar-Background-Product-Carbonization-Cont-Recover-

Pyroligneous-Liquor-Collector-Procedure-Im-as-Education-pptpowerpoint/.

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Woolf, D., J. E. Amonette; F. A. Street-Perrott; J. Lehmann; S. Joseph, 2010. Sustainable biochar to mitigate global climate change. Nature Communications. 1 (5): 56.

Werner, C., H.-P. Schmidt, D.r Gerten, W.g Lucht und C. Kammann, 2018. Biogeochemical potential of biomass pyrolysis systems for limiting global warming to 1.5 °C. Environmental Research Letters, 13(4), 044036. https://doi.org/10.1088/1748-9326/aabb0e

see also: Standardized production definition and product testing guidelines for biochar that is used in soil, 2015. https://www.biochar-international.org/wp-content/uploads/2018/04/IBI_Biochar_Standards_V2.1_Final.pdf Retrieved 17 december 2019 measure and assessment)[26].

2.2 Definition of farm baseline

The baseline represents what would happen if GECO2 farm project did not occur. The baseline provides a point against which is possible to measure any changes and is used as the foundation for a carbon roadmap which can show what pathways are available. Farmer plan shall describe the original condition of the project site including details of the vegetation cover, soil type and their carbon content ad will measure, starting from the baseline, changes in the carbon stock at the site for the duration of the project in the absence of the project activities (i.e. business as usual).

Each farm must provide a soil analysis to define the baseline of the assessment for the project selected field (patch).

In order to have the data of the current quantity of organic carbon in the soil, the farm has to provide an analysis of the organic matter of the soil already available or proceed to an ad hoc measurement.

In the case the Soil carbon measure was not available GeCO2 suggestion is to use a method for carbon sampling and analysis: FAO. 2019. Measuring and modeling soil carbon stocks and stock changes in livestock production systems: Guidelines for assessment (Version 1)[27].

2.3 GECO2 controlling activities with farmers

26 see note 2

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Support and relationships with GeCO2 consultants and technicians are of a vital importance in order to collect reliable data and assure the proper management of the project.

In particular, on-site farm inspections should be approached with collaboration and mutual respect towards suppliers at all levels, with a focus on education and sustainable remediation. Farm visits are preferred during the production cycle, with special attention paid to soil and biodiversity management. The scope of the on-site audit should include, but is not limited to, a walk- through of the facility and review of the following items:

- Review of product labeling practices and procedures;
- Review of segregation and separation practices and procedures;
- Review of traceable supply chain process implementation;
- Interviews to ensure proper implementation of traceability policies, procedures, documentation, training, and selected practices compliance;
- Issues identified during the document review;
- Complaint policies;
- All other requirements as established by GeCO2 project rules.

3. Cultivation selected practices and farm management

The project conditions describe the gases emissions/removals that occur once the selected practices have been implemented in compliance with farmer plan. Calculator can provide the carbon balance before and after the project.

As already mentioned, at least three of ten of 'project management activities' must be undertaken in a project in order to increase the stock in soil and biomass and reduce the soil carbon loss. Each of these choices is made up of specific 'management actions.

Farm management practices to be considered - and modelled by carbon calculator - are listed below.

Agriculture carbon sequestration, i.e. the process in which CO2 is removed from the atmosphere and stored in the soil / plants carbon pool is already defined by literature. Lal (2020) shows how creating a positive soil and ecosystem C budget:

1. Managing soil fertility by enhancing SOM content, biological N fixation, and recycling of nutrients rather than by indis-criminate inputs of chemical fertilizers

2. Improving soil structure by increasing activity and species diversity of biota (e.g., earthworms and microorganisms) and prolific plant roots rather than by plowing

3. Increasing availability of green water by conserving precipitation, reducing losses by runoff and evaporation, moderating soil temperature, and encouraging deep

root systems

4. Controlling water and wind erosion through preventative measures of maintaining a continuous groundcover, cover cropping, and CA rather than by curative land forming and engineering structures

5. Managing soil acidification and elemental imbalance by biofertilizers (e.g., compost, manure, mycorrhiza) rather than by indis- criminate dumping of chemicals

6. Enhancing water infiltration rate by reducing crusting, compaction, hard-setting, and desiccation through retention of residue mulch, cover crop- ping, and creation of bio-pores through bioturbation of the rhizosphere

On this scientific elements the practices are defined

Carbon stock farming practices (included in carbon calculator):

- Practice 1: organic management
- Practice 2: conservative plowing
- Practice 3: confers crops
- Practice 4: conservative land use management & biodiversity
- Practice 5: conservative use of woody residues as carbon source for SOC.
- Practice 6: conservative use of green residues as carbon source for SOC.
- Practice 7: use of organic amendments[28].
- Practice 8: avoid the use of synthetic fertilizers[29].
- Practice 9: reduction of pesticides[30]: use of pesticides less than 1 kg / ha.
- Practice 10: optimal recycling of organic matter due to biomass produced within the experimental field[31].

28 Called also agricultural soil improvers are used in order to increase a carbon gain. A distinction is made between amendments of animal and vegetable origin. Soil amendment improve soil fertility, increasing the amount of carbon present in the soil. There are three carbon pools present in the soil improver (Recalcitrant, labile vegetable and labile animal).

29 A minimum threshold of 10 kgCO2Eq / ha of tolerated emissions is inserted to avoid numerical problems. This threshold can be considered negligible compared to total emissions and less than 1% compared to emissions due to conventional fertilization.

30 The massive use of pesticides kills the soil biome and therefore this leads to a drastic reduction in the carbon storage capacity in the soil.

31 A threshold has been inserted to avoid numerical problems. The threshold value is (emission) value of 20 kgCO2Eq / ha.

In addition to the previous practices, GECO2 takes into account the following factors for the purpose of impacts and the assignment of credits, including the following management actions that affect the amount of carbon stored in the system:

- Amount of biomass present in the orchard, determined on the basis of their age. This factor influences both the root biomass (underground) and therefore the structure of the soil, and the aerial biomass (epigeal) for the amount of carbon stored in the branches and leaves.
- Recycling of company waste both from woody and green biomass of the field itself, and from plant and animal biomasses.
- Direct emissions of fuels and indirect emissions of imported electricity.
- Carbon loss due to weathering processes and soil erosion. The assessment is made using carving calculator. It is implemented a soil loss model, in the Revised Universal Soil Loss Equation (RUSLE) framework, based on both Cover and Tillage practices[32].

Tables regarding practices and thresholds are included in the Annex E.

With reference to the tables of practices and thresholds (Annex E) some specification are needed concerning GHG emissions practices and management actions (considered in carbon calculator): in Practice 7 the use of organic amendments can create GHGs emissions. Indirect emission of GHG for amendments production is considered by carbon calculator. Direct GHG emissions are due to emission of N2O (due to the nitrogen present in soil improvers): this amount and its variation is due to the method of application and of the possible use of inhibitors; in Practice 8 the use of synthetic fertilizers creates GHG indirect emissions and it is considered by carbon calculator. Direct GHG emissions are due to emission of N2O (due to the nitrogen present in soil improvers): this amount and his variation is due to the method of application and of the possible use of inhibitors; in Practice 9 the use of pesticides

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Soil erosion assessment is made using equations defined by David, W. P. (2018). Soil and Water Conservation Planning: Policy Issues and Recommendations. J. Philipp. Dev., 15(1), 47–84,

Merritt, W. S., Letcher, R. A., and Jakeman, A. J (2003). A review of erosion and sediment transport models. Environ. Model Softw., 18(8–9), 761–799.

created GHG emission. Indirect emission of GHG for pesticides production is considered by carbon calculator.[33]

[33] Ref. Lal, R. 2016. Beyond COP21: Potential challenges of the "4 per thousand" initiative. Journal of Soil & Water Conservation, 71(1): 20A-25A
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Spiertz H., 2010. Food production, crops and sustainability: Re- storing confidence in science and technology. Current Opinion in Environmental Sustainability, 2: 439–443.

Permanent crops (https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Permanent_crops).

4. Model, algorithms and data

In order to assure a more user friendly working tool the above mentioned cultivation criteria have been transformed in an ad hoc operational tool that the project decided to create.

The sustainable practices have been modelled and inserted in an informatic form, published on web.

The calculator enables farmers, supported by project technicians, to assess the

positive or negative impacts of the different practices applied in order to calculate their co2e sinking potential and their credits production.

Here below we list the practices accounted in the calculator and a coarse estimation of the range of their contribution.

- Practice 1: organic / non-organic

Data are based on two assumptions: in industrial farm management carbon amount from the roots to the field is 370 kg / ha. In organic farming management carbon flux is assumed as 695 kg / ha, following Hu et al. 2018:

The carbon left in the field decays on an annual scale according to an exponential equation (quoted) for which the difference in stored carbon is about 200 kgC / ha year-1.

This must be multiplied by the factor 3.67 (from stoichiometry) to determine the CO2Eq: it is approximately 700 KgCO2Eq / ha year-1. This value must be corrected on the base of soil management. Soil Management change according to adoption of one on practice between the follows: use of cover crops, grassed orchards / vineyards, perennial sparse vegetation and contiguous forest areas.

- Practice 2: conservative plowing

The model has a baseline for the calculation of carbon oxidation based on carbon values referring to IPCC standards.

The model takes into account two types of conservative plowing: minimum tillage and no tillage. These methods contribute to reducing carbon emission from soil.

Soil organic carbon increase in soil - on a base of 20 years no-tillage - with respect to conventional tillage (from IPCC 2006): increase is set on 0.8% per year in temperate moist climate and 0.5% in temperate dry climate.

Soil organic carbon increase in soil -l on a base of 20 years due to minimum tillage with respect to conventional tillage. Increasing rate is 0.45% per year in temperate moist climate and and at 0.15% in temperate dry climate respectively.

Practice 2 affects the RUSLE equation (with a reduction factor between 0 and 1). Potential erosion (bare soil) is accomplished based on the slope of the field, soil texture and average annual precipitation. Conservative plowing practices affect with a damping factor of 0.26 when no tillage is applied, and 0.52 if minimum tillage is applied.

The minimum surface extension, to be considered as a conservative practice, is : 100 sm.

- Practice 3: cover crops increase the organic carbon in soil.

From IPCC 2006 the use of cover crops increase carbon in soil with respect to seasonal bare soil. Values are set at 0.49% per year and at 0.43% per year, in temperate moist climate and in temperate dry climate respectively.

Practice 3 affects the RUSLE (reduction factor between 0 and 1). Potential erosion (bare soil) is accomplished based on the slope of the field, the texture of the soil and the average annual precipitation. Cover crops have an impact with a damping factor of 0.26.

Practice 3 is a carbon gain.

The minimum surface extension, to be considered as a conservative practice, is : 100 sm.

- Practice 4: Farm management with hedge, rows and forest patch integrated within field crops

  Presence of hedges and rows.

  The minimum surface extension, to be considered as a conservative practice, is : 50 sm.

- Practice 5: wood residues

Carbon values can increase using wood residues. Carbon gain in soil grows when wood residues are incorporated; if not used wood residues became emissions sources (Hillier et al. 2011).

When incorporated carbon is modelled as 36% (54% for lignin and 14% cellulose and suppose 50% of the carbon in wood is lignin) of the carbon is considered stored and the rest lost (i.e. 64% becomes labile carbon). When residues are burned 95% of the carbon becomes CO2; in case of biochar production 50% becomes CO2. The algorithm also calculates the emissions due to the fermentation and denitrification processes. The fermentation value is of an order of magnitude higher in the case of heaps management.

- Practice 6: green residues

Carbon gain or carbon loss according to the treatment. Carbon gain in soil is assured when green residues are incorporated; if not used wood residues became emissions sources (Hillier et al. 2011). If incorporated carbon is modelled as 36% (54% for lignin and 14% cellulose and suppose 50% of the carbon in wood is lignin) of the carbon is considered stored and the rest lost (i.e. 64% becomes labile carbon). When residues are burned 95% of the carbon becomes CO2; in case of biochar production 50% becomes CO2. The algorithm also calculates the emissions due to the fermentation and denitrification processes. The fermentation value is of an order of magnitude higher in the case ofheaps management.

- Practice 7: use of organic amendments Carbon gain Carbon loss

A distinction is made between amendments distinguishing their animal or vegetable origin. The soil improver increases the percentage of carbon present in the soil. There are three carbon pools present in soil improvers (recalcitrant, labile vegetable and labile animal). The emission of N2O due to the nitrogen present in soil improvers is susceptible to variation according to the method of application and to the use or not of inhibitors.

- Practice 8: no use of synthetic fertilizers

A minimum threshold of 30 kgCO2Eq / ha of tolerated emissions is considered in order to avoid computation problems. This threshold can be considered negligible compared to total emissions and less than 1% compared to emissions due to conventional fertilization.

- Practice 9: use of pesticides less than 3 kg / ha. The massive use of pesticides kills the soil biome and therefore this leads to a drastic reduction in the carbon storage capacity of the soil.

- Practice 10: optimal recycling of organic matter due to biomass produced within the experimental field. A threshold has been inserted to avoid numerical problems equal to an emission of 30 kgCO2Eq / ha.

In addition to the previous practices, GECO2 takes into account the following factors for the purpose of impacts and the assignment of credits:

- Amount of biomass present in the orchard determined on the basis of the age of the orchard and which affects both the root biomass (hypogeal) and therefore the structure of the soil, and the aerial biomass (epigeal) for the amount of carbon stored in the branches and leaves.

- Recycling of wastes both from woody and green biomass of the field itself, and from plant and animal biomasses.

Annex A Farm data for GeCO2 project

Each farm, for the insertion of data in the carbon calculator and for the definition of its project, have to provide veritable data.

Farm data:

Name, Address, phone, e-mail, Name of referent / conductor

Organic / not certificated organic /

a. Geographical and pedological data[34]:

If sources are unreliable is possible to make reference to European Soil data base (https://esdac.jrc.ec.europa.eu/ESDB_Archive/ESDBv2/fr_intro.htm):

Coordinates, climatic data (average temperature, annual precipitation[35]), elevation above sea level, slope gradient, parental rock (lithology), soil texture, Topsoil organic carbon content

b. Agronomic data:

	Examples
Cultivation	Apple, citrus, grape, olive, peach
Cultivar	Gala, Tarocco, Aglianico, Nocellara, Duchessa d'Este
Planting year	

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Density (tree /shrub/vineyeard s ha^{-1})	average range: 100 – 1200
Training system	Spindlebush, Globe, Spur cordon, Open Centre (OC) or Vase system, Central leader system (CL), Perpendicular V system (PV), Hex V system, Quad V system
Biomass per tree /shrub/vineyeard (average biomass calculated with a model)	
Pruning wood (t ha^{-1})	average range: 0,9- 9
Average fruit yield (t ha^{-1})	average range: 7-65

Annex B Farm Balance of greenhouse gases (GHG): GHG inventory

For the base year in agriculture multi-years periods is recommended the use of the Norm ISO 14064-1: 2018.

Base year inventories may need to be recalculated when changes occur to the inventory boundaries and development processes significant impacting the inventory.

Agriculture emission and removals are report in the carbon balance (GHG Inventory) under:

G.1 direct emissions;

G.2 indirect emissions; G.3 organizational emission (upstream / downstream of organization)

G.4. biogenic emission and removals, which are reported separately.

G.5. biogenic emission and removals, which should not be reported.

GHG Inventory = G.1 + G.2 + G.3 + G.4 (+ G.5) = carbon balance

if carbon balance > 0 -> no credit production

if carbon balance = 0 -> project measures has to be implemented

if carbon balance < 0 -> GHGs offset, credit production

GHG inventory is define by follows categories and subcategories (following ISO 14064-1:2018).

Table G.1 - Reporting direct GHG emissions:

GHG emission sources Category, sub-category	Examples
Category 1: direct GHG emissions	

1.1	direct emission from stationary combustion	
	stationary equipment – fossil	Generators, pumps, irrigation
	stationary equipment - biogenic	Generators, pumps, irrigation
1.2	direct emission from mobile combustion	
	mobile equipment - fossil	Tilling, sowing, harvesting, transports
	mobile equipment - biogenic	Tilling, sowing, harvesting, transports
1.3	Industrial process	
	Not applicable	N/A
1.4	Direct fugitive emissions arise from the release if GHGs in anthropogenic systems	
	Refrigeration, air conditioning	N/A
	Addition of fertilisers and amendments	Synthetic fertilize formulations (e.g. anhydrous ammonia, ammonium nitrate, urea)
	Addition of livestock waste to soils	Manure
	Addition of crop residues to soil	Corn stocks, wheat straw, pruning residues
	Tillage an drainage of soils	Ploughing, tile drainage

	Enteric fermentation	Ruminants
	Addition of lime to soils	addition of lime, rock dust
	Paddy rice cultivation	N/A
	Open burning of savannahs, crop residues left on fields, DOM	ash, green mulch
	Anaerobic digestion	N/A
	Composting organic waste	Compost, vermi-compost of cultivation residues or agronomic residuals
1.5	Direct emission and removals from land use, land use change and forestry	
	Direct land use change (dLUC)	emission and removals for conversion of forest/wetland into cropland or orchard, or vice-versa

Table G.2 - Reporting for indirect Emerson from agricolture:

GHG emission sources Category, sub-category		examples	GHG reported
2	Category 2: Indirect emission from imported energy		
2.1	Indirect emission from imported electricity	Refers to standard for grid emissions calculations	CO_2, CH_4, N_2O, CO_{2e}

Table G.3 - Reporting Organisational (upstream / downstream) emissions from agricolture:

GHG emission sources Category, sub-category		examples
3	Category 3: Indirect emission from transportation	
3.1	Emissions for upstream transport and distribution for goods	Trucking, warehousing
3.2	Emissions for upstream transport and distribution for goods	Trucking, warehousing
4	Category 3: Indirect emission from products used by organisation	
4.1	Emission from purchased goods	
	Energy production	Fossil fuels
	Fertilizer production	Nitrogen, urea, phosphorus, potash
	Feed production	Milling, drying
	Agrochemical production	Pesticides, herbicides, fungicides

Table G.4 - Biogenic carbon from agricolture

GHG emission sources Category, sub-category		examples
	Category 1: direct emission from products used by organisation	
Direct emission and removals from land use change and forestry	Land use manegement	
		CO_2 fluxes to /from C stocks in soils
		CO_2 fluxes to /from above and below ground woody biomass (i.e woody vegetation in orchards, vineyards and agroforestry systems)
		CO_2 fluxes to /from dead organic material (DOM)
		Combustion of crop residues for non-energy purposes
		Managed woodland (e.g. tree strips, timber belts)

	C sequestration due to land use change (LUC)	CO_2 removals by soils and biomass following afforestation or reforestation
Direct emission from mobile combustion	Biofuel combustion	mobile equipment: tilling, sowing, harvesting, transports
Direct emission from stationary combustion		stationary equipment: generators, boilers, CHP, milling, Dryers, Irrigation
Direct fugitive emissions arise from the release of GHG in anthropogenic systems	Composting organic waste	
	Oxidation of horticultural growing media	

For natural disturbances, the GHG fluxes may be reported in a line item separate from the direct, indirect, and biogenic carbon categories.

Table G.5 - GHGs the not should be reported, emissions and removals from other categories:

GHG emission sources Category, sub-category		examples
CO_2 removals by herbaceous vegetation		Annuals, biennials or perennials plants with no woody stem
CO_2fluxes from / to livestock		The carbon that is part of animal tissue or from animal respiration should not be reported in an inventory

Annex C Farm soil organic carbon measure and baseline

In order to participate in the project, each farm must provide existing data or an analysis of soil organic carbon.

Soil organic carbon (SOC) is a measurable component of soil organic matter (SOM)[36]. SOM supports key soil functions being a critical factor for the stabilization of soil structure- Furthermore it favors retention and release of plant nutrients allowing water infiltration and storage in soil. Soils potential role in mitigation of climate change, through carbon sequestration[37] in soil organic matter,[38] is seen as an

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SOM is composed mainly of carbon, hydrogen and oxygen, and has small amounts of other elements, such as nitrogen, phosphorous, sulfur, potassium, calcium and magnesium contained in organic residues. It is divided into 'living' and 'dead' components and can range from very recent inputs, such as stubble, to largely decayed materials that are thousands of years old. About 10% of below-ground SOM, such as roots, fauna and microorganisms, is 'living'.

SOM exists as 4 distinct fractions which vary widely in size, turnover time and composition in the soil: a. dissolved organic matter (size: <45µm, in solution; turnover time: minutes to days; It generally makes up less than 5% of SOM); b. particulate organic matter (size: 53µm–2mm; turnover time: 2-50 years; it makes up 2–25% of SOM); c. humus (size: <53µm; turnover time: 10-500 years; it can make up more than 50% of SOM); d. resistant organic matter (size: 53µm–2mm; turnover time: 100-10.000 years; it can be up to 10% of SOM). See for example: *a.* Schnitzer, M., 1991. Soil organic matter-The next 75 years. *Soil Science*, 151, 41-58. *b.* Schmidt, M.W.I.; Torn, M.S.; Abiven, S.; Dittmar, T.; Guggenberger, G.; Janssens, I.A.; Kleber, M.; Kögel-Knabner, I.; Lehmann, J.; Manning, D.A.C.; et al. 2011. Persistence of soil organic matter as an ecosystem property. *Nature, 478*, 49–56.

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Horwath, W. R. Y. Kuzyakov, 2018. Chapter Three - The Potential for Soils to Mitigate Climate Change Through Carbon Sequestration, In W. R. Horwath, Y. Kuzyakov (Eds.) Developments in Soil Science,Elsevier, Amsterdam - New York, Volume 35, pp. 61-92,

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Organic matter makes up just 2–10% of most soil's mass and has an important role in the physical, chemical and biological function of agricultural soils.

Organic matter contributes to nutrient retention and turnover, soil structure, moisture retention and availability, degradation of pollutants, and carbon sequestration.

important element to reduce atmospheric carbon dioxide[39]. The quantity of soil organic matter (SOM) was estimated through the determination of soil organic carbon (SOC) which can be assumed as 58% of the SOM[40].

Soil organic carbon (SOC) refers only to the carbon component of organic compounds. Soil organic matter (SOM) is difficult to measure directly, so laboratories tend to measure and report mainly SOC[41].

Each farm must provide a soil analysis to define the baseline of the assessment per each project selected field (patch). In order to have the data of the current quantity of organic carbon in the soil, farmers can provide an analysis of the organic matter of the soil already available or proceed to an ad hoc measurement. In this last case a sampling project to define the soil organic carbon values will be implemented.

The method proposed in GeCO2 is based on:

1. Soil sampling;

1. Bulk density definition.

2. Soil organic carbon (SOC)analysis.

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Lal, R. 2018, Digging deeper: A holistic perspective of factors affecting soil organic carbon sequestration in agroecosystems. Glob. Chang. Biol. 24, 3285–3301.

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Brady, N. C., 1974. Organic matter of mineral soils. In: Buckman, H. O. and Brady N. C. ed. The nature and properties of soils. Macmillan Publishing Co., New York, p. 137-163.

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Schumacher, B. A., 2002. Methods for the determination of total organic carbon (TOC) in soils and sediments. Ecological Risk Assessment Support Center. US. Environmental Protection Agency, Washington (DC), 23p.

The reference methodology for carbon sampling and analysis is FAO, 2019 (Measuring and modelling soil carbon stocks and stock changes in livestock production systems: Guidelines for assessment- Version 1)[42].

In order to determine SOC stocks, the user shall quantify within a specific soil sampling depth: (i) SOC content of the fine earth mass (< 2 mm size), (ii) coarse mineral fraction content (> 2 mm size) and, (iii) soil bulk density. Sampling depth shall be at least 30 cm, and should be as deep as possible where soil depth is greater than 30 cm. All samples shall be georeferenced. Appropriate error and uncertainty should be reported.

To identify the most appropriate approach for soil sampling, Technical analyst shall take key decisions considering: (i) purpose and linked requirements, (ii) stratification and representativeness, (iii) soil depth, and (iv) land management.

To sample a study area in a representative way, the user shall identify a minimum of three sampling strata (relatively homogeneous units) based on the main environmental factors determining SOC variability, including –depending on the scale– climate, soil type, hydrology, topography, land use and management and land use history, amongst others. Within each homogeneous unit (stratum) at least 5 soil cores should be collected to form a composite sample. Composite samples should represent the total area of the unit/strata and be collected in the same day.

In the frame of GeCo2 is recommended to organize collection in project field (i. e. farm selected patch) of a minimum amount of 3 samples per hectare. Each sample has to be composed by five soil cores.

Soil bulk density should be considered in the same core on which SOC concentration is measured. Bulk density is usually expressed in Mg /m3 or the numerically equivalent g cm-3. The most common and scientifically accepted direct methods to determine soil bulk density are the undisturbed (intact) core method and the excavation method (see FAO 2019, page 25)

Soil organic carbon content analysis shall be performed in well-regarded laboratory using quality control and assurance systems. Soil organic carbon content is expressed as gravimetric percentage of dry (105 °C) soil [g SOC kg-1 dry (105 °C) soil]. Standard procedures for the determination of soil moisture are available. Soil organic carbon may be estimated as the difference between total carbon and inorganic

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Measuring and modelling soil carbon stocks and stock changes in livestock production systems http://www.fao.org/3/ca2934en/CA2934EN.pdf carbon, directly after removal of inorganic carbon, or by dichromate oxidation-titration methods. In all cases, SOC content shall be quantified in the fine-earth fraction which is obtained by passing the soil through a 2 mm mesh size. In most cases, soil samples are further ground and reduced to powder (<0.2mm) to allow adequate homogenization (see FAO 2019, page 25).

Selected analytic methods for soil carbon determination are the followings:

A. Dry combustion is a direct chemical method to measure SOC content based on the combustion of soil samples containing carbon (see FAO 2019, page 31);

B. Wet digestion/oxidation of organic carbon compounds by dichromate ions (Cr2O72-)(see FAO 2019, page 32).

C. Spectroscopic techniques for soil organic carbon determination (see FAO 2019, page 33).

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Annex E Table of practices and thresholds

		Definition	Threshold in order to define a new practice (one a practice is already implemented)	NOTES and References
1	Organic farm management	Organic farming is a set of practices and management in compliance with Commission Implementing Regulation (EU) 2020/464 of 26 March 2020 laying down the rules for the application of Regulation (EU) 2018/848 of the European Parliament as regards the documents needed for the production of organic products and information to be provided by Member States.	No threshold is defined. It si possible only provide true/false boolean response.	Organic farming is an agricultural method that aims to produce food using natural substances and processes. This means that organic farming tends to have a limited environmental impact as it encourages: a responsible use of energy and natural resources; maintenance of biodiversity; preservation of regional ecological balances; enhancement of soil fertility; maintenance of water quality. Additionally, organic farming rules encourage a high standard of animal welfare and require farmers to meet the specific behavioral needs of animals.

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				microbial abundance and activity– A meta-analysis and meta-regression.PLOS ONE | https://doi.org/10.1371/journal.pone.0180442July 12, 2017, 25 pp Morgan K.J., Murdoch J. 2000. Organic vs. conventional agriculture: Knowledge, power and innovation in the food chain. Geoforum, 31: 159–173.
2	Application of a conservative soil tillage (no tillage or minim	Conservative tillage: Set of various techniques to prepare the soil at varying depths but without turning over the soil. Reduced tillage: Pseudo-ploughing consists of mixing the residues at the surface and loosening the first 15 to 30 centimeters without turnover. Several passages	To be considered a new practice conservative soil tillage has to cover at least the 40% of farm experimental GeCO2 cultivated field and increase of at least 50% respect to the pre-project status (before the GeCo2 project).	Ref. Grandy, A.S., G.P. Robertson, and K.D. Thelen. 2006. Do Productivity and Environmental Tradeoffs Justify Periodically Cultivating No-till Cropping Systems? Agronomy Journal, 98(6): 1377-1383. Engel, R. E., P. R. Miller, B. G. McConkey, and R. Wallander. 2017. Soil Organic Carbon Changes to Increasing Cropping Intensity and No-Till in a Semiarid Climate. Soil Science Society of America Journal, 81 (2): 404-413 Kell, D.B. 2012. Large-scale sequestration of atmospheric carbon via plant roots in natural and

	um tillage)	can result in less than 30% of soil covered by residues, which no longer meets the criteria of a conservative agriculture. Shallow tillage mixes crop residues and sometimes leaves a portion at the surface to limit erosion, but there is no turnover. It is equivalent to a pseudo-ploughing for a depth of less than 15 centimeters. Strip-till is based on the establishment of crops in a strip of land worked to a depth of 15 to 23 centimeters. The intact inter-		agricultural ecosystems: Why and how. Philosophical Transactions of the Royal Society B: Biological Sciences, 367(1595): 1589– 1597. Lal, R. 2019. Conceptual basis of Managing Soil Carbon: Inspired by Nature and Driven by Science. Journal of Soil and Water Conservation, 74(2): 29A-34A Smith P., Martino D., Cai Z.C., Gwary D., Janzen H., Kumar P., McCarl B., Ogle S., O΄Mara F., Rice C., Scholes B., Sirotenko O., Howden M., McAllister T., Pan G.X., Romanenkov V., Schneider U., Towprayoon S. 2007. Policy and technological constraints to implementation of greenhouse gas mitigation options in agriculture. Agriculture, Ecosystems and Environment, 118: 6–28.

		row is covered by plant residues or living mulch. (https://dicoagroecologie.fr/en/encyclopedia/reduced-tillage/)		
3	Use of cover crops and/or permanent grass / meadow	Cover crops are plants that are sowed to cover the soil rather than for the purpose of being harvested. A cover crop is defined as a close-growing crop that provides soil protection, seeding protection, and soil improvement between periods of normal crop production (Soil Science Society of America, 2008). Permanent cover grass /	No threshold is defined. It is possible only to provide true/false response.	Cover crops manage soil erosion, soil fertility, soil quality, water, weeds, pests, diseases, biodiversity and wildlife in an agroecosystem—an ecological system managed and shaped by humans. Ref. Han, Z., M. T. Walter, and L. E. Drinkwater. 2017. Impact of cover cropping and landscape positions on nitrous oxide emissions in northeastern US agroecosystems. Agriculture, Ecosystems and Environment, 245: 124-134. Silva, E. and V. Moore. 2017. Cover crops as an agroecological practice on organic vegetable farms in Wisconsin, USA. Sustainability, 9(1):55. doi:10.3390/su9010055

		meadows are usually herbaceous grass or shrubs, occupying the soil and yielding harvests for several (usually more than five) consecutive years (see https://data.oecd.org/agrland/agricultural-land.htm).		
4	Farm management with hedge, rows and forest patch	Hedge or Hedgerow, Fence or boundary formed by a dense row of shrubs or low trees. Hedge rows enclose or separate fields. Rows of trees or shrubs are linear features planted in a farm field, generally in such a manner as to provide shelter from the	In order to be considered innovative this practice must cover at least the 5% of experimental field and increase at least of 50% into respect the pre-project situation	Ref. Barrios, E., Valencia, V., Jonsson, M., Brauman, A., Hairiah, K., Mortimer, P.E., Okubo, S., 2018. Contribution of trees to the conservation of biodiversity and ecosystem services in agricultural landscapes. International Journal of Biodiversity Science, Ecosystem Services & Management 14 (1), 1–16. Falloon, P., D. Powlson, and P. Smith. 2004. Managing field margins for biodiversity and carbon sequestration: A Great Britain case study. Soil Use

	integrated within field crops	wind and to protect soil from erosion. Forest is a multi-strata group of plants consisting of canopy trees and other structural layers. It contains diverse functional roles, including the following (from tallest to shortest): canopy/tall trees; sub-canopy/large shrubs; shrubs; herbaceous plants. A land area of more than 0.25 ha, with a tree canopy cover of more than 10 %. The trees should be able to reach a minimum height of 5 m at maturity in situ.	(before the GeCo2 project).	and Management, 20:240-247. Ries L, Fletcher RJ Jr, Battin J, Sisk TD, 2004. Ecological responses to habitat edges: mechanisms, models, and variability explained. Annu Rev Ecol Evol Syst 35:491–522 Ref. Chazdon R., L. et al., 2016 When is a forest a forest? Forest concepts and definitions in the era of forest and landscape restoration AMBIO A Journal of the Human Environment 45(5) DOI: 10.1007/s13280-016-0772-y

5	Reuse of wood residues in order to improve soil organic matter	Wood residues include all material left on the ground after timber is harvested (logging residue) and the pruning material.	No threshold.	Ref. Kallenbach, Cynthia M., Frey, Serita D., & Grandy, A. Stuart. 2016. Direct evidence for microbial-derived soil organic matter formation and its ecophysiological controls. Nature Communications, 7, Article number: 3630.https://www.osti.gov/pages/servlets/purl/1363941
6	Reuse of green residues (e.g. green	Green residue includes all vegetation material left on the ground after management of mowing of herbaceous plants	No threshold is defined. It is possible only to provide true/false b response.	Ref. Matos, E.D.S., E.D.S. Mendonça, I.M. Cardoso, P.C.D. Lima, and D. Freese. 2011. Decomposition and nutrient release of leguminous plants in coffee agroforestry systems. Revista Brasileira de Ciência do Solo, 35(1):141-149. http://dx.doi.org/10.1590/S0100-06832011000100013. Qin,

	mulch) in order to improve soil organic matter			W., Hu, C. and O. Oenema. 2015. Soil mulching significantly enhances yields and water and nitrogen use efficiencies of maize and wheat: a meta-analysis. Scientific Reports 5,16210. DOI: 10.1038/srep16210 Rasche, F., M.K. Musyoki, C. Röhl, E.K. Muema, B. Vanlauwe, and G. Cadisch. 2014. Lasting influence of biochemically contrasting organic inputs on abundance and community structure of total and proteolytic bacteria in tropical soils. Soil Biology and Biochemistry, 74:204-213. http:// dx.doi.org/10.1016/j.soilbio.2014.03.017 Qin, W., Hu, C. and O. Oenema. 2015. Soil mulching significantly enhances yields and water and nitrogen use efficiencies of maize and wheat: a meta-analysis. Scientific Reports 5,16210. DOI: 10.1038/srep16210
7	Use of organic	Organic amendment: composition of organic moieties derived from	No threshold. Practice considers the use of the following organic	https://ec.europa.eu/environment/ecolabel/documents/soil_improvers.pdf; https://ec.europa.eu/environment/archives/ecolabel

	amendments (which therefore store carbon in the soil) and use soil improvers (e.g. biochar, earthw	biomass and/or living beings. It generally includes compost, wood chips, biochar, animal manure, straw, husk, geotextile, and sewage manure. Soil improvers are substrates that improve soil structure and soil fertility. Soil improvers have to be mixed through the upper layer of the ground, in the root zone of the plants, so that plants could grow better and healthier. In this way the soil structure is improved and the fertility of the soil is increased. Furthermore, plants	amendments (soil improvers): Compost, Biochar, volcanic dust, wood chips: Compost_zero_emissions_1N; Compost_nonfully_aerated_production_1N Biochar Volcanic_rock_dust; v. Wood_chips; vi. Straw	/pdf/soil_improvers/usermanual_oct2001.pdf; https://ec.europa.eu/docsroom/documents/5403/attachments/1/translations/en/renditions/pdf. Ref. Blanco-Canqui, H. 2017. Biochar and Soil Physical Properties. Soil Science Society of America Journal, 81 (4): 687-711 Donn, S., Wheatley, R.E., McKenzie, B.M., Loades, K.W. and Hallett, P.D. (2014). Improved soil fertility from compost amendment increases root growth and reinforcement of surface soil on slope. Ecol. Eng., 71: 458-465. Goss, M.J., Tubeileh, A. and Goorahoo, D. (2013). A review of the use of organic amendments and the risk to human health. Adv. Agron., 120: 275-379.

	orm compost, bio-stimulating products)	biostimulants contribute to plant nutrition. Agronomic fertiliser additives act on fertilisers and fertilising materials, prior uptake by the plant of the released nutrients, enhancing their efficacy for plant nutrition and reducing losses to the environment.		
8	No application of synthesis fertilizers	Synthetic fertilizers are those composed of the synthesized chemicals of nitrogen, phosphorus and potassium. In general, natural fertilizers contain lesser amounts of N-P-K than their synthesized counterparts; so more	No threshold. Practice considers no application of fertilizers.	Ref. Hasler K., Bröring S., Omta O.S.W.F., Olfs H.-W.: (2017): Eco-innovations in the German fertilizer supply chain: Impact on the carbon footprint of fertilizers. Plant Soil Environ., 63: 531–544. Snyder C.S., Bruulsema T.W., Jensen T.L., Fixen P.E. (2009): Review of greenhouse gas emissions from crop production systems and fertilizer management

		quantities' are needed to supply the plant with the required amount of nitrogen, phosphorus or potassium		effects. Agriculture, Ecosystems and Environment, 133: 247–266.
9	Reduction in pesticides application (application rate lower than 1 kg/ha of pestici	Pesticides are substances that are meant to control pests. The term pesticide includes all of the following items: herbicide, insecticides (which may include insect growth regulators, termiticides, etc.) nematicide, molluscicide, piscicide, avicide, rodenticide, bactericide, insect repellent, animal repellent, antimicrobial, and fungicide.	No threshold. Practice considers pesticides application lower than 3 kg/ha	Ref. Aguilera E., Lassaletta L., Gattinger A., Gimeno B.S. (2013a): Managing soil carbon for climate change mitigation and adaptation in Mediterranean cropping systems: A meta-analysis. Agriculture, Ecosystems and Environment, 168: 25–36. Aguilera E., Lassaletta L., Sanz-Cobena A., Garnier J., Vallejo A. (2013b): The potential of organic fertilizers and water management to reduce N2O emissions in Mediterranean climate cropping systems. A review. Agriculture, Ecosystems and Environment, 164: 32–52.

	des, 'pesticide' prevents, destroys, or controls a harmful organism ('pest') or disease. Pestici			

	des include Plant Protection Products (PPPs) and biocides)			